FINAL REPORT
BENEFITS OF HIGH EFFICIENCY FILTRATION TO CHILDREN WITH ASTHMA

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ABSTRACT

One-hundred ninety-one asthmatic children 6-12 years old in regions with high outdoor air pollution (in and around Fresno and Riverside, CA), were enrolled in a randomized, placebo-controlled, cross-over design trial to evaluate the effectiveness of high efficiency air filtration in reducing indoor exposures and asthma symptoms. The goal of the study was to recruit 200 children from 200 households. In total, 172 households were enrolled, 19 of which had two siblings with asthma who were both enrolled. These 19 pairs of siblings brought the total number of participants to 191. High efficiency filters were installed, utilizing the central system in 43 households and stand-alone air cleaners in 129 households. Of the 191 participants, 149 participants completed the study from 136 households.

Indoor air quality was significantly improved with filtration, with a 48% reduction in the geometric mean indoor $PM_{0.2}$ and $PM_{2.5}$ concentrations, and a smaller PM_{10} reduction (31%). Air quality improvements were greater with continuously operating stand-alone air cleaners than intermittent central-system filtration. Keeping windows closed and compliance with utilizing the intervention improved results. Indoor/outdoor reflectance values, a measurement that gives the fraction of black carbon particles of outdoor origin remaining in indoor air, was reduced by 77%. Greater reductions were observed for homes that did not open windows, and in homes 5 or more blocks from a major road or highway.

While there was no improvement in asthma symptoms, based on participant responses in the two week symptom diaries, there was a significant decrease in resource utilization (clinic visits, ER visits, and hospitalizations), particularly for severe asthmatics. Participants with air cleaners in their bedroom slept better if they also kept their bedroom door closed.

EXECUTIVE SUMMARY

Background

Particulate matter (PM) and other air pollutants have long been known to cause adverse respiratory health effects. Numerous studies have shown that elevated PM levels are associated with increased asthma symptoms and reduced lung function in healthy children. More recent studies have also found impacts on asthma from elevated ozone levels and exposure to VOCs. As people spend approximately two-thirds of their time indoors at home, indoor levels of air pollution have an impact on health. The aim of this study is to determine if the use of high efficiency filtration in homes can reduce exposures to particulate matter and assess whether there is a concomitant reduction in asthma symptoms.

Objectives

1. In homes of children with asthma, determine the extent to which the use of a) high efficiency central system filtration, and b) high efficiency stand-alone air cleaners reduce indoor concentrations of $PM_{0.2}$, $PM_{2.5}$, and PM_{10}, the resulting personal exposures, and the extent to which activated carbon filtration reduces indoor concentrations of ozone.

2. Determine the extent to which the use of a) high efficiency central system filtration and b) high efficiency stand-alone air cleaners reduce asthma symptoms, emergency department (ED) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.

3. In homes of children with asthma, measure indoor and outdoor concentrations of $PM_{0.2}$, $PM_{2.5}$, PM_{10}, and ozone, and resulting indoor exposures.

   Objective three was met in the course of obtaining data to meet the first two objectives.

Methods

One-hundred ninety-one asthmatic children (6-12 years), from 172 households, were enrolled in a randomized placebo cross-over trial to evaluate the effectiveness of high efficiency filtration (use of filters with a MERV 16 rating) of indoor air in reducing indoor exposures in regions with high outdoor air pollution, specifically Fresno and Riverside, CA. The goal of the study was to recruit 200 children from 200 households. Of the 172 households, 19 households had two asthmatic siblings, both of which were enrolled, bringing the total number of participants to 191. One-hundred forty-nine participants, from 136 households, completed the study. One intervention group, 129 households, had high efficiency stand-alone air cleaners placed in the child's bedroom and in the main living area. A smaller intervention group, 43 households, had high efficiency filters installed in their central forced air heating and cooling system. Each participant received true air filtration for a year and a placebo for a year, allowing the improvements related to the air filtration relative to "sham" filtration to be estimated.

For objective one, air pollution samples were collected approximately every six months, with one measurement pre-enrollment and two measures in each of the sham and true filtration periods. Indoor and outdoor one-week, time-integrated samples were collected for measurement

of $PM_{2.5}$, PM_{10}, and ultrafine particulate matter (UFP) measured as $PM_{0.2}$. Reflectance, which is an approximate measure of outdoor black carbon, was measured for $PM_{2.5}$. For a portion of the homes, during high-ozone seasons, ozone was also measured via one-week integrated samples.

As a sub-study of objective one, activated carbon filters to reduce ozone and VOCs were installed in the homes receiving the high efficiency stand-alone air cleaners. We evaluate if there are further reductions in ozone as a result of the filters.

For objective two, asthma symptoms were evaluated in the cross-over design. Measures of health effects included unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, symptom diaries, spirometry, and exhaled nitric oxide (eNO). Unplanned utilization of the healthcare system, short-term medication use and symptom diaries were recorded prior to intervention and quarterly both during the true and the sham filtration periods. Exhaled nitric oxide and spirometry were recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true filtration periods. The study was registered with clinicaltrials.gov, with registration number NCT01869543.

For objective three, reductions in personal exposure were estimated utilizing a time activity model and measured indoor and outdoor concentrations.

Results

High efficiency filtration resulted in a significant reduction of indoor concentrations of particulate matter. Particle concentrations for all size fractions, $PM_{0.2}$, $PM_{2.5}$, PM_{10}, $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ as well as I/O ratios of $PM_{0.2}$, $PM_{2.5}$ and PM_{10} were significantly lower with true filtration than sham filtration for homes with air cleaners. Overall, there was a 48% reduction in the geometric mean indoor $PM_{0.2}$ and $PM_{2.5}$ concentrations, and a smaller PM_{10} reduction (31%). For homes with upgraded central system filtration, levels were statistically significantly lower with true versus sham filtration for all size fractions except $PM_{2.5\text{-}10}$. The sham central filters primarily removed this size fraction, and thus it is anticipated that there would not be a difference for this size fraction. The mean difference between indoor sham concentrations and true concentrations was statistically significantly greater for all size fractions for homes with air cleaners as compared to those with central system filtration. Reductions in I/O ratios were also greater with air cleaners than central filtration for all size fractions, with differences being statistically significant for I/O $PM_{0.2}$ and I/O PM_{10}. These results clearly indicate that improved indoor air quality can be achieved with high efficiency filtration. Additionally, the improvements are greater with continuously operating stand-alone air cleaners than with intermittent central filtration. Keeping windows closed and compliance with utilizing whichever intervention was installed in the home improved results. Indoor/outdoor reflectance values, a measurement that gives the fraction of particles of outdoor origin remaining in indoor air, were reduced by 77%. Larger reductions were seen in homes that did not open windows, and in homes 5 or more blocks from a major road or highway.

There were no improvements in the frequency of asthma symptoms in the last two weeks with true filtration. There were slight decreases in both clinic visits (a 20% reduction) and the sum of clinic visits, ER visits, and hospitalizations (a 19% reduction), particularly for severe asthmatics. Also, participants within the stand-alone air-cleaner group, who had an air cleaner in their bedroom, awoke less often with true versus sham filtration if they tended to keep their bedroom door closed.

Conclusions

Installation of stand-alone air cleaners and high-efficiency filters in a central system improve indoor air quality across all particle size fractions, with the greatest improvements in the smaller size fractions. There were greater improvements with stand-alone air cleaners. With filtration, there was no corresponding improvement in days with asthma health symptoms, which was the primary health outcome, and there were no improvements in other asthma-related health outcomes, including eNO and spirometry. There were small but statistically significant reductions in the numbers of visits to clinics and in waking due to asthma if the bedroom door was kept closed.

BODY OF REPORT

Chapter 1: Introduction

Particulate matter (PM) and other air pollutants have long been known to cause adverse respiratory health effects. Elevated PM levels have been found to be related to increased asthma symptoms in numerous studies [1-6] as well as being related to reduced lung function in studies of healthy children [7-9]. PM10 [1, 3-5], PM2.5 [2, 3, 8], and bioaerosols [10] have been associated with asthma symptoms. Various other pollutants have also been measured and found to be significant in the different studies for various measures of lung function and asthma symptoms. Ozone has also been found to be related to asthma symptoms. One study of 25 asthmatic children conducted in a region with high ozone levels found a relation between ozone and asthma symptoms [1]. Another study found extra asthma medication use related to ozone in 138 asthmatic children [3]. Rescue medicine use and symptoms increased with ozone exposure among 130 children who use maintenance medication [11]. Two studies found increases in emergency department visits with higher ozone exposure in adult populations [12-14]. Studies have also found significant effects of elevated levels of NO_2 [2, 3, 5], sulfur dioxide [2, 6], and black smoke [4]. A number of studies have been published documenting asthma exacerbation due to VOCs in occupational populations [15, 16]. There is less literature available investigating the relationship between asthma and VOCs in the general population; however, there is some literature supporting this concern [15-18].

As people spend approximately two-thirds of their time indoors at home [19-22], indoor levels of air pollution have an impact on health. Indoor pollutants adversely affecting respiratory health include particulate matter (containing both particles non-biological in nature and bioaerosols containing allergens and inflammatory agents), oxides of nitrogen, VOCs, and ozone. Pollutants indoors result both from outdoor air infiltrating into the indoor environment and indoor sources [23-28].

Indoor concentrations of PM can be reduced by increasing the number of particles removed by filtration, either by increasing the efficiency of the filters used, or by increasing the volume of air filtered, either through the use of stand-alone air cleaners or by using high-efficiency filters installed in the central system. Both stand-alone [29-34] and high efficiency filters installed in the central system [35, 36] have been shown to reduce indoor particle concentrations. This proposal aims to determine if asthma symptoms also can be reduced by filtering indoor air to reduce air pollution concentrations.

Approximately 8.5% of children in the United States suffer from asthma [37]. In California, 8.6% have asthma currently and 13.3% have been diagnosed with asthma at some point in their lives [37]. Asthma puts considerable burden on the health care system with treatment costs ranging from 3.2-14 billion dollars per year in the United States [38-41]. Should air filtration

improve symptoms, there could be tremendous cost savings from implementing air filtration as an asthma intervention tool on a larger population, particularly in a region with high air pollution levels, such as parts of California. California experiences some of the highest air pollution in the United States, with 8 of the top 10 cities for ozone pollution and 6 of the top 10 for particulate levels [42]. Therefore, within the U.S., California is the ideal location to conduct a study to evaluate impacts of air filtration.

Previous studies that evaluated filtration's impact on asthma have been inconclusive [43]. In part, this has been due to small sample sizes, which typically have been 45 participants or fewer, minimizing statistical power. Filtration utilization has not been consistently monitored and improvements in indoor air were not necessarily quantified.

This study improves on existing studies by providing options that have superior air filtration and implementing them in regions with high outdoor air pollution levels. Two air filtration approaches were utilized. First, high efficiency filters were installed in the central forced air heating and cooling systems. Second, stand-alone air cleaners with sufficient air flows were installed. Stand-alone air cleaners that are quiet were used because air cleaner noise has caused occupants to turn off stand-alone air cleaners in prior studies. Filtration utilization was monitored and improvements in indoor pollutant levels air were quantified. To increase statistical power, the sample size was larger than in many of the previous studies evaluating filtration, which typically have been 45 or fewer participants. In addition, we used a randomized cross-over design to increase statistical power. Finally, this study includes both subjective and objective asthma outcomes.

1.1 Study Objectives

The objectives and study plan were as follows:

1. In homes of children with asthma, determine the extent to which the use of a) high efficiency central system filtration, and b) high efficiency stand-alone air cleaners reduces indoor concentrations of $PM_{0.2}$, $PM_{2.5}$, and PM_{10}, the resulting personal exposures, and the extent to which filtration reduces indoor concentrations of ozone.

This objective was met in two ways: first by comparing indoor concentrations of pollutants between periods with true and sham filtration, and with the pre-intervention measurements, and second, by comparing indoor/outdoor (I/O) ratios of pollutant concentrations between the true filtration and sham periods.

From the data obtained in Objective 1, reductions in total personal exposure and personal exposure occurring indoors at home were estimated through modeling.

As a sub-study of Objective 1, filters to reduce ozone and VOC were installed in the homes receiving the high efficiency stand-alone air cleaners. Whether there were reductions in ozone as

a result of the filters was evaluated.

2. Determine the extent to which the use of a) high efficiency central system filtration and b) high efficiency stand-alone air cleaners reduces asthma symptoms, emergency department (ED) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.

To meet this objective, health care utilization, medicine use, symptoms, and exhaled nitric oxide (eNO) between the sham and true filtration periods were compared. These outcomes also were compared with the pre-intervention period. Participants were recruited that had experienced symptoms in the previous 6 months at least two times per week for several weeks in a row.

In the course of obtaining data to meet the above objectives, the following objective also was met:

3. In homes of children with asthma, measure indoor and outdoor concentrations of $PM_{0.2}$, $PM_{2.5}$, PM_{10}, and ozone, and resulting indoor exposures.

To meet this objective, the distribution of indoor concentrations from the pre-intervention period was determined as these concentrations represent the typical indoor exposure (at home) of children with asthma in this study population. The two 1-week integrated samples collected with the sham filter in place to meet Objective 1 will also represent typical concentrations.

1.2 Background

1.2.1 Indoor Air Quality

Particles from the outdoor environment enter buildings through open windows and doors, cracks in the building shell, through forced-air ductwork, and mechanical ventilation systems. Particles are also brought into homes on clothing, shoes, and pets. Particles are removed when crossing through the building shell and from deposition on indoor surfaces, and in some cases by filtration in a forced air central filtration system [44]. Airflow from indoors to outdoors also removes particles. Indoor concentrations of particles of outdoor origin have been measured in studies and are less than outdoor concentrations [27, 44-52]. However, these outdoor particles are still a significant contributor to indoor particle levels. The Particle Total Exposure Assessment Methodology Study (PTEAM Study), a large population-based study in Riverside California, estimated that residential indoor PM10, on average, is roughly comprised of about 66% outdoor PM10; while 75% of PM2.5 is comprised of particles from outdoor sources [24, 25]. Abt et al. [53] in a study of four homes with relatively low air exchange rates in Boston, found that only 20-43% of total indoor PM2 to PM10 was from outdoors, while 63-92% of indoor PM0.02-0.3 was from the outdoors.

Indoor particle levels are also impacted by various indoor sources, such as cooking [24-28, 54-56], smoking [56, 57], burning processes such as fires or candles [26, 58-61], resuspension of settled particles from either occupant movement [53, 55, 62-65] or housecleaning activities [53, 66], unvented natural gas pilot lights [67], secondary formation of ultrafine particles from indoor reactions between ozone and, for example, cleaning products [54, 68], and use of personal care products [69]. Fibrous materials, pollen, mold spores and fragments, and tracked-in and blown-in soil particles are also components of indoor PM [23]. While these events may be intermittent, they can have a significant impact on indoor exposures. Studies using continuous measurements have often found indoor particle concentrations exceeding outdoor levels at times during the day [54, 56]. The resulting particle concentrations from these indoor sources depend on the rates of ventilation, deposition, and filtration in a forced air central system when applicable.

People's personal exposures to PM sometimes exceed both indoor and outdoor concentrations, primarily because people tend to spend time near pollutant sources, such as when cooking or cleaning [55, 62, 69, 70]. People's activities also re-suspend settled particles, increasing concentrations locally. Studies that have used personal samplers worn by study participants have often found higher personal PM concentrations than measured indoor or outdoor particle concentrations [24, 25, 71, 72], including studies conducted with sensitive populations such as individuals with chronic obstructive pulmonary disease (COPD), coronary heart disease, and asthma [70, 73-75]. However, one study with participants with COPD found the difference to be small due to subjects' limited personal activity and very little time spent near smoking, cooking, vehicles, or other major PM sources [76, 77].

Outdoor ozone (a component of smog; formed by the photochemical reaction of volatile organic compounds and nitrogen oxides emitted primarily by motor vehicles and industries) enters homes through doors, windows, and numerous air leaks in buildings and their ventilation systems, and is the most common source of indoor ozone [78]. Indoor ozone levels are typically 10 to 50% of outdoor levels [78]. Model results predict an I/O ratio of 0.1 with an air exchange rate of 0.33 hr^{-1}, 0.33 with an air exchange rate of 1.5 hr^{-1}, and 0.5 with an air exchange rate of 3.0 hr^{-1} [79]. A large study of 126 southern California homes conducted in the 1990's had a mean I/O ratio of ozone of 0.37, with a standard deviation of ± 0.25 [80]. Indoor ozone levels are generally higher in the daytime and summer months, as are outdoor levels [80-85]. Indoor levels have been found to correlate with outdoor levels and duration of time with windows open [80]. One study found that homes using a swamp cooler or whole-house fan had high air exchange rates and had indoor ozone levels similar to outdoor levels for hours at a time. Based on studies that included personal measures of ozone, it was estimated that indoor ozone exposures accounted for 43-76% of total ozone exposure, with an average of approximately 60% [79]. Accounting for the higher breathing levels outdoors, these numbers drop for intake of indoor ozone [79].

In addition to ozone itself, there are a number of products of indoor chemical reactions of ozone with other gaseous pollutants or indoor materials, many of which are known to be irritants [79]. Studies measuring levels of some of these reaction products have found correlations with outdoor ozone levels [86, 87].

1.2.2 Air Filtration

It is important to understand the impact of filtration on indoor particle concentrations to effectively select and evaluate air filtering devices. The indoor particle concentration in a well-mixed space can be determined by the following mass balance equation:

$$\frac{dC(t)}{dt} = PaC_o(t) - aC(t) - \frac{Q_f e}{V}C(t) - kC(t) + \frac{S}{V} \quad (1)$$

where C is the indoor concentration ($\mu g/m^3$), P is the penetration efficiency, a is the air exchange rate (1/hr), Q_f is the flow rate through the filter (m^3/h), e is the particle removal efficiency of the filter, V is the volume of the home (m^3), k is the deposition rate (1/hr), and S is the indoor particle source rate (μg/hr). Equation 1 assumes that the filter removes particles from a stream of recirculated indoor air, not from incoming outdoor air. Some of the parameters in Equation 1, notably P, C_o, e, k, and S vary with particle size.

If outdoor concentration, air exchange rate, and indoor source rate are constant with time, solving for the steady state concentration both with filtration (C_f) and without added filtration (C_{uf}) and dividing the steady state concentration with filtration by the steady state concentration without filtration yields the following:

$$\frac{C_f}{C_{uf}} = \frac{a + k}{a + k + {eQ_f}/{V}} \quad (2)$$

As one can see from Equation 2, since the efficiency, e, cannot exceed unity, the ratio of the flow rate through the filter to the volume of the home must be of a similar magnitude to the air exchange rate of the home for the filter to have a significant impact on the particle concentration.

Small stand-alone air cleaners will often lack a sufficient air flow rate to substantially reduce indoor particle concentrations, except in a bedroom with a closed door [88, 89]. Studies have shown that stand-alone filters can reduce bedroom particle levels by 69% to 80% in homes with indoor tobacco smoking. Our studies utilized stand-alone air cleaners characterized as quiet and with a clean air delivery rate (product of air flow rate and particle removal efficiency) of 330 cfm, sufficient to have a substantial impact.

Air exchange rates in California were measured to have an average value of 1.8 hr^{-1} in the 1980s [90], while new homes have been measured to have a median value of 0.26 hr^{-1} [91] when windows are closed. Air exchange rates when windows or doors are open can be much higher

than rates when windows or doors are closed. For particles less than 2.5 μm in diameter, values of k vary by particle size between approximately 0.1 and 0.4 hr^{-1}, with considerably higher deposition rates possible for larger particles [48, 92]. A typical house in California is around 167 m^2 (1800 ft^2), resulting in a volume of 400 m^3. A typical bedroom is 12 by 12 feet, with a volume of 32 m^3 (1130 ft^3). With the door closed and no forced air heating or cooling system mixing air throughout the house, and a room air exchange rate of 1 hr^{-1}, a filter with flow on the order of 50 L/s (100 cfm) and 98% particle removal efficiency would result in a 79% reduction of the concentration without filtration. However, for filters placed in the main living area, or if the bedroom door was open, if filtering the whole home with that same unit, the particle concentration with filtration concentration would be approximately 76% of the non-filtered concentration (assuming a=1 hr^{-1} and k=0.4 hr^{-1}). Therefore, one needs to be conscious of the airflow of the air cleaning unit relative to the size and likely air exchange rate of the home. With a second air cleaner in the main living area set at 100 L/s (200 cfm) and one in the bedroom with 50 L/s (100 cfm), indoor concentrations are predicted to be reduced to 53% from non-filtered conditions (assuming area=1800 ft^2, a=1 hr^{-1}, k=0.4 hr^{-1}, both with 98% efficiency).This calculation is only valid if the bedroom door remains open, assuming the whole home as a single well-mixed zone. Note that a relatively high air exchange rate was selected for this estimate and if actual homes had lower air exchange rates, indoor concentrations would be further reduced. These percentage reductions in indoor particle concentrations can be increased by increasing the flow rates of the air cleaners.

Studies of improvement of filtration in central forced-air heating and cooling systems have found significant reductions in indoor air pollutant levels [36, 93]. Installing improved filters in the central system can provide greater filtration because of the significantly increased airflow rates as compared to stand-alone units, typically on the order of 3 air exchanges per hour while the central system is running, resulting in a concentration 32% of that had filtration not been in place (assuming a=1 hr^{-1} and k=0.4 hr^{-1}, 90% efficiency). However, forced-air systems of homes typically operate a small portion of the time [94-96], leading to much smaller time-average flow rates, and in the mildest California climates, months can pass without any operation of forced air systems.

1.2.3 Existing Studies Evaluating Filtration

Several studies have been conducted to determine if installation of a stand-alone air cleaner can reduce asthma symptoms. The results are mixed. A reduction of either symptoms or improved lung function was found in a number of them [97-100]. Additional studies failed to find improvements in asthma, and those that did often failed to find improvements across a range of asthma outcomes [101-103]. However, most prior studies suffered from numerous shortcomings.

First, many of the studies had a small sample size, with all but one of the 12 studies included in two comprehensive reviews having 45 or fewer participants [33, 101]. Many studies used stand-alone air cleaners and did not provide information on the efficiencies, air flow rates, or resulting

decrease in particulate matter [88]. One could therefore assume filtration was not high-efficiency. Some of the existing studies focused on participants with pet allergens who had a pet living in their home. While the air cleaners in these studies generally reduced airborne allergen levels, they did not effectively remove pet allergens from surfaces which could have limited the effectiveness of the intervention [98, 99, 102].

The majority of studies had intervention periods less than 3 months, with the two studies involving children and a 1 year intervention period both finding improvements in some of the outcomes [97, 98]. It has been suggested in the review by the American Academy of Allergy, Asthma & Immunology Indoor Allergen Committee that interventions should be sustained for at least 12 months to yield meaningful clinical results [101].

To fully evaluate the impact of air filtration technology, more comprehensive studies were needed that avoided the weaknesses of prior research by having a larger study population, using filters with known high efficiency and the capacity to significantly improve IAQ, and including a suitable placebo as a control.

Chapter 2: Methods

2.1 Study Overview

Asthmatic children living in non-smoking homes in regions with high outdoor air pollution were enrolled in a randomized placebo cross-over trial to evaluate the effectiveness of high efficiency filtration of indoor air to reduce their exposure to PM and ozone, and their asthma symptoms. Each participant received true air filtration for a year and placebo filtration for a year, allowing us to estimate the improvements related to the air filtration. One intervention group had modifications of their central forced air heating and cooling system to enable the installation of a high efficiency filter. The second intervention group had high efficiency stand-alone air cleaners placed in the child's bedroom and in the main living area. As this study had a cross-over design, participants had true filtration for a fraction (one half) of the project period and a placebo for the other half of the project period. We used filters with a MERV 16 rating equivalent in both the stand-alone air cleaners and the central system filtration. Filters that remove ozone and VOCs were also used in homes with the stand-alone air cleaners.

The placebo period used a sham system. In the case of the stand-alone air cleaner, flow was diverted so that it did not pass through the filters and ran through vents in the back of the air cleaner instead. In the case of the central filtration, the high efficiency filter was replaced with one with a MERV 4 filter, typical of what is found in residential systems. Approximately half the participants began with the true filter while the other half began with the sham filter, according to a randomized allocation rule.

Two outcomes were considered: the reduction of indoor air pollution levels and the improvement of asthma symptoms or treatment. Air pollution measurements were obtained every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true filtration periods. The final air pollution measurements were not conducted for some participants. This always occurred in the sham period. Indoor and outdoor air were measured to obtain one-week integrated samples for PM_{10}, $PM_{2.5}$, $PM_{0.2}$ (representing ultrafine particles), and ozone. Ozone measurements were made for a portion (a total of 112 measurements) of participants in the high ozone season, May – October, both during the true and sham periods.

Measures of health effects included unplanned utilization of the healthcare system, short-term medication use, symptoms (via diaries), respiratory infections, cold/flu symptoms, spirometry, and exhaled nitric oxide (eNO). Unplanned utilization of the healthcare system, short-term medication use, and symptoms (via diaries) were recorded prospectively, beginning with the pre-intervention period and quarterly both during the true and sham periods. Exhaled nitric oxide, spirometry, height, weight, and Body Mass Index (BMI) were recorded every 6 months, with one measurement pre-intervention and two measures in each of the sham and true periods. The distribution of forced vital capacity (FVC) varied with height. Height was recorded in order to determine the percentile rating of the FVC. Additional information regarding the participant's health history, asthma triggers, demographic characteristics, and exposure to pets and cigarette smoke were obtained to characterize the population in a questionnaire, entitled Baseline Questionnaire Part 1. This questionnaire also included the first Symptom Recall and questions on utilization of the health system over the previous year. A second questionnaire, entitled Baseline Questionnaire Part 2, was administered to gather information about the house, including information on window use, heating and cooling systems, and gas appliances.

This study utilized two interventions, high efficiency filters installed in the central system or use of stand-alone air cleaners with high efficiency PM filters in the child's bedroom and the main living area of the home. Enrolled participants' homes were inspected to determine if it was possible to add a high efficiency filter to the central system. It was found that only a low proportion of homes were able to accommodate installation of central system filtration. Hence, filtration was installed in all households that were willing and could accommodate the intervention.

Each participant was evaluated for approximately two years, allowing sample collection for matched calendar months between the true filtration period and the sham filtration period. Participants received true filtration or sham filtration during the first period. For participants first receiving true filtration, they had true filtration for a one-year period, followed by one year of sham filtration, as diagrammed in Figure 2.1.1. The enrollment process, which includes health and air pollution measures, was completed just prior to the first month of the study. For those who received sham filtration first, the schedule was different, with the sham period split into two segments of 6-months each, with one year of true filtration in the middle. This design

modification prevented participants in the sham from being in the study for a full year with only sham filtration, a deprivation of potential air quality improvements from the intervention devices that the study sponsor considered to be ethically unacceptable as well as potentially detrimental to the recruitment and retention of participants. However, this modification resulted in a statistically suboptimal imbalance in the timing of sham and true filtration for 50 percent of the study. In the two-year post-intervention period, approximately 75% of the first year was under true filtration and 75% of the second year was under sham. This association of filtration status with follow-up time lowered the precision of estimated true versus sham contrasts in study outcomes and could have also led to confounding of the true versus sham contrasts with temporal effects such as those due to within-subject maturation (e.g. asthma severity decreasing as children age) or regression-to-the-mean effects (e.g. enrollees selected on the basis of pre-enrollment symptom severity regressing toward less severe levels over time). An alternative analysis of the symptoms in the first 6-months of each year of participation was also considered as these two times periods were balanced with respect to the two study conditions but at the cost of using only 50% of the collected data.

The study was called Asthma and Indoor air: Reducing Exposures (AIRE). Flyers were distributed in the community to describe the study with a phone number for interested family to call. Potential participants were then screened for eligibility, and those eligible and interested were enrolled. The study was further described to participants at the first visit, outlining the various activities that would occur over the two year commitment. A diagram documenting the study timeline was given to them and is included here as Figure 2.1.2. The details are further described in Section 2.3, Study Activity Timeline and Participant Tracking, but this diagram provides introductory overview.

This study was reviewed, approved and overseen by the UC Davis institutional review board (IRB). In addition, we registered the trial at clinicaltrials.gov, under registration number NCT01869543 (https://clinicaltrials.gov/ct2/show/NCT01869543).

Details regarding the study population, study timeline, intervention, baseline questionnaire, indoor air quality measurements, and health measurements are found in the subsequent sections of the methods.

GROUP	Prior	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
TRUE	x																								
SHAM	x																								

Figure 2.1.1 Timeline of receiving true filtration (green) and sham filtration (black) for true and sham groups.

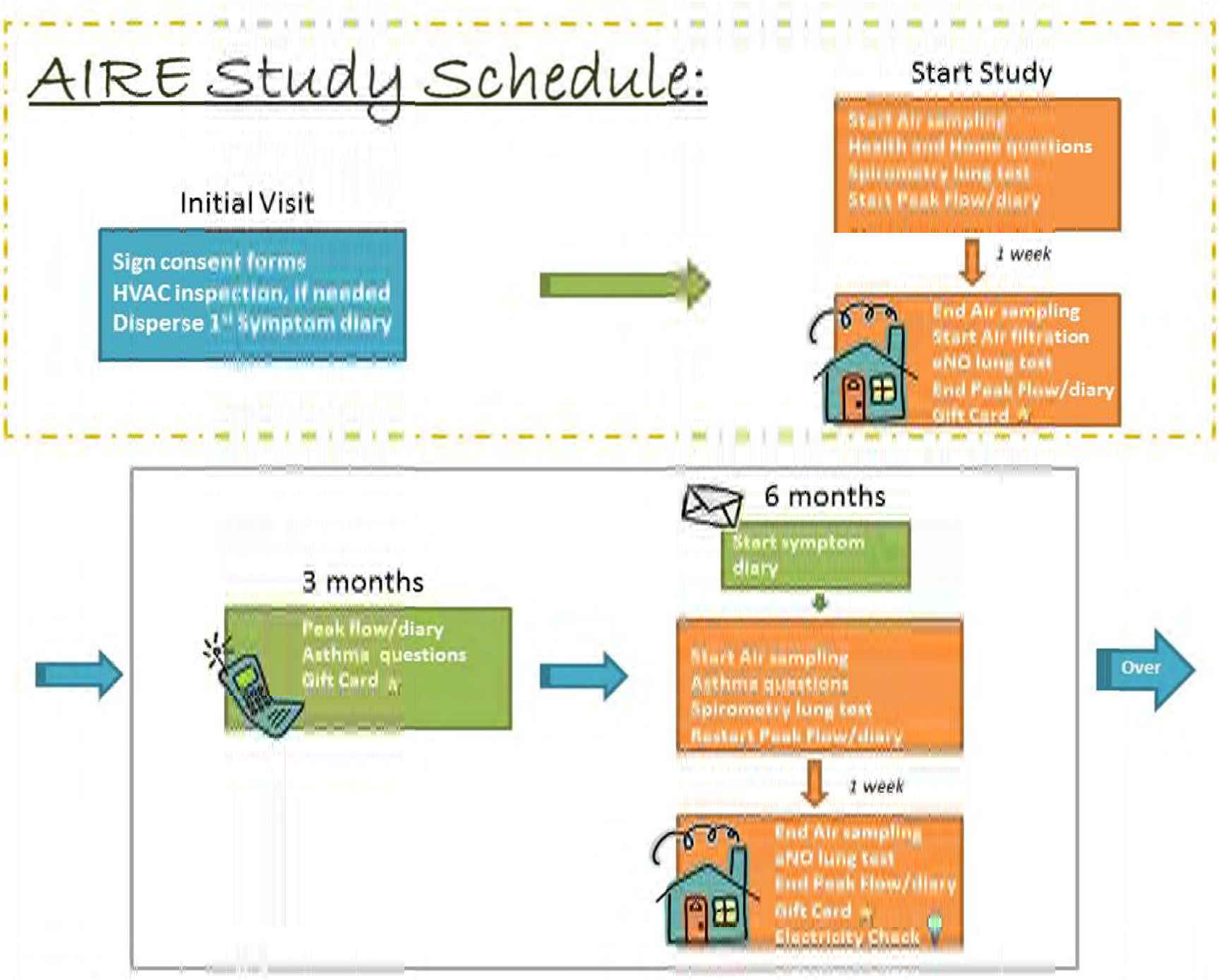


Figure 2.1.2 Diagram of the AIRE study schedule given to participants (first page).

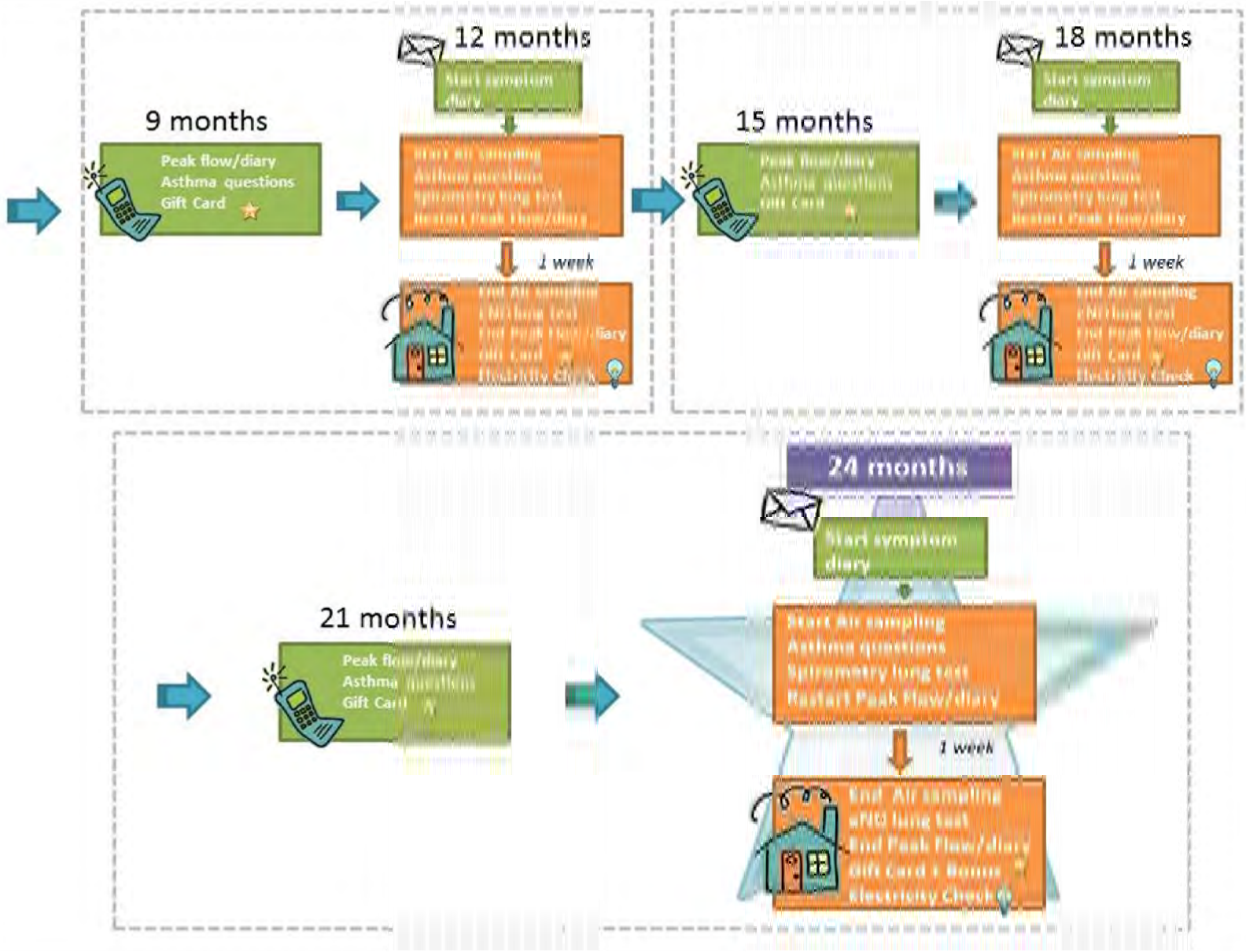


Figure 2.1.2(con't) Diagram of the AIRE study schedule given to participants (second page).

2.2 Study Population

2.2.1 Defining Study Population

The goal of the study was to recruit 200 participants. There are four factors in defining the study population: the study region, the age of the participants, the diagnosis of asthma, and the absence of any study exclusion criteria.

We note that the children are the primary participants in the study. However, their parents also answer questions about their child's asthma, or their home, and thus are also referred to as participants. A participating household refers to the unit of the household, which includes one or two participating children.

Two study populations were recruited: one in the greater Fresno area, and one in the greater Riverside area. These two cities ranked in the top 5 nationwide for ozone pollution and in the top 10 for short term particulate matter exposure in the United States [42]. Approximately two-thirds of the participants were recruited from the Fresno area, and one-third from the Riverside area.

The study population eligibility was designed to balance those individuals anticipated to have the greatest improvement in asthma resulting from air filtration with the realities of being able to recruit individuals into the study and understanding the realities of how people live. With these overarching goals in mind, study population eligibility was defined as outlined below.

Specifically, children ranging in age from 6 to 12 years with self-reported doctor-diagnosed asthma were enrolled in the study. Additionally, criteria were developed for the symptom pattern of their asthma.

A child's severity of asthma is defined based on a set of criteria related to frequency of symptoms when the child's asthma is not controlled. Once the child has been diagnosed with asthma, efforts are often made to control the child's symptoms. Therefore, the pattern of symptoms the child experiences reflects both the level of severity and the level of control. In order to see an improvement in asthma symptoms related to the intervention, the child's asthma would ideally not be controlled.

In this study, severity was determined based on whether or not they had experienced symptoms at least twice a week for several weeks in a row, and that these symptoms occurred within the last six months. Having symptoms at least twice a week for several weeks in a row is consistent with an asthma symptom pattern defined as "persistent".

In determining the inclusion criteria, the inclusion criteria used in the Inner-City Asthma Study were also considered [104]. The eligibility criteria for that study included at least one asthma-related hospitalization or two unscheduled asthma-related visits in the last six months. Children enrolled with these inclusion criteria had an average of three days with symptoms in the two

weeks prior to enrollment in the study, and an average of approximately 2.2 days per week with wheeze in the two weeks prior to enrollment in the study.

Defining eligibility in terms of symptom patterns was considered preferable for our study as many of the potential participants in this study might be children of undocumented immigrants who may not utilize the health system as readily as children whose parents are US citizens. Eligibility was determined through a structured questionnaire, referred to as the Screening Script, included in Appendix A.

The specific questions defining severity in the Screening Script are as follows:

- Has your child been diagnosed with asthma by a doctor?
- Have there ever been periods of time when your child has had asthma symptoms at least twice a week for several weeks in a row?
- Has this occurred in the last 6 months?

Additionally, the family must speak Spanish or English, not be planning to move for the next two years, and be willing to run an air cleaner for most of the day or, if using the central system filtration, be willing to run the system 15 minutes per hour. There must not be any smokers living in the home and the home must not already have high efficiency filtration. Finally, the participating child must primarily live at one house. A screening script was used to determine if criteria were met (Asthma Study Participant Recruitment/ Eligibility Screening Script, Appendix A).

Participants that kept their windows closed were ideally desired. However, individuals that tend not to have their asthma well-controlled also tend to be those individuals that come from low income households. Individuals that come from low income households tend not to use air conditioning to cool their homes due to the high electricity costs. Therefore, only participants in homes where windows were open at least eight hours a day in the cold season, November through March, were excluded. Asthma symptoms are most severe in the winter and early spring, and thus this is the most critical time period for leaving the windows shut.

If there were two eligible children in the household, both were asked if they wanted to participate in cases where they either shared a bedroom, or we thought we might be able to filter the air through a central system.

Participants were included as part of the study sample if they completed the Baseline Questionnaire Part 1 and they had an intervention installed in their home.

All study materials were prepared in both English and Spanish to accommodate participants with either native language[a]. All Spanish translations were reviewed by native speakers from Mexico. All Spanish translations are included on the website with the final report.

a. One household that spoke only Lao was included. Permission to have a sibling translate was granted by the IRB.

2.2.2 Recruitment

Recruitment occurred primarily through distribution of study flyers to children in 1st through 6th grade in school districts within the study areas. School districts were contacted and they determined if they would be willing to send flyers home with students in their district. One school district distributed flyers to asthmatic children identified by the school nurse rather than to all children. The flyers are in Appendix A.

In addition, flyers were distributed in the Riverside region through one of the local county hospitals, a mobile asthma clinic, a local asthma and allergy practice, and asthma education courses presented by a local chapter of the American Lung Association.

If the parents were interested in participating, the study phone number was included on the flyer and parents could call that number to be screened for eligibility. On this phone call, it was determined if the study participant was eligible by conducting the screening script. If they were eligible, study staff described the study to the potential participant and asked if they would like to participate. If they were eligible and did not refuse to be in the study, they were entered into the subject tracking system. The subject tracking system is a secure database and is the only place the subject's personal identifying information is stored. Subjects were given a household ID when entered into the database and randomized as to whether they would receive true or sham filtration and also randomized to receive stand-alone air cleaners or central system filtration. Not all subjects entered into the subject tracking system ended up enrolling in the study. All encounters with the participant were recorded in the subject tracking system. The system also provided the calendar interface to schedule visits and provide a calendar of visits for the study staff.

2.2.3. Randomization

The primary objective of our randomized cross-over study design is to estimate true versus sham filter effects separately and pooled for two types of filtration systems: central system filtration or stand-alone. Our randomization plan was designed to achieve, within each filtration system type, equivalent groups with respect to initial filter status (true first versus sham first). By randomizing, we provide the strongest statistical basis for estimating the effect of the intervention that is not confounded by selection and assessment biases. This allows the strength of the resulting evidence to be rated the highest. Randomized trials are considered the gold standard for study design for evaluating causal claims.

During the recruitment telephone call for eligible subjects who did not refuse to be in the study, we asked the participant whether or not they have a central forced-air system. Participants reporting that they did not have a central forced-air system were assigned a stand-alone filtration system, and were randomly assigned to "true first" versus "sham first" in a 1:1 allocation, using random permuted blocks with a block size determined by the study statistician (Dr. Daniel Tancredi) and stratified by study site (Fresno versus Riverside):

- "SX-T" – could only be in the stand alone group, true filtration first
- "SX-S" – could only be in the stand alone group, sham filtration first

The goal was to have 100 homes installed with central system filtration and 100 homes installed with stand-alone air cleaners. We anticipated that 80% of the homes would have a central forced-air system and of the homes with a central forced-air system, we anticipated that approximately three out of four would actually be able to have the central system filtration installed. Criteria for being able to have central system filtration installed are discussed in Section 2.4.2, Determining Eligibility for Central System Filtration. We therefore randomly assigned participants, who lived in homes with central forced-air systems, into one of four groups in a 1:1:4.9:4.9 allocation, also using random permuted blocks with a block size determined by the study statistician:

- "RS-T" (Randomized to stand-alone filtration, true first initially)
- "RS-S" (Randomized to stand-alone filtration, sham filter initially)
- "RH-T" (Randomized to central filtration if possible, true filter initially)
- "RH-S" (Randomized to central filtration if possible, sham filter initially)

At the study enrollment visit to homes in the "RH-T" and "RH-S" groups, a determination was made as to whether or not the participant had a central system that was able to be upgraded to use the central system filtration. The study design called for the evaluation of the assumptions regarding proportion of homes that could utilize central system filtration after evaluation of the first 30 homes. The study design was instead modified almost immediately to inspect all homes for central system filtration as it became almost immediately apparent it would be difficult to reach the initial goal of 100 homes with central filtration. As the randomization for starting true versus sham was equal for all groups, we were able to continue the block structure established, only utilizing the true versus sham portion of the randomization.

2.3 Study Activity Timeline and Participant Tracking

Once the participant was recruited to the study, the enrollment process began. The following list of activities occurred in either one or two visits, determined based on logistics. If there were two visits, the first two items occurred on the first visit, with the remaining items occurring on the second visit.

- The participant gave consent to participate in the study.
- The central air system was inspected, as applicable, to determine if the participant was eligible for the central system filtration or if they were only eligible for the stand-alone air cleaners.
- They completed a Baseline Questionnaire Part 1, which included information on health history, asthma triggers, and demographics.
- They completed a Recall Questionnaire on health care utilization over the past year, and symptoms, medicine use, respiratory infections, cold/flu symptoms, and quality of life

over the prior two weeks, as part of the Baseline Questionnaire Part 1. They were also asked to begin a 2-week diary in which they were asked to record their symptoms, medicine use and quality of life, daily. The symptom diary also contained items related to indoor air quality, such as cooking and window usage. We reviewed the diary with the participant at the end of the 2 weeks to ensure it was complete and to try to improve accuracy. For the remainder of this document, we refer to the collective health care utilization, symptoms, medicine use, and quality of life over the last 2 weeks as the Recall Questionnaire and the 2 week ongoing record as the Symptom Diary.

- Spirometry was conducted (please note that this may have been recorded at the first or second visit, which are both prior to the intervention, but was tentatively scheduled for the first visit).
- Indoor and outdoor air pollution monitors were set up to collect one-week integrated samples of $PM_{0.2}$, $PM_{2.5}$, and PM_{10}.

During the first week, symptoms were recorded while PM was collected. After one week, a second visit occurred, during which time the air pollution monitors were collected. In addition, the following activities occurred:

- Collected and reviewed the symptom diary with the participant.
- A home walkthrough was completed in conjunction with the Baseline Questionnaire Part 2 to determine significant sources and modifiers of indoor air pollution, such as wood stoves, type of cook tops, pets, and whether the participant had air conditioning.
- eNO was recorded. (This was initially scheduled to be a different visit than the spirometry to require less activity from the participant. Both measures may have occurred simultaneously at either the first or second visit, both prior to intervention, when necessary).
- The filtration system, either the stand-alone air cleaners or the central system, was installed. In some cases this occurred at a separate visit, typically within 2 weeks. In cases where there was a delay in installation, it was noted.
- A small monetary incentive was given.

The schedule of study activities following the enrollment can be seen in Figure 2.3.1 for participants beginning with true filtration and in Figure 2.3.2 for participants beginning with sham filtration. The Figures begin with the first month of each year being the month in which the intervention was installed. The timing of both air quality and health measurements are described in the following paragraphs. A simplified version given to the participants was included earlier as Figure 2.1.2.

Briefly, one-week integrated indoor and outdoor air pollution measurements were performed every 6 months. Specifically, samples for $PM_{0.2}$, $PM_{2.5}$, and PM_{10} were collected using cascade impactors for the size fractions, and also a $PM_{2.5}$ impactor for the $PM_{2.5}$. A portion of the

participants were monitored for ozone in the high ozone season, May – October. Indoor and outdoor ozone samples were collected using passive Ogawa badges. Indoor temperature and relative humidity were recorded during sampling. Some questions related to indoor air quality during the measurement week were also administered through the Symptom Diary. All exposure measures are detailed in Section 2.6, Air Quality Measurements.

Health measures include 2-week symptom diaries and 2-week recall questionnaires collected seasonally (every 3 months). Symptom diaries were filled out by the participant and then reviewed with the participant, either in person or by phone, to increase completeness and accuracy. We included both the recall period and the active diary. In addition, spirometry and eNO were collected every 6-months, with spirometry typically collected at the beginning of the air pollution monitoring period and eNO typically collected at the end of the air pollution monitoring period. In some cases, both measures were collected at one visit, if needed. For seasons where air pollution data were not being collected, the questionnaires were delivered to the participants and returned to staff via mail. All health measures collected in the study are detailed in Section 2.7, Health Measurements.

Periodic incentives is the form of gift cards to the parents, $15 for each set of questionnaires, and small toys for the children were provided to participants. Participating households also received a $100 gift card fi they completed the study.

In addition to the schedule of data collection, Figures 2.3.1 and 2.3.2 show which measurements were taken simultaneously in matched calendar months. This is important because there is a significant seasonal component in asthma. The figures also include a row that indicates the number of months the true filter has been in place in the home at the time of the data collection. It is thought that some level of improvement may occur almost immediately following installation of the air cleaning device due to the reduction of some asthma triggers while some improvements in health would require a longer time period to become evident due to reduction in inflammation of the lung. An alternative analysis of the symptoms in the first six months of each year of participation can also be considered. Such an analysis eliminates any differences in the total length of time in the study and is balanced with respect to True and Sham.

The enrollment occurred over approximately 11 months, with participants enrolled in the Fresno area in some months and in the Riverside area in other months. This is outlined in Figure 2.3.3.

Ideally, the visits and phone calls would be scheduled to occur in a six-week window that included the specified visit month. To allow for greater flexibility for the participants when they could not accommodate a visit in the specified time window, visits and phone calls were scheduled as close as possible to the specified window. A “Home visit scheduling strategy” was created and included as an Appendix of QA/QC plan (Appendix E). Visits and calls were classified to have occurred in a specified season. The seasons were defined as winter (December, January, February), spring, (March, April, May), summer, (June, July, August), and fall

(September, October, November). We spent the first month of each season in Riverside. Therefore, for Riverside data, winter is always December, spring is always March, etc. We spent the last two months of every season in Fresno. For example, winter in Fresno is either January or February. The calendar of visits for participants enrolled in various months is shown in Figure 2.3.3. Visits were categorized into which season they occurred based on the date the Recall Questionnaire was conducted. Typically, all other data were recorded within two weeks of this date.

It is noted that seven households had their pre-intervention visits in early December 2013, but to accommodate our schedule of spending one month in Riverside followed by two months in Fresno each season, the follow-ups for these participating households were shifted back to the previous month. Specifically, this occurred at the six month visit. The three month visits for these households occurred in early March, but were classified as winter. This allowed for three months of true filtration prior to the three-month recall. The six month visit then occurred in May for these households. All subsequent visits followed the schedule based on a November enrollment.

Group 1												Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM -> TRUE
Year 1	M 1	M 2	M 3	M 4	M 5	M 6 (summer)	M 7	M 8	M 9	M 10	M 11	M 12 (winter)
Group 1	TRUE	TRUE	Recall, Diary TRUE	TRUE	TRUE	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM & I/O Ozone (portion of population) TRUE	TRUE	TRUE	Recall, Diary TRUE	TRUE	TRUE	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM, TRUE -> SHAM
Year 2	M 13	M 14	M 15	M 16	M 17	M 18 (summer)	M 19	M 20	M 21	M 22	M 23	M 24 (winter)
Group 1	SHAM	SHAM	Recall, Diary SHAM	SHAM	SHAM	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM & I/O Ozone (portion of population) SHAM	SHAM	SHAM	Recall, Diary SHAM	SHAM	SHAM	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM, SHAM
Seasonally matched measurements			3 M TRUE vs. SHAM			6 M TRUE vs. SHAM			9 M TRUE vs. SHAM			12 M TRUE vs. SHAM, Effect of study participation

Figure 2.3.1 Schedule of filtration (true or sham), indoor and outdoor air pollutant concentrations, and health measurements for participants starting with true filtration.

Group 2												Enrollment Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM -> SHAM
Year 1	M 1	M 2	M 3	M 4	M 5	M 6 (summer)	M 7	M 8	M 9	M 10	M 11	M 12 (winter)
Group 2	SHAM	SHAM	Recall, Diary SHAM	SHAM	SHAM	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM & I/O Ozone (portion of population) SHAM -> TRUE	TRUE	TRUE	Recall, Diary TRUE	TRUE	TRUE	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM TRUE
Year 2	M 13	M 14	M 15	M 16	M 17	M 18 (summer)	M 19	M 20	M 21	M 22	M 23	M 24 (winter)
Group 2	TRUE	TRUE	Recall, Diary TRUE	TRUE	TRUE	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM & I/O Ozone (portion of population) TRUE -> SHAM	SHAM	SHAM	Recall, Diary SHAM	SHAM	SHAM	Health: eNO, Spirometry, Recall, Diary, IAQ: I/O PM SHAM
Seasonally matched measurements			9M TRUE vs. SHAM			12 M TRUE vs. SHAM			3 M TRUE vs. SHAM			6 M TRUE vs. SHAM, Effect of study participation

Figure 2.3.2 Schedule of filtration (true or sham), indoor and outdoor air pollutant concentrations, and health measurements for participants starting with sham filtration.

	2013	2014												2015												2016								
	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Fresno, December	x			*		x			*			x			*			x			*			x										
Fresno, January		x			*			x			*			x			*			x			*			x								
Fresno, February			x			*			x			*			x			*			x			*			x							
Riverside, March				x			*			x			*			x			*			x			*			x						
Fresno, April					x			*			x			*			x			*			x			*			x					
Fresno, May						x			*			x			*			x			*			x			*			x				
Riverside, June							x			*			x			*			x			*			x			*			x				
Fresno, July								x			*			x			*			x			*			x			*			x			
Fresno, August									x			*			x			*			x			*			x			*			x		
Riverside, September										x			*			x			*			x			*			x			*			x	
Fresno, October											x			*			x			*			x			*			x			*			x
x - indicates home visit; * - indicates phone call																																		

Figure 2.3.3 Timeline of enrollment and follow-up visits.

2.4 Interventions

Two interventions were evaluated in this study, with each home being assigned to only one intervention: upgrading the filter in the existing central forced-air system or placing high efficiency stand-alone air cleaners in the child's bedroom and main living area. Filtration in both cases was aimed at reducing fine and ultrafine particle concentrations (particles less than 2.5 or 1 μm in size). The stand-alone air cleaner also included a filter to reduce ozone concentrations, and other common VOCs.

The four primary factors to consider when devising a filtration intervention for maximum reduction of ambient air pollution in homes are: 1) The amount of air treated in relation to the size of the home 2) The filtration efficiency with which air pollutants are captured 3) compliance by the participants in using the filtration intervention as intended and, 4) air exchange with the outdoors. To address these factors, we utilized high-efficiency, high airflow and low sound level stand-alone alone air cleaners. For homes with central heating ventilation and air conditioning (HVAC or central) system air filtration installed, we also installed thermostats that allowed us to program the system to operate for a portion of every hour. We determined that in order to filter a similar amount of air as the stand-alone air cleaners the central system should ideally run for 15 minutes of every hour. Also, to minimize air exchange with the outdoors we asked participants to keep windows and doors closed while they were in the study.

One of the benefits of this cross-over and self-controlled design is that participants were exposed to both true filtration and, during the placebo period, sham filtration. During the placebo period, a sham system was used in the stand-alone air cleaners. For the central system filtration, the high efficiency filter was replaced with one with a low MERV rating, typical of those commonly found in residential systems.

To determine if the indoor levels were likely to be reduced due to the filter being used, the amount of time that the stand-alone units or central system filtration operated was automatically recorded. We asked participants about window and door usage during the week of air sampling. Finally, we noted that we supplied dust mite resistant mattress pad and pillow covers. All aspects are discussed in detail below.

2.4.1 Central System Filtration

For homes equipped with suitable, ducted Heating, Ventilation and Air Conditioning (HVAC or central) systems, a whole-home central forced-air filtration system from the IQAir Company was used. The air cleaning system was designed to attach to the central filtration return air intake where it replaces the existing return air grille. Typically, the pre-existing central filtration air filters were 1" in size and were primarily located in the return air grilles, or were located at the air handler, which is often located in a basement, attic or garage. They were removed as part of the study.

While the particle removal efficiencies of the high efficiency filters installed in forced-air systems were much higher than the efficiency of a conventional residential air filter, the high efficiency filtration system were designed to minimize the airflow resistance, to minimize the effects on air flow rates, and offer a minimum of 6 months of filter life.

Because central filtration systems are typically set to run only when they provide cooling or heating, we replaced the thermostats with programmable versions that facilitate the system's use for air cleaning as well. These thermostats included a circulation feature that operated the central system's fan for at least 15 minutes per hour to ensure that air was circulated and filtered in the home even if temperatures were mild and did not otherwise require heating or cooling.

The study's forced-air cleaning system provided space for an air filter that was about twice the size of a conventional 1" thick central system air filter, by increasing length, width, and depth. The filter utilized a high performance filter media with a combination of mechanical and electrostatic filter effects. The media was pleated tightly with hot melt separators for an increased filter-media surface area. The larger dimensions and increased depth combined with mini-pleat design of the filter allowed an overall increase in filter media surface area. Compared with a traditional low-efficiency fiberglass panel filter, the IQAir filter had a filter-media surface area that was 17 times larger. Compared with higher efficiency 1" pleated filters, the filter-media surface area was 3-10 times larger. The increased filter media surface area increased the filter's particle removal efficiency, while simultaneously reducing the airflow resistance across the filter. This can be seen in Figure 2.4.1. The larger surface area also allowed a larger dust holding capacity and increased filter life. The result was a filter efficiency rating of MERV 16, which indicated a minimum composite particle removal efficiency of 95% for particles 0.3 to 1.0 microns in size and a pressure drop that was similar to a typical 1" MERV 8 filter.

For the control portion of the central system intervention study, IQAir produced a special "sham" filter that had similar physical appearance to the "real" filter used for the intervention portion of the study, but had a lower-efficiency rating of MERV 4, which reflected the performance of most common residential central system filters.

A number of thermostats were used during the project. It was required that we install a thermostat that could run the fan for a portion of every hour, called a "clean-air" cycle. Ideally, the fan should run for 15 minutes of every hour, and we used thermostats that ran either 15 or 20 minutes of every hour. Many of the thermostats available are for newer homes which have a five-wire connection between the thermostat and the central heating or cooling unit. However, many of the homes in this study were older and had only a three-wire system, limiting the choices for the thermostat. Additionally, the initial thermostat had to be replaced in several homes because the thermostat malfunctioned, causing the air conditioning system to run continually. More information on the thermostats used can be found in Appendix A.

A B C

Figure 2.4.1: A) The central system return grille B) the grille with filter installed and C) the central system filtration system mounted to the return intake. Please note that while these pictures show a system mounted to a wall, homes in the study typically had the system mounted to the ceiling.

During the installation process, the airflow through the central system was measured both before and after the installation of the whole-home central air filtration system. Airflow was measured using an Alnor balometer (EBT721). The airflow hood was placed over the return grille, and airflow was measured with the central system running in fan only or heat mode. Measurements were only made when time allowed.

2.4.2 Determining Eligibility for Central System Filtration

Only some homes were eligible for a central system upgrade. The criteria for a home to be eligible are listed below:

- The home must have a central forced-air system.
- The central system must work well.
- In the case of a multi-unit dwelling, the unit must service only the participant's home.
- The central system must service the participant's bedroom.
- The central system must have a fan-only mode in order to operate for a portion of each hour.
- There cannot be a swamp cooler associated with the system.
- The participant must agree to have their system operate 15 minutes out of every hour.
- If the participants are renters, the landlord must give permission.
- We must be able to install a study thermostat (details provided in Appendix A).
- The filter casing must be able to be installed; specifically there must be 2 inches of clearance around the existing filter holder and no reason it cannot be installed. For

example, the intake must be accessible, be either high on the wall or on the ceiling, and be mounted to a flat, intact wall board.

The UC Davis field staff conducted the initial inspection to determine eligibility. Homes that seemed like they may be eligible for the central system filtration were further evaluated by an IQAir technician. The central system grilles and thermostats were installed by an IQAir technician.

2.4.3 Stand-Alone Air Cleaners

For homes not equipped with suitable central systems, we selected stand-alone air cleaners from IQAir, as seen in Figure 2.4.2. Two models were used for this study, which varied in width and airflow only and will be described as Large Air Cleaner and Small Air Cleaner. Both air cleaners were designed to provide high particle filtration efficiency and clean large volumes of air while operating at low sound levels (48 dB(A) @ 400 cfm, and 49 dB(A) @ 240 cfm, respectively, Table 2.4.1). The air cleaners contained a particle and gas-phase filter element that incorporated true HEPA filter media to achieve a total system efficiency of greater than 99% for ultra-fine and fine particles (0.01 – 10µm), and a 1 cm thick activated carbon bed to reduce ozone. The particle filtration included no ionization and did not generate ozone. The study air cleaners included the ability to be converted into placebo air cleaners for use during the sham period.

Table 2.4.1 Corresponding Airflow Rates and Sound Levels for Each Fan Speed for the Large and Small Air Cleaners

Fan Speed	**Large Air Cleaner (Model 401.1)**				**Small Air Cleaner (Model 411.1)**			
	Air Flow (cfm)	Sound Pressure (LpA) dB(A)	Sound Power (LwA) dB(A)	Power Consumption (W)	Airflow (cfm)	Sound Pressure (LpA) dB(A)	Sound Power (LwA) dB(A)	Power Consumption (W)
Speed 1	120	25	35	45	120	35	45	55
Speed 2	175	33	43	55	175	42	52	60
Speed 3	300	42	52	70	240	49	59	80
Speed 4	400	48	58	100				

Notes:
Sound power is the total sound energy emitted. This value is independent of room size and determined in a standardized test.
Sound pressure is the sound level achieved in a typical room in 3 feet distance.
A 10 dB(A) increase in sound pressure is equal to a perceived doubling sound.

Each home received two stand-alone air cleaners: one for the bedroom, and one for the living room. The Large Air Cleaner was preferred whenever possible because it provided the highest air cleaning performance to noise ratio. The Small Air Cleaner was deployed in situations where the Large Air Cleaner was not able to fit, such as in small bedrooms.

The stand-alone air cleaners were operated and controlled via the electronic control panel. The Large Air Cleaner could be set to run at four different fan speeds which corresponded to four different air flow rates, while the Small Air Cleaner could be set to run at three different fan speeds, each corresponding to a different airflow rate (See Table 2.4.1). Speed 1was the lowest speed, and speed 4 or 3 was the highest fan speed, for the Large and Small Air Cleaners, respectively.

For the Large Air Cleaner, speed 3 was generally quiet enough for large rooms, and thus, this speed setting was the study goal for the living room. If there was any noise concern, staff reduced the fan speed to level 2. The selected fan speed was recorded on the usage log. In the participant's bedroom, fan speed 2 was the default. Due to the smaller size of these rooms, less airflow was sufficient to provide a high level of air cleaning at a low sound. In cases where there was exceptional sensitivity to sound, the fan speed was reduced to level 1. The Small Air Cleaner was deployed in cases where staff could not fit the Large Air Cleaner in the room.

For placebo operation, the air cleaners were equipped with a special "sham" filter that had similar physical appearance to the "real" filter used for the intervention portion of the study, but incorporated a solid panel hidden between the particle filtration media and the carbon bed. This blocked airflow through the filter. Special vents were opened on the back of the air cleaner to bypass the filter and draw air into the system. (During normal operation, those vents were covered on the inside by a clear plastic foil, thereby maintaining the same outward appearance of the air cleaner for both study periods.) This effectively turned the air cleaner into a room fan, with similar airflow and noise level as when it is in the true mode. A diagram can be seen in Figure 2.4.3.

During placebo operation, the air cleaners were designed to have a total system efficiency of less than five percent for removing ultra-fine and fine particles (0.01 – 10μm).

The initial carbon bed utilized a micro-spherical activated carbon matrix that maximized gas-phase adsorption kinetics while minimizing airflow restriction. Partway through this study, some study participants complained about odors because the activated carbon reached its holding capacity. The material to remove ozone also absorbs other VOCs, lowering concentrations of those compounds as well. The material in some of the homes reached its maximum holding capacity, at which time it began to emit an unpleasant smell. In cases where participants called as soon as the problem occurred, their filters were replaced as soon as possible. In other cases, the participating household simply turned the air cleaner off and did not notify staff that there had been an offensive smell until they were contacted to conduct a recall interview or to remind them of an upcoming home visit. In these cases, we replaced the filter as quickly as possible. However, the air cleaner was off for a period of time and the child was breathing unfiltered air. These periods of time were recorded to the best of our ability based on the information provided to staff by the participating family. Once it became apparent that the activated carbon filters did

not last a full year, they were replaced at every visit. The design was altered, and a 1 cm thick carbon mesh panel was used instead of the carbon microsphere matrix. Filters with the new design were installed at all subsequent visits and changed every 6-months. No complaints regarding smell occurred with the new design. IQ Air stated there was no change in materials to reduce PM levels.

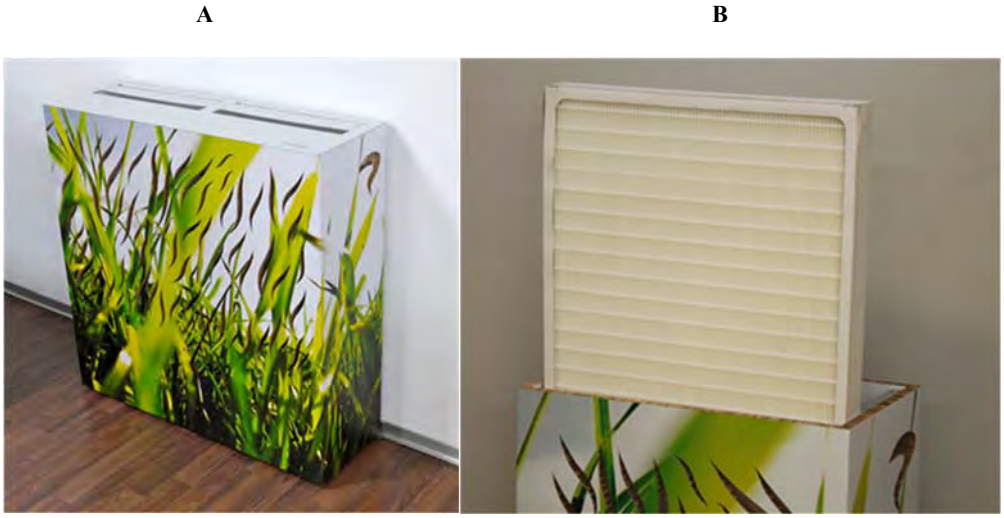


Figure 2.4.2: A) The large IQAir stand-alone air cleaner used in the study. B) View with the filter being removed.

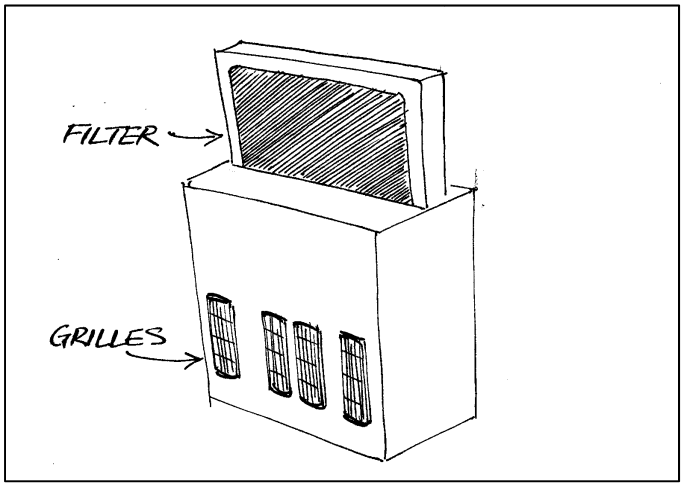


Figure 2.4.3 Diagram showing backside of air cleaner, and the locations of grilles utilized in converting to sham mode.

2.4.4 Recording Usage of Interventions

In order for the intervention to be effective, it needs to be utilized. It was anticipated that actual usage would be an important modifier relative to the reduction in indoor air concentrations and also in improving asthma symptoms. Therefore, both the stand-alone air cleaners and the central system filtration were equipped with devices to record usage.

Each stand-alone air cleaner recorded on a computer memory device, both the number of hours that it ran in total and the estimated amount of air that passed through it. By pressing a series of buttons on the control panel operating the air cleaner, this information could be retrieved. By subtracting the total number of hours of operation from the total elapsed hours between periods of data recording, one can estimate the fraction of the time the device ran, and at what airflow rate. Field staff recorded the total operation time and the total air volume that had passed through the system at installation and at every home visit, including both before and after the one week air sampling events.

The instructions for downloading and processing the data from the unit are available in the SOP for Stand-alone Air Cleaners (Appendix G). Following data entry, the data were extracted into the Air Cleaner Data set, described in the Stand-Alone Usage Data Dictionary. The Data Dictionary also includes the variables for calculating the fraction of time the air cleaner was utilized, and the average flow rate while it was operating. As a summary measure, the time average flow rate for each air cleaner was calculated, i.e., the total volume of air that passed through the air cleaner divided by the elapsed time. We then summed the flow rates of the two air cleaners in the home and divided by the targeted sum flow rate, yielding a fraction of the total air filtered in the home relative to the targeted amount of filtered air.

It was noted that if the air cleaner was replaced at some point during the six-month period between visits, the total hours of operation and airflow must be the sum of the two air cleaners installed in that location. This was done manually, and any manually-entered data was utilized, producing the final estimates for the fraction of airflow relative to the desired airflow rate. The process is outlined in the Data Dictionary. Sufficient notes were also included in a field of the data set such that the calculations could be replicated for houses that had a switch in air cleaners. Air cleaners were replaced in homes when they broke or otherwise became unusable for some reason, and also because a portion of the participants wanted to switch from air cleaners with a printed cabinet design to an alternative white-cabinet air cleaner that was manufactured partway through the study.

Ideally, we wanted to measure usage in these settings:

- The fraction of time the stand-alone air cleaner ran during the air quality sampling period.
- The fraction of time the stand-alone air cleaner ran for each three-month period, inclusive of the two week recall period.

Usage data for the stand-alone system were downloaded two times every six months, before and after the one week air sampling period. Therefore, we were able to determine the exact fraction of time during the air quality sampling period. We assumed that the average time over the six-month period between our home visits was applicable to each three month period. As noted above, some participants turned their air cleaner off due to an offending smell. We noted incidence of an offending smell in the stand-alone usage data set.

The central forced-air filtration system included a pressure sensor and a microchip to record the pressure difference across the filter. The pressure difference in combination with a threshold pressure value was used to determine when the central system was actively drawing air through the filter. It could not determine whether the system was running to heat or cool the home, or if it was running in fan-only mode. However, since the air was filtered in all of these situations, the total operation time was the desired measure.

The pressure difference was originally recorded every 15 minutes. The recording interval was later changed to every 5 minutes, when it was realized that some central systems were cycling between on and off too quickly for proper recording. The downloaded data records from the unit included the date, the time, and the pressure difference. From these records, summary measures for all of the prior 3 months and sampling week were created by dividing the fraction of measurement points with a measured pressure difference by the total number of measurement points. In the case of missing or otherwise problematic data, notes were included in the data set, and where appropriate, an approximate portion of time the central system ran was included.

Additionally, the portion of air in the home per hour for the sampling week was calculated. Specifically, the volume of air cleaned per hour divided by the volume of the home, assuming all homes had 8ft ceiling height as this was not measured. For the homes with filtration though central filtration system, the flow through the intake was measured following the installation of the filter holder if logistically feasible.

2.4.5 Allergen-Impermeable Covers

The use of allergen-impermeable covers on mattresses and pillows has been demonstrated to be effective at reducing asthma symptoms in some previous studies. The majority of previous studies included both mattress pad covers and asthma education [97, 104-109] with some measures of health effects showing improvement in asthma in almost all the studies [97, 104, 106-109]. In a number of studies, the control group received asthma education, and while both groups often improved, there were greater improvements with the use of the bed coverings [97, 104, 107].

If participants had dust mites and allergy-based asthma, and we did not provide them with covers, air filtration may have only had a very limited impact on their symptoms as they would still be exposed to dust mite allergen each night in bed, which would limit our probability of finding a significant improvement. If these participants had the covers, filtration may provide

additional benefits over the sham filtration alone, as we would be evaluating the improvements based on decreasing air concentrations of other potential triggers without the strong dust mite trigger. Therefore, allergy mattress and pillow covers were installed on the beds of all participants and remained installed in both true-filtration and sham-filtration periods. At subsequent visits, staff checked to confirm the covers were still in place, and if not, new ones were provided.

2.5 Baseline Questionnaires

Each participant completed a Baseline Questionnaire. The Baseline Questionnaire was broken into two parts, the Baseline Questionnaire Part 1 and the Baseline Questionnaire Part 2. The Baseline Questionnaire Part 1 collected information related to the child's health history as related to asthma and allergies, information about exposures to smoke and pets, and basic demographic information. In addition, it contained a Recall Questionnaire that was the same as the ones administered every three months, with the exception that it asked for hospitalizations, doctor visits, emergency room visits, steroids, and ear and respiratory infections over the past year as opposed to the past three months. The questions and answer choices for the components of Baseline Questionnaire Part 1, not related to the Recall Questionnaire can be found in Appendix B. The questions and answer choices to the Recall Questionnaire are also included in Appendix A. Additionally, there were a series of questions related to obtaining information about the allergen mattress covers that needed to be brought to the home as an intervention, and these questions are not included in the questionnaire as they were asked for logistical reasons rather than to obtain analysis data about the home. The actual Baseline Questionnaire Part 1, both English and Spanish versions are in Appendix B.

Baseline Questionnaire Part 2 included questions about the home environment, specifically covering basic information about the home, heating and air-conditioning systems, window usage, gas appliance use, mold and water damage, and flooring. The question and answer choices for Baseline Questionnaire Part 2 are in Appendix B. The actual Baseline Questionnaire Part 2 is also in Appendix B. Both parts of the Baseline Questionnaire were translated to Spanish.

The Baseline Questionnaire Part 1 was typically administered at the first visit of the baseline measurement week, referred to as the enrollment visit. The questionnaire was administered by one of our staff members to one of the caregivers of the participating child. If there were two participating children in the study, the caregiver completed the questionnaire for both children. The Baseline Questionnaire Part 2 was typically administered one week later, referred to as the installation visit. If there were two participants in the same household, only one Baseline Questionnaire Part 2 was conducted, and the information was applied to both participants.

Details on questionnaire administration were assembled and these were included in the final data dictionary. This document included general guidance for administering the questionnaire as well as specific instructions for identifying the participant, the date the questionnaire was conducted,

and specific guidance on how to respond to questions the respondent might have on a question-by-question basis. Please note that some notes on administering the questionnaire were included directly in the questionnaire, such as specific alternative wording on questions we felt might frequently need additional clarification. The Data Dictionary specifically included the question number, the variable name, a brief description of the question, the variable values for each response option, any notes related to questions that might arise during the administration of the questionnaire, and any notes related to how information should be data entered into the database.

All Baseline Questionnaires were entered into a secure electronic database using a data entry interface. The data were retrieved from the data set by the creation of a SAS® software (Version 9.4, SAS Institute Inc., NC) data set. The data set was checked for any missing values, and all missing values were checked with the paper copies of the questionnaires. If data were on the paper questionnaire and had inadvertently not been entered during the data entry process, it was entered. The data were checked for outliers or otherwise suspect data. Suspicious values were checked versus the original paper questionnaire and entries were corrected if there was a mistake in data entry. A series of derived variables were also created that allowed us to combine responses to multiple questions or present results in a manner that was more conducive to interpretation. These created variables are included in the Data Dictionaries, as well as in Appendix B.

Because some participants moved over the course of the study, a very short version of the Baseline Questionnaire Part 2 was created, titled the Mover's Questionnaire, which was administered to participants to gather information about their new home. Specifically, participants were asked what type of home it was, whether it had an attached garage, when it was built, the square footage, what type of heating and cooling system it had, whether the stove and oven were gas or electric, and what type of flooring the home had. The Mover's Questionnaire can also be found in Appendix B.

There are several variables collected in the Baseline Questionnaire that were used as covariates in either the exposure or health analysis. These variables were utilized as follows:

1. Having an allergy to furry animals and having a furry animal reside in your home. This is a time-invariant binary covariate for each participant. Having allergies to the pet living in your home may result in differential response to the air cleaners, with a greater decrease in symptoms for allergic children living with a furry pet.

2. Age of home, collected as continuous integers and converted to categorical variables split into before and after 1977. Older homes may have greater air exchange rates and thus less significant reductions in pollution levels.

3. Distance to roadway, expressed as a binary variable with living within one block of a busy road; considered close to roadway. Traffic generated particles may be more likely trigger asthma symptoms.

2.6 Air Quality Measurements

At each home, integrated one-week air pollution samples were collected every 6 months, with one measurement pre-enrollment and two measurements in each of the sham and true periods. In indoor and outdoor air, $PM_{0.2}$, $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ were measured using a cascade impactor with the $PM_{0.2}$ mass collected on a Teflon filter and the $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ mass collected on a Polyurethane Foam (PUF) substrate. From these size fractions, $PM_{2.5}$ and PM_{10} were also calculated. A one-week integrated $PM_{2.5}$ sample was also collected using an impaction-based Personal Exposure Monitor (PEM) for $PM_{2.5}$ designed for 1.8 LPM flow with particles collected on a Teflon filter. This second measure for $PM_{2.5}$ was collected directly onto a filter. Indoor and outdoor ozone were measured using Ogawa passive badge samplers in a portion of the homes, during the warm months of the study. Indoor and outdoor black carbon levels were measured using reflectance on the $PM_{2.5}$ filters. Indoor temperature (T) and relative humidity (RH) were measured indoors using HOBO U23-001 data loggers (Onset Corp., Cape Cod, MA).

There were three additional measurements included in the original proposal that were not ultimately implemented. First, it was planned to collect surface dust on a Nylon DUSTSTREAM™ filter fitted in a polypropylene tube installed on a Eureka Boss vacuum cleaner. The plan was to find an additional source of funding for allergen analysis. Surface dust sampling was conducted at the three pilot homes. Ultimately, dust collection was deemed to add too much complexity to the study visits and was eliminated from the study. Second, it was planned to collect measurements from integrated 48-hour personal samplers twice from 25-30 children with asthma during the true and sham period using a Harvard $PM_{2.5}$ 4.0 LPM PEM. Personal sampling was attempted at two of the pilot homes. Neither child wore the samplers and, like the dust sampling, personal sampling was deemed to add too much complexity to the study. Third, collection and analysis of indoor NO_2 concentrations was planned for homes during the non-ozone season with the concentration data to be utilized as a potential confounder in the models used to analyze data. These samples were to be collected using Ogawa passive badge samplers. Analysis was to be paid for with matching funds provided by UC Davis. Ultimately, there were budgetary concerns and it was determined these funds should be saved for other unexpected costs.

2.6.1 Indoor and Outdoor PM Measurements

PEM Samplers

Indoor and outdoor one-week integrated $PM_{2.5}$ samples were collected using an impaction-based PEM for $PM_{2.5}$ designed for 1.8 LPM flow with particles collected on a 37mm Teflon filter [110].

The PEM samplers used in this study are well-established and have been used in numerous studies [72, 77, 111, 112]. Greased impactor plates were used to minimize particle bounce. The PEMs utilized have an indentation for the grease which is significantly elevated above the filter. This limits the potential for grease getting on the filter which was a problem with earlier designs [110]. Particles were collected onto 37mm Teflon filters (SKC 225-1709, Eighty Four, PA). A diagram of the sampler can be seen in Figure 2.6.1.

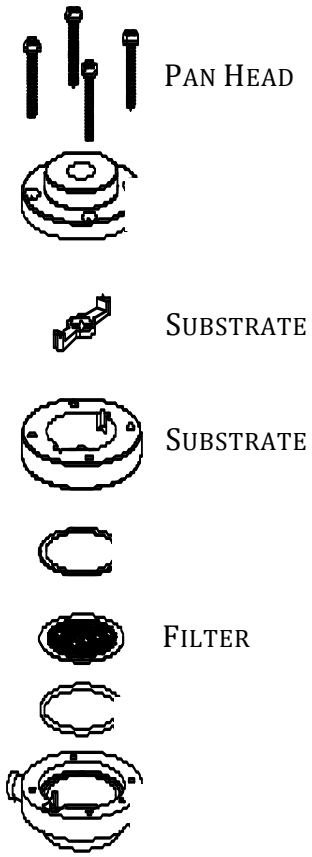


Figure 2.6.1 PEM parts and configuration.

Cascade Impactors

Indoor and outdoor $PM_{0.2}$, $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ as one week integrated samples were collected using a cascade impactor (CI) [113] with a flow rate of 5 LPM. $PM_{0.2}$ mass was collected on a Teflon filter and the $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ masses were collected on Polyurethane Foam (PUF) substrate. $PM_{2.5}$ and PM_{10} were determined by summing the mass across the stages. Figures 2.6.2 and 2.6.3 are pictures of the outside and inside of the cascade impactor. The PM_{10} stage has been compared to reference methods [114] and has been used in a number of large field studies [111, 115-118].

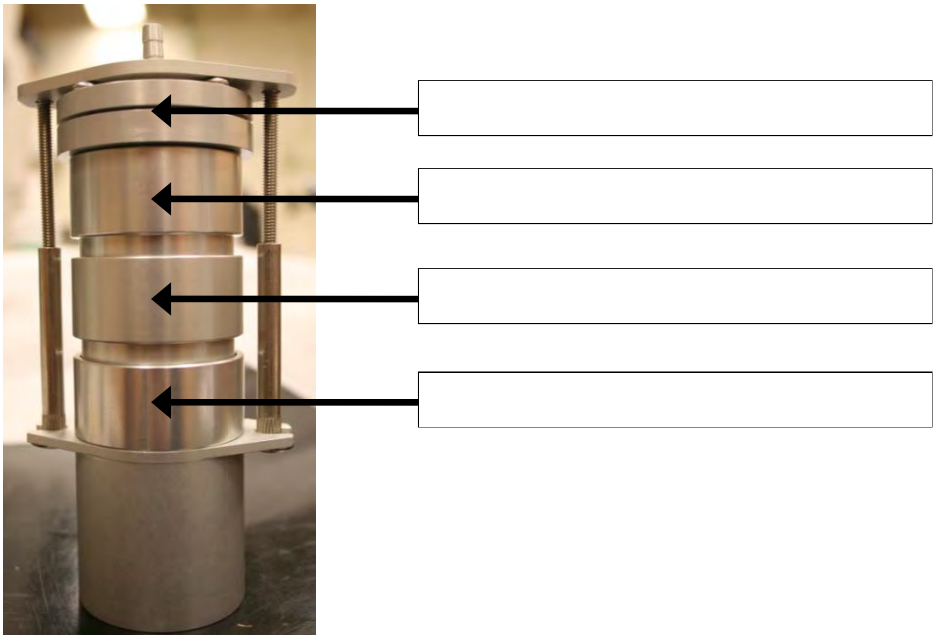


Figure 2.6.2 Assembled Cascade Impactor.

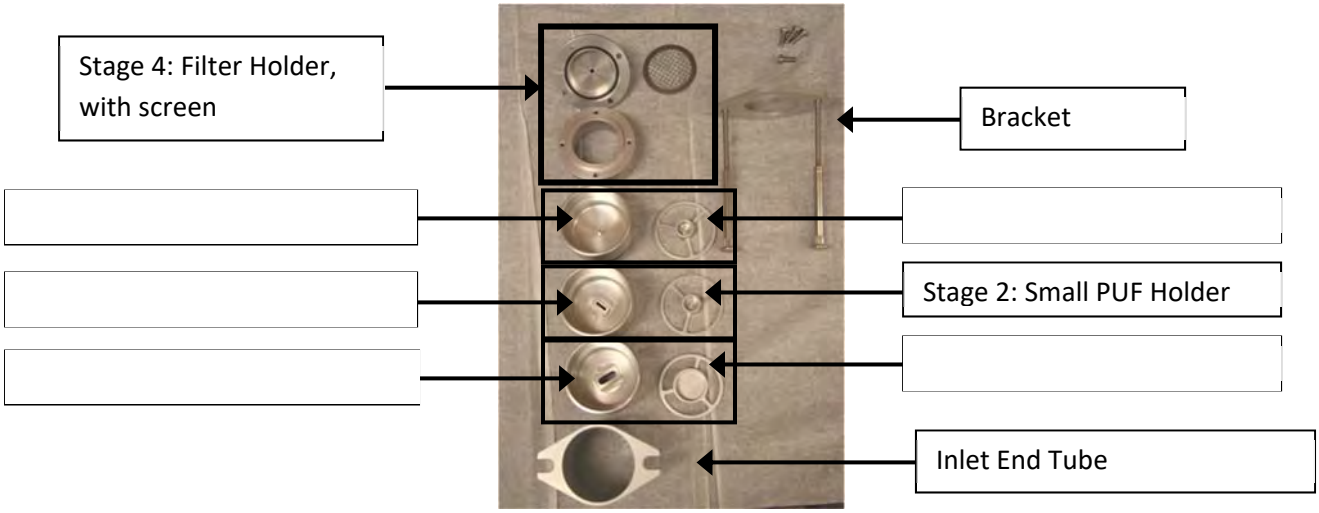


Figure 2.6.3 Disassembled Cascade Impactor.

The impactor was originally designed to have one stage at PM_{10} and a second stage at $PM_{2.5}$ [110, 119]. Due to the needs of a study conducted at the University of Southern California, an additional stage was designed with a cut point at $PM_{0.2}$. The $PM_{0.2}$ stage was tested in the

laboratory to determine the cut-off curve. Exact details are found in the paper evaluating the other stages as the same process was used [119].

Sample Collection

The samplers were placed in pump boxes to prevent access by occupants of the homes. The pump boxes were designed to hold one 5 LPM Cascade Sampler with two Medo pumps VPO125- 7 LPM (MEDO, Roselle, IL), one 1.8 LPM PEM with one Medo pump VPO140 -3 LPM (MEDO, Roselle, IL), and connect them to sampling inlets. A picture of the inside of the pump box is in Figure 2.6.4. The inlets are 0.625 inch inside diameter, made of aluminum. The tubes are in the shape of a candy cane, with a gentle, swept 180^{o} turn near the top. Each sampler has its own inlet tube. The pump boxes are also equipped with a flow control valve Milli-Mite 1300 Series 1315G4B (Hoke, Spartanburg, SC) for each sampler, a two-channel timer Talento 992+ (RS, Northamptonshire, UK), and an exhaust system. In the case of a power outage, the pumps turned back on when the power came back on with this control timer. Each pump has its own hour meter to record elapsed time. Identical boxes and inlets were used indoors and outdoors.

Figure 2.6.4 Inside view of a pump box.

Indoor samplers were placed on a wooden base in the main living area of the home, as seen in Figure 2.6.5. The inlets were at 45 inches above ground. The goal was to locate the samplers at least 30 cm away from any wall, if possible. If this was not possible, samplers were placed as far

from the wall as possible. We also tried to avoid placing the samplers behind furniture, near windows, near combustion sources (i.e. fireplaces in use), near the door to the garage, near sources of water (such as in the bathroom or near the kitchen sink), directly under a light, or in the air-stream from ventilation inlets or outlets. The locations selected were easily accessible and useable for subsequent occasions.

For outdoor samplers, pump boxes were supported by a tripod, with inlets at 72 inches above ground. The goal was to locate them away from walls or other surfaces, trees, sprinklers or other water sources, garage or driveway, trucks, buses, cars or other internal combustion engines. We tried to achieve a distance of 1 m or more from vertical surfaces. During the main study, samplers were sometimes set up on a balcony, which may not meet these criteria. This option was employed only if it was the only outdoor location available. In this case, the tripod and sampling box was located as far from the wall as possible. The outdoor location needed to have access to power with the cord secured to ground.

Figure 2.6.5 Outside view of a pump box set up indoors.

Air flow was measured at the start and end of each sampling event using an electronic piston volumetric gas flow meter Bios 520 (Bios international, New Jersey). Both the time from the pump box timer and the watch time were recorded before and after sampling. Details of the sample collection, the loading and unloading of samples, and the pump box can be found in Appendix G, "SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly", "SOP for PEM Cleaning, Assembly, and Disassembly", "SOP for Indoor/Outdoor Air Quality Field Sampling", and "SOP for Pump Box".

Determining Mass

Samples were weighed at The University of Wisconsin State Laboratory of Hygiene (WSLH – www.slh.wisc.edu), an operating unit of the University of Wisconsin-Madison. PM mass was quantified by automated (Bohdan Automation) gravimetric analysis using a high-precision (± 0.001 mg) balance (Mettler Toledo MX-5). Filters and PUF were equilibrated in a temperature (21±2 °C) and humidity (35±3% RH) controlled dedicated weighing room for a minimum of 24h before weighing. Filters were re-weighed twice both before and after sampling. The details are in Wisconsin's SOP, "Weighing Substrates for TECL Analysis" in Appendix G.

Calculating Sample Volumes

Sample volumes were only calculated if the sampler ran for at least half of the nominal sampling time of 168 hours. The target flow for the cascade impactor was 5 LPM, with the acceptable range for the initial flow being between 5-5.25 LPM, and the acceptable range for the final flow being between 4.5-5.5 LPM. The target flow for the PEM sampler was 1.8 LPM, with the acceptable range for the initial flow being between 1.8-1.83 LPM, and the acceptable range for the final flow being between 1.62-1.98 LPM. If flows were slightly above these ranges, they were still included in the analysis, but values were flagged. Sample volumes were not calculated if the off-flows were below the target flow.

The sample time was calculated in two ways: using the recorded watch times and using the pump elapsed timer. These two times were compared and considered comparable if values were within 2 hours of each other, approximately 1% of the nominal run time of 168 hours. Both times were recorded in order to determine if the participant had turned off the sampling pumps. If the values were different by more than 2 hours, the field logs were checked for data entry errors. The process for calculating the volumes is included in Section 3.6.1, as it was developed as part of the QA/QC evaluation process.

O-rings used in samplers

There were contamination issues with the initial O-ring ("red O-ring'), as well as the first replacement O-ring ("black O-ring') used in the impactors, resulting in samples needing to be discarded. For more information about the types of O-rings used and the issues encountered with them, please consult the pilot report (Appendix D), as well as the evaluation conducted by Dr. McDade entitled "Quality Assurance Report: O-Ring Assessment", located in Appendix E. To

determine if the sample was valid, the type of O-ring used was recorded for each filter sample. For the black O-rings, it was determined that filters in the sampler for less than 14 days were not contaminated, and thus, the length of time in the sampler was determined for filter samples collected with the black O-rings. Data were only included if it utilized an acceptable (used or Viton) O-ring, or a black O-ring in the sampler for less than 14 days.

Calculating I/O Ratios

The indoor outdoor concentration ratio was calculated directly from measured concentrations when both indoor and outdoor concentrations were available. In cases where the outdoor concentration was not available, the average concentration of all other outdoor samples collected that week for either Fresno or Riverside was substituted.

2.6.2 Indoor and Outdoor Reflectance

We estimated indoor and outdoor levels of black carbon (which is primarily emitted in the outdoor environment) by measuring reflectance on the $PM_{2.5}$ filters. This allowed us to determine the reduction of particles of outdoor origin. Reflectance was measured using an EEL43M Smoke Stain Reflectometer (Diffusion Systems Ltd., London, UK), and transformed into an absorption coefficient according to ISO 9835 [120, 121]. The evaluation found the reflectance measure was well-correlated with elemental carbon, with a coefficient of over 0.93 in two of the locations. This approach has been used in numerous studies [117, 118, 122, 123]. The reflectance value of the unused filter served as a blank and was deducted from the value measured after the filter was used. The difference of the reflectance value corresponds to the actual black carbon collected on the filter. This accounts for the differences in brightness of the unused filters. The reflectometer was calibrated at the beginning of every measurement session. There is an additional calibration check performed after every 6 filters are measured. Each filter was measured twice, and the reported values must have been within ± 0.2, or the filter was remeasured. The estimate of the μg of elemental carbon was calculated using the following equation:

$$\mu g\ EC = 33\ x\ LN\left(\frac{100 + Reflectance}{2\ x\ Reflectance_{wb}}\right)$$

Where: Reflectance = the average of the two reflectance measures for the filter

$Reflectance_{wb}$ = the average of the two reflectance measures for the working blank recorded following the set of six filters

The mass calculated prior to using the filter was subtracted from the mass after using the filter to determine the mass collected on the filter. The concentration was then determined by dividing by the sampling volume. The indoor/outdoor ratio of black carbon was calculated, allowing for an estimation of particles of outdoor origin in the indoor air. Details on reflectance measurements can be found in the SOP for Reflectance Analysis in Appendix G.

2.6.3 Indoor and Outdoor Ozone

One-week integrated ozone measurements were collected indoors and outdoors using a passive Ogawa badge (OGAWA & Co., Pompano Beach, FL) [124]. For both indoor and outdoor samplers, the badges were placed inside the inlet cover of the Harvard 5 LPM cascading impactor, which drew air across the face of the sampler [125].

Ogawa filters were sent to Research Triangle Institute (RTI) (Research Triangle Park, North Carolina) for analysis. Mass of nitrate was extracted and quantified. Ozone concentrations were calculated based on the equations described in the Ogawa sampler protocol. The sampling rate for ozone was constant, each filter having a sampling rate of 11.4 mL O_3/min (outdoor) or 8.9 mL O_3/min (indoor), based on the value in the Harvard school of Public Health SOP. Two filters were collected and analyzed together and thus the sampling rates of two filters, resulting in a total sampling rate of 22.8 mL O_3/min (outdoor) and 17.8 mL O_3/min (indoor). Outdoor ozone concentration was provided by RTI using the following equation:

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{22.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6} M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6 \mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

Multiplying the constants in the equation yields 17.30, and substituting:

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 17.30$$

Indoor ozone concentration was calculated using the following equation:

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{17.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6} M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6 \mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

Multiplying the constants in the equation, yields 22.16, and substituting results in the following equation:

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 22.16$$

2.6.4 Temperature

Temperature (T) and relative humidity (RH) were measured indoors using HOBO U23-001 data loggers (Onset Corp., Cape Cod, MA) while air pollution measurements were being conducted indoors. Samples were collected following standard protocol "SOP for Hobo U23/U10 Deployment and Maintenance", found in Appendix G.

Outdoor temperature and relativity humidity data were obtained from ambient monitoring stations. A map of meteorological monitoring stations in the Fresno and Riverside areas is available at http://batchgeo.com/map/0c267cbe124e25fbd146e291fa9d3775. The monitoring station closest to each participating household was determined based on the address of the house.

Temperature was collected as a potential modifier of asthma symptoms. It was ultimately determined that indoor and outdoor temperature were not going to be included in the final analysis because resources were limited and this factor was thought to be less influential than others. Real-time indoor temperature and RH were collected at all visits. The nearest meteorological station to each participant was identified. The indoor temperature files, list of nearest stations, and directions for extracting the data were provided to CARB.

2.6.5 Questions related to Indoor Air Quality

There were a number of questions on the recall questionnaire and the symptom diary related to potential pollutant sources in the indoor environment. In the recall questionnaire, these questions primarily obtained information also obtained in the Baseline Questionnaire for home conditions that may have changed, such as pets, mold, water damage, wood burning activities or events, and smoking habits. The questions are located in Appendix C.

The symptom diary included specific pollutant sources or home conditions that occurred during the sampling week such as, smoking in the home, wood or candle burning, cooking activities, cleaning product use, and usage of windows and doors in the home.

The questions from the Symptom Diary are located in Appendix C.

Variables for Analysis

There were several outcome variables used for data analysis. Specifically:

1. Indoor levels of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone – one-week integrated indoor concentration for each measurement.
2. Indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone – calculated by dividing the one-week integrated measured indoor concentration by the one-week integrated outdoor concentration.
3. Indoor/outdoor reflectance ratios – one-week average of the indoor/outdoor reflectance ratio which is calculated by dividing the indoor reflectance value by the outdoor reflectance value. Reflectance values are correlated with black carbon concentrations.

4. Corresponding outdoor levels of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone - one-week integrated outdoor concentration for each indoor measurement. These will influence indoor levels. (I/O $PM_{2.5}$).
5. Open window usage, expressed as the proportion of days that windows are left open for more than two hours over the one-week measurement period. Less significant reductions in pollution levels from air cleaning are anticipated when doors and windows are left open as this increases the air exchange rate.
6. The sum of the following two variables:

    - Frying or sautéing, expressed as the number of days frying or sautéing on a stove was conducted over a one week sampling period.
    - Smoke sources, expressed as the number of days there was either someone smoking in the home or having a fire, using a wood burning stove, or burning candles or incense over a one week sampling period.

Households with indoor frying or sautéing, smoking, wood burning, candles, or incense may have higher indoor/outdoor ratio of $PM_{2.5}$ and $PM_{0.2}$.

2.7 Health Measures

The primary measures of health effects were number of days with asthma symptoms over a two week period, measured through a Recall Questionnaire. This outcome was also recorded through a 14-day Symptom Diary. Secondary measures include unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, spirometry, and exhaled nitric oxide (eNO). Allergy symptoms were recorded as a covariate. Symptoms, unplanned utilization of the healthcare system, and short-term rescue drug medication use, were recorded prior to intervention and quarterly both during the true and the sham periods. Exhaled nitric oxide and spirometry were recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true periods.

Multiple measures of health were used because, while these various measures are somewhat correlated, they provide different information on the severity of disease [126-128]. Each endpoint was evaluated separately, rather than using a combined measure. The EPR-3 guidelines stress the importance of using multiple measures to evaluate asthma [129]. For example, FEV1 is a useful measure for future exacerbation in children while FEV1/FVC appears to be a more sensitive measure of severity of current obstruction in the impairment domain [129].

Exhaled NO is an objective measure of airway inflammation [127, 130-133]. It is also related to airway hyper-responsiveness [134, 135], which has been found to improve with air cleaner interventions in prior studies [98]. We utilized both 2-week symptom diaries and 2-week recall questionnaires. While the 2-week symptom diary is considered the gold standard in terms of accuracy, studies have found that recall questionnaires over a 2-4 week period are accurate [129,

136, 137]. Participants completed the recall more often. There was a greater percentage of missing data for the symptom diary. Therefore, the recall instrument provides a more complete evaluation of symptoms in this study and therefore considered the primary outcome.

All questionnaires can be found in Appendix C. For all questionnaires, we either used the provided Spanish translation if one was available with the instrument, or our study staff translated them. All translations were confirmed to be specific for Mexican Spanish. A brief description of all variables utilized from the instrument is given in this section, with more detailed descriptions available in data dictionaries that we created for each instrument. The data dictionaries also include notes on responding to a participant's questions while administrating the questionnaire as well as instructions for data entry.

In the original proposal, we planned to include Peak Expiratory Flow Rate as one of the health measures. Participants were given a Piko electronic Peak Flow Meter (nSpire Health Inc. Longmont, CO) and asked to use it two times a day (morning and evening) for one week, with three attempts per time period. The measure was eliminated in the first year of the study because too many participants failed to complete the full number of samples each week.

2.7.1 Symptoms and Health Care Utilization

Health outcomes were obtained through the use of three questionnaires. A two-week recall was administered to the parent prior to enrollment and every three months during both the true and sham periods. This measure is our primary health outcome. A questionnaire designed to determine the quality-of-life based on asthma symptoms, the Mini PAQLQ, was administered to the child prior to enrollment and every three months during both the true and sham periods. A symptom diary was administered for two one week periods, one of which coincided with the air sampling event.

The goals when developing the questionnaires were to utilize standardized questions from other studies, and where possible, entire portions of questionnaires used previously in other studies. The second goal was to minimize participant burden. Numerous instruments were considered in making the decision [104, 128, 137-142]

Recall Questionnaire

The first portion of the Recall Questionnaire determined the number of days with asthma symptoms; it is based on questions used in the inner-city asthma study (ICAS) and additional studies conducted by those researchers [97, 143, 144]. The instruments used in the inner-city asthma study are available at: http://www.icasweb.org/. Spanish translations were available. These questions utilized as outcomes are in Table 2.7.1. In addition to the questions directly asked, we created variables, listed in Table 2.7.2. This questionnaire also contained questions on missed school and missed work for the caregivers, which were not ultimately used as outcomes. The full Recall Questionnaire is located in Appendix C.

The second portion of the questionnaire obtains information about unplanned health care utilization and was modified from a questionnaire developed by the American Academy of Pediatrics [145], included in Table 2.7.1. The modification was to increase the time period of two months to three months for the quarterly recalls administered throughout the study. In the initial Baseline Questionnaire, these questions were asked over the last year. Spanish translations are also available. This portion also contained questions written at UC Davis to ask about respiratory illness and ear infections over the last three months. These tertiary outcomes were not included as part of the analysis.

The third portion of the questionnaire obtains information about the use of asthma control medication and the questions were developed by the UC Davis team, included in Table 2.7.1. These questions were translated into Mexican Spanish at UC Davis.

There are also a number of questions related to allergies based on Nelson et al. (2011) [146], interspersed throughout the questionnaire. These questions were tertiary, and not used in the analysis.

Finally, there are questions on changes in the home environment that may contribute to asthma, specifically mold and moisture, time spent with smokers, presence of pets, etc. The questions are discussed in Section 2.6.5.

Table 2.7.1 Health Questions Included in Recall Questionnaire

Q # BQ [1]	Q# Recall [2]	Question text	Answer choices
Pre-Intervention Recall			
1	1	During the last 14 days, how many days did [CHILD] have wheezing, tightness in the chest, or cough because of asthma?	Fill in days
14	2	During the last 14 days, how many days did [CHILD] have to slow down or stop his/her play or activities due to wheezing or tightness in the chest, or cough because of asthma?	Fill in days
15	3	During the last 14 days, how many days did [CHILD] use his/her rescue inhaler during the day for relief of asthma symptoms? Please do not include use of the recue inhaler taken prior to physical activities such as playing sports or exercising.	Fill in days
15a	3a	During the last 14 days, on average, on the days [CHILD] used his/her rescue inhaler, how many total puffs or inhalations did he/ she use each day?	Fill in days
16	4	During the last 14 nights, how many nights did [CHILD] wake up due to wheezing or tightness in the chest, or cough because of asthma?	Fill in days
16a	4a	During the last 14 nights, how many nights did [CHILD] wake up and use a recue inhaler or breathing machine/nebulizer after going to sleep?	Fill in days
Baseline part 1 recall asks about the last year, subsequent recalls ask about the last 3 months			
Health Care Use and Respiratory Disease			
27	16	During the last year/last 3 months, because of problems with asthma, how many times has [CHILD] stayed overnight in the hospital?	Fill in times
28	17	During the last year/last 3 months, because of problems with his / her asthma, how many times has CHILD been seen in the emergency room?	Numeric
29	18	During the last year/last 3 months, because of problems with asthma, how many times has [CHILD] been seen in the doctor's office or clinic for a sick visit?	Fill in times
30	19	During the last year/last 3 months, how many times has [CHILD] been given steroid pills or liquid, or steroid shots (such as prednisone)?	Fill in times
Medication			
39	22	Please tell me (show me) all medications [CHILD] is taking for asthma. (Medication use in the last year/last 3 months).	
39	22	Medication name	Fill in
39	22	Medication prescribed frequency	Fill times/day
39	22	Medication typical frequency	Fill in times/day
39	22	Medication puffs per time	Fill in #

[1] Question number in Baseline Questionnaire

[2] Question number in Recall

Table 2.7.2 Created Variables from Recall Questionnaire [1]

Variable Description	How Variable was Created
Total number of puffs used in the last 14 days	Total number of puffs used in the last 14 days. Number of days inhaler was used * total number of puffs child uses each day (Q15 * Q15a)
Number of days of asthma symptoms	Number of days of wheezing/tightness in chest/cough symptoms, slow down play or activities, or wake up due to wheezing (Take max number of days from Q13, Q14, Q16)
Number of days used inhaler	Number of days used inhaler for relief of asthma symptoms or wake up and used a rescue inhaler or breathing machine/nebulizer after going to sleep (Take max number of days from Q15, Q16a)
Total of hospital, ER, and clinic visits, 1 yr (BR) / 3 m (R)	The total number of hospital, ER, and clinic visits over one year (BR) / 3 months (R). Sum of Q27a, Q28a and Q29a answers
Controller medication total score	Sum of scores for all controller medications The methods for calculation are explained in the appendix
Allergy steroid total score	Sum of scores allergy steroid medications The methods for calculation are explained in the appendix
Antihistamine total score	Sum of scores for all antihistamine medications The methods for calculation are explained in the appendix

[1] These variables were created for both the Baseline Recall and Recall with differences noted. Information related to the Baseline Recall is marked (BR) and information related to the recall is marked (R). All question numbers refer to the number in the Baseline Questionnaire. The corresponding question numbers in the recall were used.

The responses to questions in the recall were converted to outcome measures, specifically:

1. Number of days with asthma symptoms over a two week period. From the two-week Recall Questionnaire, we determined the maximum number of days during the two-week recall period with symptoms, defined as the largest value among the following three variables: (i) number of days with wheezing, tightness in the chest, or cough because of asthma, (ii) number of days that the child had to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough, or (iii) number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough. This method of counting "symptom days" has been used in the National Cooperative Inner-City Asthma Study [104]. Multiple symptom types are considered, as different individuals experience different symptoms from their asthma. This is the primary outcome of the study.

2. Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during a two-week period. This is obtained as the greater of the number of days using inhalers during the daytime or nighttime.

3. Unplanned health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma over the one-year true/sham filtration period:
    a. overnight hospitalization
    b. emergency room visit
    c. clinic visit for asthma
    d. receiving additional oral steroids treatment

There were also several variables created from the recall questionnaire to use as covariates:

1. Controller medicine use: specifically, taking the controller medication regularly as instructed. The variable is categorically incorporating the number of controller medicines the participant was taking, if they were taking them regularly, if they were taking them as prescribed, or if they were taking ½ the dosage, or if they were taking them irregularly. There is a detailed description in Appendix C.

2. Whether or not the participant had a cold or the flu during the same two-week period. Having cold or flu may trigger asthma symptoms.

Mini PAQLQ

Diaries were administered to both the child and their caregiver, as studies have found information provided by the child and caregiver can differ [128, 147-150]. The Mini PAQLQ was administered to the child as part of the Recall Questionnaire. This survey covers a one-week period. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ) is a validated tool developed to assess the impact of symptoms on quality of life. It is part of the suite of questionnaires often referred to as the Juniper questionnaires [137, 151, 152]. As the original PAQLQ is quite long, a shorter version was developed, called the Mini PAQLQ. This instrument was validated against the PAQLQ in a group of 42 asthmatic children [153]. Correlation coefficients for each of the corresponding domains of the PAQLQ with the Mini PAQLQ were moderate to strong (r=0.50-0.94). Reliability was strong for the Mini PAQLQ (ICC>0.91). The responsiveness index value for the Mini PAQLQ (1.05) was higher than that of the original PAQLQ (0.90). These results provide confidence that the Mini PAQLQ is valid, reliable, and responsive to change and suitable for use for long-term monitoring in clinical trials. This instrument was used in its entirety. The questions are listed in Table 2.7.3. It has been noted that the last question does not specify activity limitation due to asthma. Also, it is noted that it does not specifically ask if the activity was limited, but rather were the children bothered. We felt that because this instrument is validated, it was still the best one to use despite these limitations. This instrument had a Mexican Spanish translation and this was used for Spanish-speaking participants.

Table 2.7.3 Mini PAQL Questions

Q#	Question text	Answer choices
How bothered have you been during the last week by:		
1	Coughing	1 Extremely bothered
2	Wheezing	2 Very bothered
3	Tightness in your Chest	3 Quite bothered
		4 Somewhat bothered
		5 Bothered a bit
		6 Hardly bothered at all
		7 Not bothered
In general (because of asthma), how often during the last week did you:		
4	Feel out of breath	1 All of the time
5	Tired	2 Most of the time
6	Trouble sleeping	3 Quite often
7	Frustrated	4 Some of the time
8	Frightened or worried	5 Once in a while
9	Irritable	6 Hardly any of the time
10	Different of left out	7 None of the time
How bothered have you been during the last week doing:		
11	Physical activities	1 Extremely bothered
12	Being with animals	2 Very bothered
13	Activities with friends and family	3 Quite bothered
		4 Somewhat bothered
		5 Bothered a bit
		6 Hardly bothered at all
		7 Not bothered

The Mini PAQLQ has a standard scoring system developed for use with the instrument, and includes a score for symptoms, emotional function, and activity limitation, as shown in Table 2.7.4.

Table 2.7.4 Mini PAQL Created Variables

Sum of symptom responses	Sum questions 1-6 (Coughing, wheezing, tightness in the chest, feel out of breath, tired, trouble sleeping)
Sum of emotional function responses	Sum questions 7-10 (Frustrated, frightened of worried, irritable, different or left out)
Sum of activity limitation responses	Sum questions 11-13 (Physical activities, being with animals, activities with friends and family)

Symptom Diary

Many of the questions in the Symptom Diary were taken from the inner-city asthma study [104]. The symptom areas recorded are the same as in the Recall Questionnaire. The staff reviewed the Symptom Diary with the participant either in person or over the phone at the end of the two one-week periods to improve completeness and accuracy. Because this instrument was not completed as regularly as the recall diary, this data is not included in the analysis. There were additional questions in the symptom diary related to indoor air quality and those are discussed in Section 2.6.5.

2.7.2 eNO

Chronic airway inflammation is a hallmark of asthma, particularly eosinophilic airway inflammation. It is difficult to monitor inflammation and exhaled nitric oxide (eNO) levels give us the best opportunity to do this longitudinally and non-invasively. Recent guidelines for the interpretation of eNO emphasize that levels correlate best with the degree of eosinophilic airway inflammation.

Measurement of eNO provides a measure of airway inflammation. Concentrations of eNO were collected using two NIOX devices, both handheld units appropriate for field applications. The NIOX MINO™ (Aerocrine AB, Solna, Sweden) was used initially [154]. The company then discontinued that model and individuals using it were able to exchange their units for the NIOX VERO, free of charge. As the majority of the features are the same between the two units, we will refer to them collectively as the NIOX units. The reliability of the NIOX MINO™ has been demonstrated for field studies. This device is FDA-approved for the measurement of eNO in both the research and clinical settings and it has proven quality control measures. It has been previously used in studies concerning children [127, 134, 135, 155].

The American Thoracic Society/European Respiratory Society 2005 statement recommends collection of two eNO measurements and the averaging of the two values at each study visit in which we followed this protocol. Participants were given 6 attempts to complete the successful measurements. There were no modifications to the protocol for children. The entire protocol, including details on calibration procedures, is included in Appendix H. Samples were collected according to the ATS and ERS guidelines [156, 157]. This measure was collected at the

participant's home. Collections in children were measured at 50 mL/sec as recommended. eNO collection is flow rate dependent and the NIOX units have visual clues to ensure the eNO levels are measured at this flow rate in children. eNO was collected every 6 months, typically directly following each air-monitoring period.

Per a 2011 consensus statement, eNO levels in children are categorized as "low", "intermediate", and "high" (<20 ppb, 20-35 ppb, >35 ppb respectively). A 20% change in eNO levels for baseline eNO >35 ppb is considered significant, while an absolute change of at least 10 ppb is significant for baseline levels in the "low" or "intermediate" ranges.

Lastly, a series of questions was asked when collecting the measures related to activities that may have affected the eNO levels. Specifically, questions were asked about tobacco products, exercise, any food in the last hour, specific foods in the last 3 hours, inhaled steroids, or respiratory illness. These questions can be found in "Questions Associated with Spirometry and eNO" in Appendix C. While these activities are thought to influence levels, they were not specifically used in analysis. In some case, we were unable to collect eNO data, and the reasons were recorded. A Data Dictionary was created for the eNO results.

The following variable was used for analysis:

1. Exhaled NO - The participant tried to complete two successful attempts, but may only have had one or no successful attempts. If they had two successful attempts, the average of the two attempts was used. If they only have one successful attempt, that single attempt was used in the analysis.

2.7.3 Spirometry

Standard measures of spirometry (forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), FEV1/FVC) were used in the pulmonary function analyses. These measures were collected in the participant's home with a portable spirometer. Age, sex, ethnicity, height and weight were used for determining normal ranges for spirometry values. Height and weight were recorded every 6 months using a scale and stadiometer following standard protocol. Absolute measures of pulmonary function were used as one component to classify asthma severity at baseline. We recorded actual flow-volume and volume-time tracings that were reviewed.

To ensure the safety of participants while conducting spirometry, a number of exclusion criteria were included. Specifically, it was not conducted on children with blood pressure that was too high (only measured on children with a BMI over the 95th percentile), those who had had an injury or surgery related to their chest, lungs, abdomen, or eye, had heart problems, or were taking tuberculosis medicine. If the participant's asthma was aggravated by conducting spirometry, it was not attempted at future visits. A flow chart was developed to determine if spirometry should be conducted and included in Appendix C.

At the time of spirometry, questions were also asked about factors that could affect the child's lung function, such as recent respiratory infection, use of asthma medication, exercise, or smoking (for children over the age of 13 only). These questions did not exclude participants from attempting Spirometry, but answers were noted on the field log. These questions can be found in Appendix C.

We used the AstraTouch™ Spirometer, developed by SDI Diagnostics. This spirometer is compliant with the American Thoracic Society spirometry standards. This instrument is integrated with a screen that will display results that can be seen by the participant as they are performing spirometry. The spirometer recorded flow-volume and volume-time tracings and calculated the best FEV1, FVC, and FEV1/FVC, based on American Thoracic Society criteria for acceptability [158]. Obtaining accurate FEV1 values, in particular, is important because, analysis of a large, longitudinal study of children confirmed a relationship between the severity of airflow obstruction and the risk of asthma exacerbations [159].

Subject technique during spirometry must be done according to strict standards and staff were properly trained and certified in how to conduct the vital capacity maneuvers on children. These strict standards also include regular spirometer calibration checks of all the equipment used. All staff conducting spirometry successfully completed the NIOSH approved Spirometry Training and Respiratory Surveillance Training Program through Palmer Associated, Inc. The spirometry data acceptability criteria were included in the SOP for Spirometry (Appendix H) and field staff strived to get participants to perform acceptable maneuvers. The tracings were then evaluated for acceptability and reproducibility by Dr. Kenyon, the study physician, using criteria for children that have been previously established [160].

We understood that some participants, particularly young children less than age 7 would not be able to provide 3 acceptable and 2 repeatable maneuvers. The goal was to meet the acceptability and repeatability criteria, but ultimately these were not absolute requirements for data to be used. Based on Dr. Kenyon's judgment during review of the curves and absolute data values, in cases where requirements were not strictly met, maneuvers were determined to be useable or not, and the values to use were selected.

A valid test required that there be a minimum of 3 acceptable and 2 repeatable maneuvers. An acceptable test consisted of the following:

- Good start: deepest breath and a big blast out (hard and fast with maximal effort).
- Smooth, continuous exhalation with proper posture: upper torso upright and chin up.
- Satisfactory length of maneuver: 2 seconds or longer maneuver.

The reproducibility criteria for children were as follows:

- The current PEF and the previous largest PEF from an acceptable effort must be within 20%.
- The current FEV1 and the previous largest FEV1 from an acceptable effort must be within 10%.
- The current FVC and the previous largest FVC from an acceptable effort must be within 10%.

In order for a test to be considered acceptable, it must not have any of the acceptability errors listed below. This was reviewed in the field by the tester and Dr. Kenyon.

Acceptability errors:

1) Slow Start (Extrapolated Volume Error)
2) Coughing during the first second
3) Premature termination of effort
4) Extra Inhalations/Hesitations/Valsalva Maneuver (glottis closure)
5) Leaks around the mouthpiece
6) Obstructed mouthpiece
7) Evidence of an extra breath being taken during the maneuver

The goal during testing was to obtain 3 maneuvers without any of the 7 conditions listed above. This is considered an acceptable maneuver. If the curve did not indicate a slow start or coughing during the first second (conditions 1 and 2), but failed the other acceptability criteria, it may be considered useable. A test may be usable but not acceptable. Ideally we wanted acceptable tests, but if after six attempts only useable tests (that are not acceptable) were recorded, then we used results based on the three best useable trials, noting that data are less reliable.

FEV1 and FVC were also expressed as a percentage of the expected value. The percentage of the expected value is determined by comparing the actual value to the distribution of normal values for children of the same age, ethnicity, and height, using the data from NHANES [161]. This allowed us to account for changes as the children grew. The participant made multiple attempts at spirometry. The usability of the data was determined by Dr. Kenyon and if useable we took the best attempt of all acceptable attempts for each measure, as identified by Dr. Kenyon. So, for example, if their best FEV1 was on their first attempt and their best total volume was on their second attempt we took the FEV1 from the first attempt, and the total volume from their second attempt. The pre-intervention spirometry values were also used to classify asthma severity discussed in the next section.

Variables were created to determine whether or not spirometry was conducted, and if not, why not, and if spirometry was useable or not. The analysis variables include a percent predicted value for FEV1, FVC, and FEV1/FVC.

2.7.4 Asthma Severity

Asthma severity was determined based on the spirometry measurements obtained at the pre-intervention visit and symptoms recorded in the first Symptom Recall Questionnaire. A measure of asthma severity as defined by the asthma guideline provided by the National Heart, Lung, and Blood Institute/National Asthma Education and Prevention Program (NAEPP) is included in Table 2.7.5. The challenge of defining severity with the NAEPP severity table is that it does not take into account the asthmatic child already on controller therapy. To account for this, we modified our criteria to include the domain of controller medication and the domain of "risk", which includes emergency department visits and hospitalizations. In addition, we combined the asthma classes "intermittent" and "mild", using the lung function criteria for "mild".

"Mild" subjects had normal lung function (FEV1>80% predicted, FEV1/FVC>80%), were on zero or one asthma controller medication, and had fewer than 5 ED visits or hospitalizations in the past year. If they were on no controller medicines, they also had symptoms 7 or fewer days in the 2 weeks prior to enrollment. If they were on 0.5 controller medicines (took controller medicine ay ½ dose or irregularly) or 1 controller medicine, they had symptoms 4 or fewer days in the 2 weeks prior to enrollment.

"Moderate" persistent asthma subjects met ***one*** of the following conditions:

- Reduced lung function (FEV1=60-80% predicted, FEV1/FVC= 75-80%) regardless of controller medicine.
- Were on at least 1.5 controller medications.
- Had 5 or more ED or hospitalizations in the last year and did not take a controller medicine.
- Were on 0.5 controller medicines (took controller medicine ay ½ dose or irregularly) or 1 controller medicine, and they had symptoms 5 or more days in the 2 weeks prior to enrollment.
- Were on no controller medicines, and had symptoms 8 or more days in the 2 weeks prior to enrollment.

"Severe" persistent asthma was defined as meeting one of the following conditions:

- Having reduced lung function (FEV1< 60% predicted, or FEV1/FVC<75%) while on ≥ 0.5 controller asthma medications.
- Having >5 ED visits or hospitalizations in the past year while on ≥ 0.5 controller asthma medications.

If they did not complete spirometry at their first visit, in limited cases we considered future spirometry attempts in classifying participants, and this is noted in the data set.

Participants with more or less severe asthma may differentially respond to improved air quality.

Table 2.7.5 Guideline for Determining Asthma Severity Provided by the National Heart, Lung, and Blood Institute/National Asthma Education and Prevention Program

Determine Severity When Initiating Therapy

Components of Severity		Classification of Asthma Severity (5-11 years of age)			
		Intermittent	Persistent		
			Mild	Moderate	Severe
Impairment	Symptoms	≤2 days/week	>2 days/week but not daily	Daily	Throughout the day
	Nighttime awakenings	≤2x/month	3-4x/month	>1x/week but not nightly	Often 7x/week
	SABA* use for symptom control (not prevention of EIB†)	≤2 days/week	>2 days/week but not daily	Daily	Several times per day
	Interference with normal activity	None	Minor limitation	Some limitation	Extremely limited
	Lung function	• Normal FEV_1‡ between exacerbations • FEV_1 >80% predicted • FEV_1/FVC§ >85%	• FEV_1 = >80% predicted • FEV_1/FVC >80%	• FEV_1 = 60-80% predicted • FEV_1/FVC = 75-80%	• FEV_1 <60% predicted • FEV_1/FVC <75%
Risk	Exacerbations requiring oral systemic corticosteroids	0-1/year	≥2/year		
		Consider severity and interval since last exacerbation Frequency and severity may fluctuate over time for patients in any severity category			
		Relative annual risk of exacerbations may be related to FEV_1			
Recommended Step for Initiating Therapy See bar chart on the following page for treatment steps		Step 1	Step 2	Step 3, medium-dose ICS‖ option and consider short course of oral systemic corticosteroids	Step 3, medium-dose ICS option, or step 4 and consider short course of oral systemic corticosteroids
		In 2-6 weeks, evaluate level of asthma control that is achieved and adjust therapy accordingly.			

Notes: EIB is “Exercise induced bronchoconstriction”, FEV_1 is “forced expiratory volume in 1 second”, FVC is “forced expiratory vital capacity”, ICS is “inhaled corticosteroids” and SABA is “short-acting beta agonists”.

2.8 Pilot Study Summary

The pilot involved both a pre-pilot and pilot phase. Everything needed to conduct the study was developed and obtained prior to the pre-pilot. All the equipment and supplies were ordered and all equipment and supply kits to take into the home were prepared. The data entry system process was tested. All air quality measurements protocols and field logs were developed as well as all health endpoint questionnaires and field logs. All the sampling equipment, protocols and logs, and questionnaires were tested in the pre-pilot and pilot study. The full pilot report is included as Appendix D.

The goals of the pilot study were:

1. To determine if participants had difficulty answering any questionnaire questions so that modifications could be made prior to the main study. This was done by observing the participants while they answered the questionnaire questions.

2. To test if each protocol worked well in the home and to determine if there were any changes that needed to be made. We also tracked how long each activity took, to determine if there were any aspects of the protocols that could be modified to reduce time in the participant home, and thus participant burden.

3. To observe how effectively all of the protocols could be conducted by the two field staff and to determine if there were any changes that needed to be made in the distribution of work or other logistical items to increase efficiency in the home.

4. To obtain information related to the QA/QC evaluation of both the environmental and health measures.

2.8.1 Pre-Pilot Study

The pre-pilot was conducted in one convenience home of a family with a child to confirm the logistics of following all protocols. No actual samples were collected in the pre-pilot. A one-day trip was made to the home to go through all activities of the four types of visits. The staff left and reentered the home between each visit. Sampling equipment was set up and taken down without collecting actual samples. Health measurements were conducted on a parent rather than a child (to reduce logistic constraints) without recording data. All activities were observed by another staff member to look for ways to improve protocols and the flow of the visit. For all questionnaires, one staff watched the participant's response and recorded questions they had, or facial expressions they made that would indicate they might be confused by the question. Staff watched for any other verbal or nonverbal cues suggesting the participant did not understand a question. The study team discussed if wording should be changed for the pilot study.

2.8.2 Pilot Study

The goal of the pilot study was to see if there were any problems in the sampling procedures, how long each activity took, whether participants had problems with any questionnaire questions, diaries, etc., any other problems that needed to be addressed, and to assure all QA/QC criteria would be met in the main study. Once the protocols were demonstrated to work well in the pre-pilot, a pilot study was conducted in three convenience homes in Northern California. The homes had children within the specified age range (6-12 years) with doctor-diagnosed asthma. Households had 3 visits with two weeks of air sampling. In the first week, air samples were collected without filtration. The first week of air sampling was done without air cleaners in the home. For the second week of air sampling two portable air cleaners were placed in participants' homes: one in the child's bedroom and one in the main living area.

Six sets of outdoor PM and ozone samples were collected, as were three sets of indoor samples of PM and ozone without filtration and three sets with filtration. All indoor PM samples, three sets of the outdoor PM samples, and two sets of the ozone samples, were collected in duplicate. All indoor PM samples had a blank collected and two indoor ozone blanks were also collected. All of the environmental samples were analyzed.

As in the pre-pilot, an additional staff member observed all protocols as well as the administration of the questionnaires to determine if improvements could be made. A de-brief was held after each visit to discuss potential changes.

A question by question guidance document (QxQ) for the Baseline Questionnaire was initially created following completion of the pilot study. Following the pilot, the study team evaluated questionnaire observation notes, determining if questions should be modified or if notes should be added to the QxQ. The QxQ was to make sure our responses were consistent across staff when administered all participants. The QxQ instructions have been integrated into the relevant Data Dictionaries.

2.9 Quality Assurance and Quality Control

A Quality Assurance Project Plan (QAPP) was developed based on the guidance provided by the U.S. Environmental Protection Agency (US EPA) document "Guidance for Quality Assurance Project Plans EPA QA/G-5". This document provides guidance of Quality Assurance and Quality Control (QA/QC) measures for environmental projects. The format was adapted to include health measures as well. The full QAPP is available in Appendix E, with an overview and the most critical components included in this section. The QAPP was reviewed and approved by the entire project term as well as by the project manager at ARB.

The QAPP begins with the project management plan, the objectives of the study, the total number of samples that were planned for collection, a list of equipment used in the study, the planned schedule, and the data analysis plan.

In order to ensure that the data collected were of proper quantity and quality to meet the scientific objectives of this study, measurement performance criteria were established for this study and were used to evaluate the quality of the analytical data.

Criteria for environmental measurement data for this study were defined in terms of the completeness, precision, limit of detection, and recovery. However, there is no official guideline for quality control of health measures available; therefore, the study team developed the criteria for health measurements. Since these criteria may be defined in a variety of ways, it is important that the method by which each criterion will be evaluated is clearly defined beforehand.

Completeness in this study is defined as the percent of valid samples of a given parameter from all samples scheduled. There are three factors influencing the completeness: 1) whether or not a particular visit was able to be conducted, 2) if all aspects of the visit were successfully completed in the field, and 3) if all samples collected yielded valid results.

Every effort was made to collect complete data including a subject tracking database used to guide staff on what phone calls needed to be made. We called participants repeatedly to remind them of visits. At the visits, staff had checklists in addition to their training to ensure all samples were collected.

Several participants were ultimately removed from the study due to loss-to-follow-up. We retroactively marked their last successful point of data collection and eliminated all subsequent visits from the number of scheduled visits. Some participants completed their phone call or visit outside their scheduled seasonal window. These visits were considered "completed", and the frequency of visits out of the seasonal window was determined.

The environmental samples were also evaluated by collecting duplicates in the field to measure precision. Blank samples were also collected in the field.

Health measures collected in this study included Recall Questionnaire and Symptom Diary data and direct measurements of peak expiratory flow rate (PEFR), spirometry, and exhaled nitric oxide (eNO). These end points were primarily evaluated on completeness. For eNO, we attempted to collect two measurements and thus calculated the precision of the measurement from the replicate data.

The reliability of the NIOX MINO^{TM} has been demonstrated for field studies. The MINO^{TM} was replaced by the VERA model approximately half-way through the study, due to NIOX no longer manufacturing or supporting the MINO model. Both models were tested side-by-side to ensure consistency between the models. Results from this test were conducted in the pulmonology clinic at UC Davis and were not recorded. This device is FDA approved for the measurement of eNO in both the research and clinical settings and it has proven quality control measures. Device specifications for calibrating were followed.

The AstraTouch™ Spirometer, developed by SDI Diagnostics, was used in this study. This spirometer was compliant with the American Thoracic Society spirometry standards. Device specifications for calibrating the AstraTouch™ Spirometer for exhaled flows and volumes were followed. Criteria for acceptability and reproducibility are different for children than adults, and are listed in the section on health measures. All staff conducting spirometry were trained as described in Section 2.7.3.

The QAPP also includes information on staff training, record keeping, planning for and utilizing results from the pilot study, and details on sample collection, including sample collection schedule, methods, handling, and custody.

All investigators and staff have appropriate degrees and/or necessary experience. All field staff received training specific to the study. In addition, all research personnel having direct contact with the study participants or participant's data completed a Department of Human Health Services on-line Human Subjects Training Program.

Documentation was primarily recorded on field and lab logs, available with the study materials. All relevant information for each sample was recorded on a field data log, including any special notes needed to determine if a given sample must be voided or flagged for any reason. Sample collection records used in the field included the following: date and time of activity; names of field staff collecting data; participant ID number, type of sample; comment area for any unusual observations or changes in procedure; and general climatic conditions. All field logs were scanned. Paper copies were stored in locked file cabinets. In the event that changes were required to any documentation, a single line was drawn through the entry and the field personnel initialed the change. All documentation was in ink. Scanned copies were saved on a secure server. Chain-of-custody forms accompanied all samples that were transferred between two separate parties. Chain of custody forms were scanned and copied prior to shipment. Laboratory logs were used to track loading and unloading of samples.

All data collected were stored in a relational SQL (structured query language) database created for this project by UC Davis staff. All UC Davis staff regularly undergo training and certification on protection and confidentiality of human subject data. The database allowed us to store all the data, and the common elements could be cross-referenced. The database does not permit manipulation or alternation of data, so data was outputted to SAS. All data handling procedures were documented in SAS program records, which can be exported to a Microsoft Word document for review. ARB was provided the SQL database, as well as SAS datasets used for analysis.

Electronic data were downloaded from the monitoring instruments using a field computer, and were uploaded to the secure UC Davis server. Data were identified by participant ID. All data are evaluated for completeness and correctness.

To ensure that data were collected consistently, detailed Standard Operating Procedures (SOPs) were created for each measure. The overview of each method can be found in the relevant methods section in this document. All SOPs are included in Appendices G and H and/or the study materials. Some small changes may have occurred to the methods following the completion of the original QA/QC plan and the SOPs reflect the actual procedures conducted in the field.

Procedures for ensuring proper labeling and tracking of PM filters, PUFs, and ozone filters were developed and followed throughout the project. All filters came with multiple pre-printed labels that were used to eliminate possible transcription errors.

Initially, QA/QC evaluations were conducted by May Wu. Later in the project Chuck McDade became the QA/QC officer and conducted QA/QC evaluations, one on field procedures, one on lab procedures, and one evaluating the problems encountered with the O-rings.

2.10 Data Analysis

The data analysis conducted for each objective is described in the subsequent sections below. The initial statistical analytical plan is provided in Appendix F. Please note that there are some deviations between the statistical analytical plan and the actual analysis conducted as presented in this report. Significant deviations are listed at the end of each section.

2.10.1 Data Analysis for Objective 1

Objective 1: Determine the extent to which the use of a) high efficiency central filtration, and b) high efficiency stand-alone air cleaners reduce indoor concentrations and resulting exposure of $PM_{0.2}$, $PM_{2.5}$, and PM_{10}, and the extent to which they reduce indoor concentrations of ozone.

The first component of this analysis plan was to conduct a correlation analysis to determine which covariates may be important to include in the filtration impacts analysis. The second component was the primary analysis. There are two secondary analyses, one for black carbon and one comparing pre-installation to post-installation.

Correlation Analysis

The bivariate association between outcomes, I/O ratio, and indoor concentration of all size fractions and a suite of variables that may potentially be related to changes in filtration effectiveness was conducted, either using Spearman correlation analysis (for continuous or interval variables) or ANOVA (for categorical variables). For some variables, the relationship with the I/O ratio of $PM_{0.2}$ was also examined as specified below. Separate analyses were conducted.

We list the variables included in this analysis, along with whether or not they are time-varying or time-invariant, and whether or not they are continuous or categorical, below:

- Outdoor level of PM, time-varying continuous covariate with a unique value for each measurement period.
- Filtration utilization, a time-varying continuous covariate with a unique value for each measurement period, a 3-level converted to categorical variable.
- Open window usage, a time-varying continuous covariate with a unique value for each measurement period.

- Frequency of combustion related sources, either someone smoking in the home, frying or sautéing, or having a fire, using a wood burning stove, or burning candles or incense over a one week sampling period. Households with more or stronger indoor sources may have higher indoor concentrations.
- Distance to roadway, a time-invariant binary covariate for each household.
- Age of home, a time-invariant binary covariate for each household, categorized as homes newer or older than 1977.
- Presence of gas stove, a time-invariant binary covariate for each household.
- Presence of air conditioning or swamp cooler, a time-invariant 3-level covariate for each household. For the analysis with true concentrations, only air cleaner homes were included as all central filtration homes had central air and no swamp coolers.

We also ran bivariate analyses with indoor concentrations as well as I/O ratios among pollutants, i.e., I/O ratio of $PM_{2.5}$ vs. I/O ratio of PM_{10}. Each outdoor concentration ($PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone) was also correlated with the corresponding indoor concentration.

Defining Primary Analysis of Filtration Impacts and Modifiers of Filtration Effects
The primary analysis compares the values of the outcome variables between the periods having true filtration and having sham filtration. In cases where we have values for the primary outcome at multiple time points with and without true filtration, all measured values were included in the model.

Our primary assessment of the intervention uses generalized linear mixed-effects (GLMM) regression models in order to provide the most efficient analysis of the available data from our randomized placebo self-controlled cross-over study. This regression strategy allows us to account for important features of our longitudinal study data, including a variety of response variable distributions (e.g. continuous, binary, and counts), the need to account for time-varying confounders, especially seasonal effects, and partial follow-up from subjects not completing all scheduled assessments. Although generalized linear mixed-effects modeling was our preferred approach, alternative regression approaches for clustered longitudinal data were required in cases where the stringent modeling assumptions for GLMM are violated or when numerical algorithms were not able to converge on valid estimates. In these cases, either generalized estimating equations or survey data analysis methods for clustered data from comparative experiments were used. Analysis conducted in using an alternative approach are specified when results are presented.

Data analysis has been conducted using an “as treated” approach rather than an intention-to-treat approach. The difference is that if there were any errors in administering the filtration, such as a household remaining in sham for the entire first year rather than switching to true for the last six months, in an “as treated” approach the data collected at 9 and 12 months is considered to be collected in sham, as opposed to in true, as would be the case in an intention-to-treat model.

Although intention-to –treat is considered the ideal analysis, "as treated" was conducted as it is more straight forward to conceptualize analyzing data in an "as treated" approach. There were very few deviations from the protocol. Statistical analyses estimate the intervention-specific effects of filtration by comparing periods with true versus sham filtration, with appropriate statistical adjustments to estimated effects, confidence intervals and test statistics to account for the study design, and to minimize confounding by other covariates influencing the distribution of study outcomes.

To account for response distributions, standard link functions were used (e.g. logistic links for binary outcomes, log links for count data and identity links for linear regression models of continuous outcomes). Independent variables include binary indicator variables for randomization strata (to adjust for stratification) and each of the two experimental intervention conditions and time-varying binary indicators for true vs. sham filtration.

To maximize the efficiency of the analysis, some measures that had been collected at the time of enrollment were included as independent variables as a way to statistically adjust for characteristics that may be associated with between-person differences in outcomes. Random effects were used to account for residual within-person correlation in the vector of repeatedly measured outcomes. The effects of each intervention were assessed by the intervention-specific adjusted mean difference in outcomes in true vs. sham filtration periods. In addition, between-intervention comparisons of true vs. sham filtration contrasts were estimated to compare the interventions on effectiveness. We make statistical comparisons between the measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally adjusted measurements from the true and sham filtration periods. Additional fixed effects specified prior to model fitting are included to adjust statistically for study stratum identifiers, covariates and/or mediators, or modifiers of intervention effects. In addition, offset terms specified in logistic or Poisson regression models to account for such subject-to-subject variations in exposure periods as, for example, when the number of potential school days lost in the past two weeks varies due to vacations and holidays. The regression modeling framework also allows us to assess the relationship between changes in exposure and changes in health and pollution outcomes.

Outcome

- Indoor concentrations of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone (primary outcome).
- Indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone (secondary outcome).

Comparison of interest

- With and without true filtration.
- Type of filtration: central system filtration vs. stand-alone air cleaner.

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter.
- City: Fresno vs. Riverside.
- Household ID (random effect).

Potential modifiers (to understand the factors associated with heterogeneity of the treatment effect). All modifiers listed in the correlation analysis were included except for the presence of air conditioning. Many participants opened windows even if they had air conditioning, and window opening was thought to be a better predictor.

Statistical Analysis

The primary analysis compares the indoor levels using generalized linear mixed-effects regression models. For the t^{th} measurement on the i^{th} individual, $Y_{i,t}$ is the outcome,

$$E(Y_{i,t}) = \mu_{i,t}$$

$z_{i,t}$ is the matrix of covariates, where $Riverside_i$ is the reference level for the city variable and $Spring_{i,t}$ is the reference level for the season variable.

$$z_{i,t} = \begin{bmatrix} outdoor\ level_{i,t} \\ Fresno_i \\ summer_{i,t} \\ fall_{i,t} \\ winter_{i,t} \end{bmatrix}$$

$g(\mu)$ is a link function that depends on the outcome:

$g(\mu) = \mu$ for normal-distributed variables;

$g(\mu) = \log \mu$ for count or log-normal distributed variables;

$g(\mu) = \log ODDs = \frac{\mu}{1-\mu}$ for binary or proportion data in [0,1] range

The core model is

$$g(\mu_{i,t}|\gamma_i) = \beta_0 + z'_{i,t}\bar{\beta}_{covariates} + \beta_{true,SA} \times True_{i,t} + \beta_{HVAC} \times HVAC_i + \beta_{true,HVAC} \times True_{i,t} \times HVAC_i + \gamma_i \qquad \gamma_i \sim N(0, \sigma_N^2)$$

$True_{i,t}$ is a time-varying binary indicator for with (1) vs. without (0) true filtration;

$HVAC_i$ is a time-invariant binary indicator for whether the individual has been assigned to the Central (1) or the Stand-alone (0) filtration system study arm,

$\beta_{true,SA}$ explains the effect of filtration for stand-alone air cleaner;

$\beta_{true,SA} + \beta_{true,HVAC}$ explains effect of filtration for central systems;

$\beta_{true,HVAC}$ explains the difference between central system and stand-alone filtration in the effects of filtration.

The goal is to be able to be able to see the differences with or without filtration and also to determine if there are differences between the systems in these true vs. sham contrasts.

When incorporating the actual use time of the filtration into the model, the $True_{i,t}$ terms needs to be replaced by $True_{i,t} \times ActUse_{i,t}$.

Separate regression models are specified for each outcome (indoor concentrations and indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone). We statistically adjust for the three listed independent variables (season, city, and household ID).

Assessment of Effect Modification (Heterogeneity of Treatment Effects)
To assess whether intervention effects were modified by candidate effect modifiers, a series of models based on the core model were fitted, one effect modifier at a time. For each candidate effect modifier, interaction terms were added to allow estimated intervention effects to vary according to the value of the candidate effect modifier. Nested likelihood ratio tests were used to assess whether the model with effect modification provides statistically significant improvements in model fit, compared to the core model. For these tests, maximum likelihood estimation was used for both the core model and the model enhanced with the additional interaction terms; the test statistic is -2 times the difference in model log-likelihoods, which is referred to a Chi-square distribution with degrees of freedom equal to the number of additional parameters estimated in the enhanced model to assess statistical significance, with the significance threshold set at 0.05 (i.e., $p < 0.05$). To illustrate how the interaction terms was specified, consider the candidate effect modifier NewHome, a binary indicator for whether a house was built after 1977:

$$\beta_{NH} \times NewHome_i$$

$$+\beta_{NH,true} \times True_{i,t} \times NewHome_i$$

$$+\beta_{NH,HVAC} \times HVAC_i \times NewHome_i$$

$$+\beta_{NH,HVAC,true} \times True_{i,t} \times HVAC_i \times NewHome_i$$

The interpretation of these terms is

$\beta_{NH,true}$ explains whether new home modifies filtration effect for stand-alone filtration;

$\beta_{NH,true} + \beta_{NH,HVAC,true}$ explains whether new home modifies filtration effect for central system filtration;

$\beta_{NH,HVAC,true}$ explains whether new home modifies central system/stand-alone and filtration effects.

Some variables are time-varying and collected at each measurement point of the outcome variable, while some variables are time-invariant and collected only at the beginning of the study and remain the same throughout the study (unless a household moves). In addition, some variables, such as filtration utilization, windows/door usage, and indoor sources, were initially included as continuous variables and were converted to bivariate variables to facilitate the interpretation of results.

The heterogeneity of treatment effects analysis was considered exploratory and hypothesis generating. For reporting purposes, we enumerate the set of candidate effect modifiers that were evaluated in presenting the results. Point and interval estimates are only reported for the subset of candidate effect modifiers that resulted in statistically significant improvements in model fit.

Analysis for Black Carbon

We compared the distribution of indoor/outdoor black carbon ratios obtained with and without true filtration to determine if there is a statistically significant difference between the distributions.

Outcome

- Indoor/outdoor reflectance ratios.

Comparison of interest

- With and without true filtration.

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter.
- City: Fresno vs. Riverside.
- Household ID (random effect).

*Exploratory analysis considering the following potential modifiers (*aim to understand the factors associated with heterogeneity of the treatment effect)

- Proximity to roadway.
- Filtration utilization (as discussed before).
- Windows usage (as discussed before).

Similar to the primary analysis, we also used generalized linear mixed-effects regression models for this analysis. We statistically adjusted for the three listed independent variables (season, city, and household ID). Modifiers were included in the model as the interaction with true/sham filtration one at a time. Some variables are time-varying and collected at each measurement point of the outcome variable, while some variables are time-invariant and collected only at the beginning of the study and remain the same throughout the study (unless a household moves). In addition, some variables, such as filtration utilization and windows usage, were initially included as continuous variables and were converted to bivariate variables to facilitate the interpretation of results.

Comparison of Pre-Installation to Post-Installation Period

Pre-installation period is the period with least influence from the study. Awareness bias may occur during the sham period, so that participants may change their behaviors, e.g., cooking less or more diligent use of range hood, which may result in changes in indoor levels of pollutants. Therefore, the pre-installation measurements were considered the baseline level. Regression models with similar specifications as described above were used to perform statistical comparisons between the air quality measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods.

Outcome

- Indoor concentrations of $PM_{0.2\text{-}2.5}$ *and* $PM_{2.5\text{-}10}$.
- Indoor/outdoor ratio *of* $PM_{0.2\text{-}2.5}$ *and* $PM_{2.5\text{-}10.}$

Comparison of interest

- "Pre-installation" vs. "with true filtration" measurements: a binary variable.
- "Pre-installation" vs. "without true filtration" (sham) measurements: a binary variable.

Independent variables included in the model to account for study design

- Season, four-level categorical variable. Season was adjusted, as pre-installation air quality was only measured once in one season.
- City, two-level categorical variable.
- Household ID variable (random effect).

Regression models with similar specifications as described above were used to perform statistical comparisons between the concentration measurements collected during the enrollment period (prior to installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods. We adjusted for season, as pre-installation information was only collected in one season. Statistically-adjusted mean differences between the "sham filtration" and

"pre-installation" measurements are used to characterize the net impact of participation on the study. Statistically adjusted mean differences between the "true filtration" and "pre-installation" measurements were reported as exploratory findings representing the net impact of true versus sham filtration and participation in the study. We note some differences may arise between "pre-installation" and sham that are unrelated to participation. The differences calculated here can be compared to differences calculated between true and sham. No effect modification was considered.

Changes from planned analysis

In the original statistical analytical plan, the indoor/outdoor ratios had been specified as the primary outcome and the indoor concentrations as the secondary outcome. Because there were more homes that had indoor measurements than outdoor measurements, the primary and secondary outcomes were reversed.

To account for missing outdoor values, when calculating the I/O ratio, the mean outdoor level of the smaller size fraction was calculated and used to estimate the outdoor value when calculating the I/O ratio. Analyses were conducted with both only true I/O values, and the substituted values presented in the appendices. Results with the estimated values are presented in this report.

As a cost saving measure, some homes did not have indoor concentrations measured at 24 months, with the thought that the pre-intervention value could be substituted. However, we subsequently decided this was not an advisable substitution because the sham measurements were significantly lower than the pre-intervention measures. Substituting sham values would have artificially lowered the difference between pre-intervention and sham values. Therefore, only homes with valid pre-intervention data were utilized.

2.10.2 Data Analysis for Objective 2

Objective 2: Determine the extent to which the use of a) high efficiency filtration in central systems and b) high efficiency stand-alone air cleaners reduces asthma symptoms, emergency department (ED) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.

There are three components of the analysis for Objective 2:

- Primary analysis for both primary and secondary health outcomes.
- Inclusion of potential modifiers.
- Comparison of pre-intervention and post-intervention periods.

Primary Analysis of Real versus Sham Filtration Impacts and of Modifiers of Filtration Effects

Primary health outcome

Number of days with symptoms over two week period: From the two-week Recall Questionnaire, we determine the maximum number of days with symptoms, defined as the largest value among the following three variables:

- Number of days with wheezing, tightness in the chest, or cough because of asthma.
- Number of days that the child had to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough.
- Number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough, during the two-week recall period.

Secondary health outcome

- Number of days that the participating children use their rescue inhaler during the day for relief of asthma symptoms during a two-week period. The measure was obtained from the recall questionnaire.
- Days of missing school due to asthma obtained from the recall questionnaire.
- Health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma over the one-year true/sham filtration period obtained from multiple recall questionnaires.
    - overnight hospitalization
    - emergency room visit
    - clinic visit
    - receiving steroids treatment
- Mini PAQLQ score with three outcomes: symptoms, emotional function, and activity limitation.
- Exhaled NO – a continuous outcome.
- Spirometry parameters: Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), and FEV1/FVC a continuous outcome.

Primary comparison of interest

- True versus sham filtration (binary variable).

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter.
- City: Fresno vs. Riverside.
- Study year: Year 1 vs. Year 2.
- Subject ID (random effect).

All analyses were done using the generalized linear mixed-effects regression models. Separate regression models were specified for the health outcomes listed above. The same approach was used as for Objective 1.

Including Potential Modifiers

Exploratory analysis considering potential modifiers (aim to understand the factors associated with heterogeneity of the treatment effect) was conducted only on the primary outcomes. Methods for assessing effect modification are detailed above for Objective 1.

Indoor $PM_{2.5}$ was evaluated as mediators (used to understand mechanism of action) of the intervention effects on the primary health outcomes, using statistical mediation analysis techniques as described by [162, 163].

Proposed mediators

- Indoor $PM_{2.5}$ – a time-varying continuous covariate –the average of the two measurement periods within the true/sham period was applied to the health outcomes collected at all time points during the true/sham period.
- Controller medicine use, a time-varying three-level categorical covariate.
- Having a cold or the flu during the two-week recall period: For analyzing the Recall Questionnaire, we only consider whether or not the participant had a cold based on questions in the Recall Questionnaire. For analyzing data in the Symptom Diary and peak flow, we consider having a cold in either the Recall Questionnaire or Symptom Diary. For exhaled nitric oxide, we only consider whether or not the participant reported a cold in the Symptom Diary.

Candidate effect modifiers

- Filtration utilization, a time-varying continuous covariate.
- Type of filtration: central system filtration vs. stand-alone air cleaner.
- Asthma severity, a time-invariant categorical covariate for each participant.
- Ever having allergies, a time-invariant binary covariate for each participant.
- Allergies to furry pets, a time-invariant binary covariate for each participant.
- Presence of a gas stove, a time-invariant binary covariate for each participant.
- Presence of mold or water damage, a time-varying categorical variable.

A series of "effect modification analyses" to assess whether and by how much the impacts of filtration were modified by measured household and user characteristics were used. Generalized linear mixed-effect regression models were used as in Objective 1. In addition, the difference of the primary health outcome, number of days with symptoms, between the true and sham filtration period was calculated.

Analysis of first 6-months of each study year

An additional analysis was conducted considering only the first 6-months of each study year. No variable for the year in study was included in this analysis. As participants who started in SHAM were in SHAM the first year and TRUE the second year, while participants who started in TRUE were in TRUE the first year and SHAM the second year, this results in a balanced study design.

Comparison of Pre-Installation to Post-Installation Period

Pre-installation period is a period with the least influence from the study. Awareness bias may occur during the sham period, so that participants may change their behaviors, e.g., use of medications, and thus symptoms. Therefore, the pre-installation measurements were most close to participants' prior condition and were considered the baseline level.

Primary health outcome

- The number of days with symptoms over two week period reported in the recall questionnaire.

Secondary health outcomes

- Number of days that the participating children use their rescue inhaler/puffer during the day for relief of asthma symptoms during a two-week period.
- Mini PAQLQ score with three outcomes: symptoms, emotional function, and activity limitation.
- Exhaled NO – a continuous outcome.
- Spirometry parameters: Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), FEV1/FVC, forced expiratory flow 25–75% (FEF 25–75), a continuous outcome.

Primary comparison of interest

- "Pre-installation" vs. "with true filtration" measurements: a binary variable.
- "Pre-installation" vs. "without true filtration" (sham) measurements: a binary variable.

Independent variables included in the model to account for study design

- Season, four-level categorical variable.
- City, two-level categorical variable.
- Subject ID variable (random effect).

Regression models with similar specifications as described above were used to perform statistical comparisons between the asthma symptom measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods. We adjust for season, as pre-installation information was only collected in one season. Statistically adjusted mean differences between the "sham filtration" and

"pre-installation" measurements were used to characterize the net impact of participation on the study. Statistically adjusted mean differences between the "true filtration" and "pre-installation" measurements were reported as exploratory findings representing the net impact of true versus sham filtration and participation in the study.

Changes from planned analysis
The original plan did not explicitly specify that an indicator variable to control for year 1 versus year 2 effects would need to be included in the analysis model, but that omitted detail was an oversight on the part of a statistician who had envisioned that a balanced cross-over design would be used when he first drafted the analysis plan. For the unbalanced cross-over design that was ultimately used, all households use sham filters in the last 6 months of the study. Hence, it is necessary to control for confounding by calendar time of the true versus sham contrasts. Otherwise, expected over-time average changes in patient outcomes (which tend to be favorable for pediatric asthma studies, but which could, in theory, be unfavorable) would confound the sham versus true contrasts, an unacceptable bias that is easily controlled by simply including a binary year-in-study term in the model as a covariate to control for time effects.

Given the lack of findings, three of the modifier analyses were not included, specifically:

- Highest education of the parents, a time-invariant categorical covariate.
- Household income, a time-invariant categorical covariate.
- Open bedroom door usage, a time-varying continuous covariate with a unique value for each measurement period.

2.10.3 Data Analysis for Objective 3
Objective 3: Measure indoor and outdoor concentrations for children with asthma to $PM_{0.2}$, $PM_{2.5}$, PM_{10}, and ozone, and resulting personal exposures.

Primary Analysis of Distribution of Indoor and Outdoor Concentrations for Children with Asthma to $PM_{0.2}$, $PM_{2.5}$, PM_{10}, and Ozone
This objective is met by presenting summary statistics for the outcomes listed.

Modeled Personal Exposures
We constructed a basic personal model. Personal exposure results from the concentration in typical microenvironments and the typical time spent in that microenvironment. The personal model will allow us to estimate children's personal exposures to $PM_{2.5}$. This model was applied with all participants' indoor concentrations. This can be expressed by the following equation:

$$Personal\ Exposure = C_1t_1 + C_2t_2 + C_3t_3 + ...C_nt_n$$

where C_i is the concentration in a given microenvironment and t_i is the time spent in that microenvironment. The subscript i refers to the specific microenvironment, with n being the number of microenvironments the individual was in over the course of the day.

We considered using a typical distribution of the number of hours indoors at home and outdoors along with the typical number of hours indoors at school, and in transit for each age group, making adjustments as appropriate to create 24-hour days.

Time-activity data was taken from two California based sources. Time spent outdoors was collected in 1996 among 1,678 4th graders from Southern California [164]. The median time spent outdoors was 1.3 hours, with the 10th and 90th percentiles reported as 0.5h and 2.3h, respectively, fitting a log normal distribution with a coefficient of variation (CV) of 0.65. Information on other time location patterns of children were also collected in 1989 and 1990 [165]. Neither the original report, nor the EPA child-specific Exposure Factors Handbook [166] reported distributions, just mean values and, for some values, fraction of "doers". Mean time spent at school/childcare for all children under 12 for doers was 330 minutes per day, with 33% of children participating in the activity. The mean value for time spent at school/childcare among children 6-10 years was 110 minutes per day for boys and 116 minutes per day for girls, and was 99 minutes per day for 11 year old boys and 128 for 11 year old girls. The average of the two age specific values was used in the simulation, with an assumption that data was collected to be representative of an annual average, accounting for days not at school during summer or weekends. A log normal distribution with a CV of 0.2 was assumed. Ninety-nine percent of children spend time at home. The mean times in minutes per day are presented for girls 6-10 years (1,016 m/d), girls 11 years (1,010 m/d), boys 6-10 (1,012 m/d), and boys 11 years (862 m/d). The average between these 4 values is 16.25 hours per day, and a CV was 0.15 was assumed. Time in transit was originally planned as a category, but the only concentrations found in transit were significantly less than outdoor levels in our study area, likely because they were collected near Redwood, CA, an area with lower air pollution [167]. Therefore, this location was not included in the model. The three distributions, indoors at home, outdoors, and schools, were utilized, with the remainder of time assigned to other, unspecified, indoor locations. The concentration in other unspecified locations was taken from the distribution of unfiltered indoor concentrations. In cases where the categories of home, school, and outdoors exceeded 24 hours (approximately 5.5% of the time), time was proportionally reduced in those three categories.

The indoor concentrations were calculated for both filtered and unfiltered homes using the log-normal distributions of outdoor concentrations and I/O ratio from the study. Concentration distributions were taken from what was measured in the study, and are reported along with the results of the model. A Monte-Carlo simulation utilizing 2000 simulations was conducted to generate a distribution of the average exposure assuming filtered air at home and also if there was unfiltered air at home.

Chapter 3: Results

3.1 Results of Pilot Study

A pre-pilot was conducted in one home prior to conducting the actual pilot. As a result, there were some small wording changes to the Baseline Questionnaires, as well as some suggested additions made to the questions by questions (QxQ) guidance. Additionally, the order of some questions was changed to improve flow, and there were a few formatting changes.

The study staff also evaluated which staff member was completing which activities, and made some slight changes to improve work flow. Other slight changes were made to protocols, such as shutting pump boxes while they were warming up to reduce noise. Additional details can be found in the pilot report in Appendix D.

The study team continued to make very slight wording changes to the questionnaires during the pilot visits, with particular focus on the medicine section. The pilot visits provided good experiences for conducting spirometry and eNO, and staff worked on optimizing verbal instructions and coaching.

Ozone Results

Three field blanks were collected and the Limit of Detection (LOD) was calculated as 0.13 ppb. Our target LOD value as stated in the QA/QC plan was 1.2 ppb.

Indoor ozone concentrations were significantly lower than outdoor concentrations. The average ± SD blank corrected indoor ozone concentration was 0.35 ± 0.33 ppb, and the median was 0.29 ppb. The average blank corrected outdoor ozone concentration was 33.5 ± 7.8 ppb, and the median was 32.4 ppb. The indoor/outdoor ratio varied from 0.0005 to 0.0230, with an average of 0.0109 ± 0.0090.

Two pairs of indoor duplicate samples and one pair of outdoor duplicate samples were collected. The precision between the two pairs of indoor ozone samples were 0.45 and 0.37 respectively, compared to the criteria of 0.20, likely because the indoor concentrations were low. The precision between the one pair of outdoor ozone samples was 0.004, compared to the criteria of 0.10.

Particulate Matter Results

The average mass change on the field blank filters was 0.37 ± 0.33 mg and 0.66 ± 0.43 mg for $PM_{2.5}$ and $PM_{0.2}$, respectively, while the four lab blank filters had an average mass change of -0.013 ± 0.003 mg with actual values being -0.014 mg, -0.011 mg, -0.010 mg, and -0.017 mg. The field blank values clearly exceeded any acceptable target value, and indicated contamination or gross error.

The field blanks of measurement using PUF were acceptable, with the average net mass change of -0.02 ± 0.03 mg for $PM_{0.2\text{-}2.5}$ PUF and -0.02 ± 0.004 mg for $PM_{2.5\text{-}10}$ PUF. A set of lab controls

were weighed at each session and mass changes for the sample PUFs were adjusted by the changes in these lab controls. The PUF mass change was converted to nominal PM concentration assuming the sampling time was 7 days. The LOD was calculated as three times the standard deviation of the nominal PM concentrations of field blanks, with a value of 1.71 $\mu g/m^3$ for $PM_{0.2-2.5}$ and 0.25 $\mu g/m^3$ for $PM_{2.5-10}$. All $PM_{2.5-10}$ PUF samples and 14 out of 17 available $PM_{0.2-2.5}$ PUF samples had a concentration above the LOD. Ideally, the target set in the QA/QC for the LOD was 0.425 $\mu g/m^3$. Given the small number of blanks collected, we were not concerned about exceeding this value for $PM_{0.2-2.5}$, especially considering that blanks were under the target value for $PM_{2.5-10}$.

The precision was within 10% for six duplicate pairs of $PM_{0.2-2.5}$ concentrations which were collected on PUF substrates, with one pair of indoor samples having poor precision. The mass on the pair of PUF samples that exceeded the criteria was the lowest mass of any duplicate pairs, with the two resulting concentrations being 2.02 $\mu g/m^3$ and 1.21 $\mu g/m^3$. The precision between duplicate pairs of $PM_{2.5-10}$ PUF samples ranged from 0% to 23% (N=7), four of which were above the criteria of 20% for indoor samples with filtration and 10% for outdoor/indoor samples without filtration. The mass on the two pairs of PUF samples where precision exceeded 20% was also the lowest of any duplicate pairs, with resulting concentrations of 1.93 $\mu g/m^3$ and 1.53 $\mu g/m^3$ from one pair of duplicates and 2.19 $\mu g/m^3$ and 2.72 $\mu g/m^3$ from the other pair of duplicates.

The indoor/outdoor PM ratio was calculated when paired indoor and outdoor concentrations were available for PUF measurements, and we found that the ratio was lower with filtration, as expected.

Due to the contamination of the field blanks, a series of steps were taken to diagnose and solve the problem. For a detailed discussion, please refer to Appendix D.

3.2 Enrollment and Follow-up

Participants were recruited to the study through the distribution of flyers. The flyers included the study phone number which potential participants could call if they were interested in being a part of the study. Once they called, the study was briefly described and they were asked if they wanted to be screened for participation. They were screened based on the Screening Script (see Appendix A) described in Section 2.2.3. If they were eligible, they were given more details about the study and asked if they wanted to participate.

People who took the screener were either eligible, ineligible given current screening criteria, or their eligibility was undetermined. Participants that had eligibility “undetermined” were moved to one of the other categories once their eligibility was determined, or were classified as a passive refusal if they never called back to provide the additional information. For those that were “eligible”, they either “agreed” and entered the subject tracking system, were “unsure”, or “refused”. The “unsure” participants generally were classified as a passive refusal as they never

called back with a decision, or if they left a phone number, were never able to be contacted. Screening criteria were not changed and thus those ineligible when initially screened remained ineligible. A total of 404 potential participants were screened for eligibility, with the results of screening shown in Table 3.2.1.

Table 3.2.1 Screening for Eligibility

Assessed for eligibility – 404	
Eligible – 268	
	Agree – 253 – enter subject tracking system
	Passive Refusal– 14
	Refused –1
Eligibility undetermined – 3	
	Passive Refusal– 3
Not eligible – 133	

Of the households entered into the subject tracking system, 81 did not end up participating in the study, with the majority being passive refusal prior to the consent visit. A smaller portion had either a consent visit, or both a consent and enrollment visit, and either actively or passively refused at that point. A small number of participants became ineligible, for example deciding to move out of the state during the enrollment process or upon discovery of an existing UV filtration system in their central forced-air system.

Section 2.2.3 outlined the plan to randomize participants as to whether they started in sham or true and if they were eligible for central system filtration (CSF in figures) or a stand-alone air cleaner. For logistical reasons, the randomization occurred when they entered the tracking system and eligible homes were later screened to determine if central system filtration could be installed. As inspections began, it quickly became evident that all homes would need to be evaluated for central system filtration in order to meet the goal of 100 homes with central system filtration, and thus randomization to the central system filtration group was discontinued. Optimally, randomization for true and sham filtration would have occurred later in the process; however, we did not feel it was appropriate to change the time point for randomization once we had started the study.

The flowchart for participation in Figure 3.2.1 has one component for enrollment and one component for randomized but not entering the participant data set. Flowchart for participation in Figure 3.2.2 and Figure 3.2.3 has a final component tracking participants included in the participant data set. Inclusion in the participant data set required that the participant complete a Baseline Questionnaire Part 1 and that an intervention be installed in their home.

Due to the early randomization between true and sham, the numbers starting central system filtration in true versus sham are not equal. However, given that every participant serves as their own control and, if they complete the study, undergoes one year of true filtration and one year of

sham filtration, this is not anticipated to affect study results. While participants were not randomized between stand-alone air cleaners and central system intervention, we still list the numbers for tracking participants through this study separately for central system filtration and stand-alone air cleaner groups.

We note that asthmatic siblings were included in the study if they either shared a bedroom with the participant or we anticipated the house would be eligible for central system filtration. All numbers reported in Table 3.2.1 and on Figure 3.2.1 are on a household basis. Siblings are added to the enrollment at the top of Figure 3.2.2 (air cleaner) and Figure 3.2.3 (central system), and all subsequent numbers in the figures are on a per participant basis.

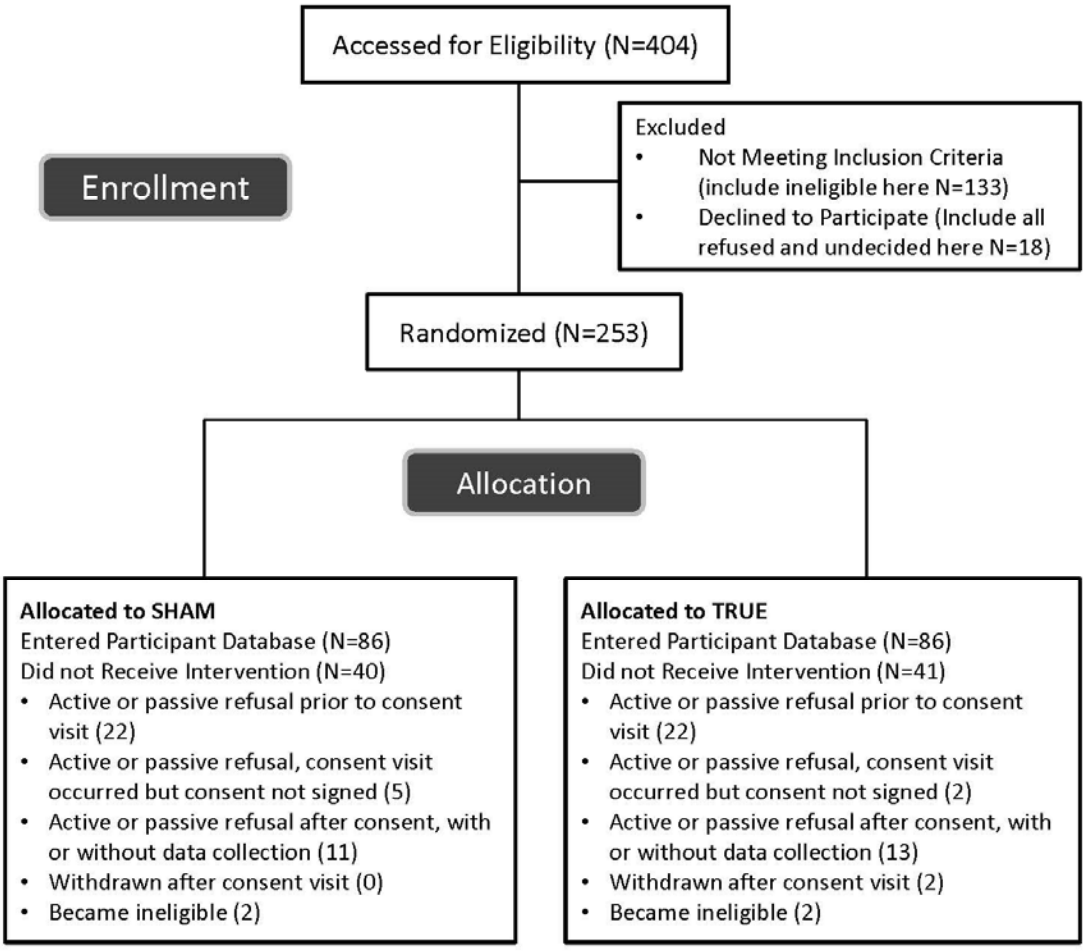


Figure 3.2.1 Flow chart of enrollment, randomization, and follow-up.

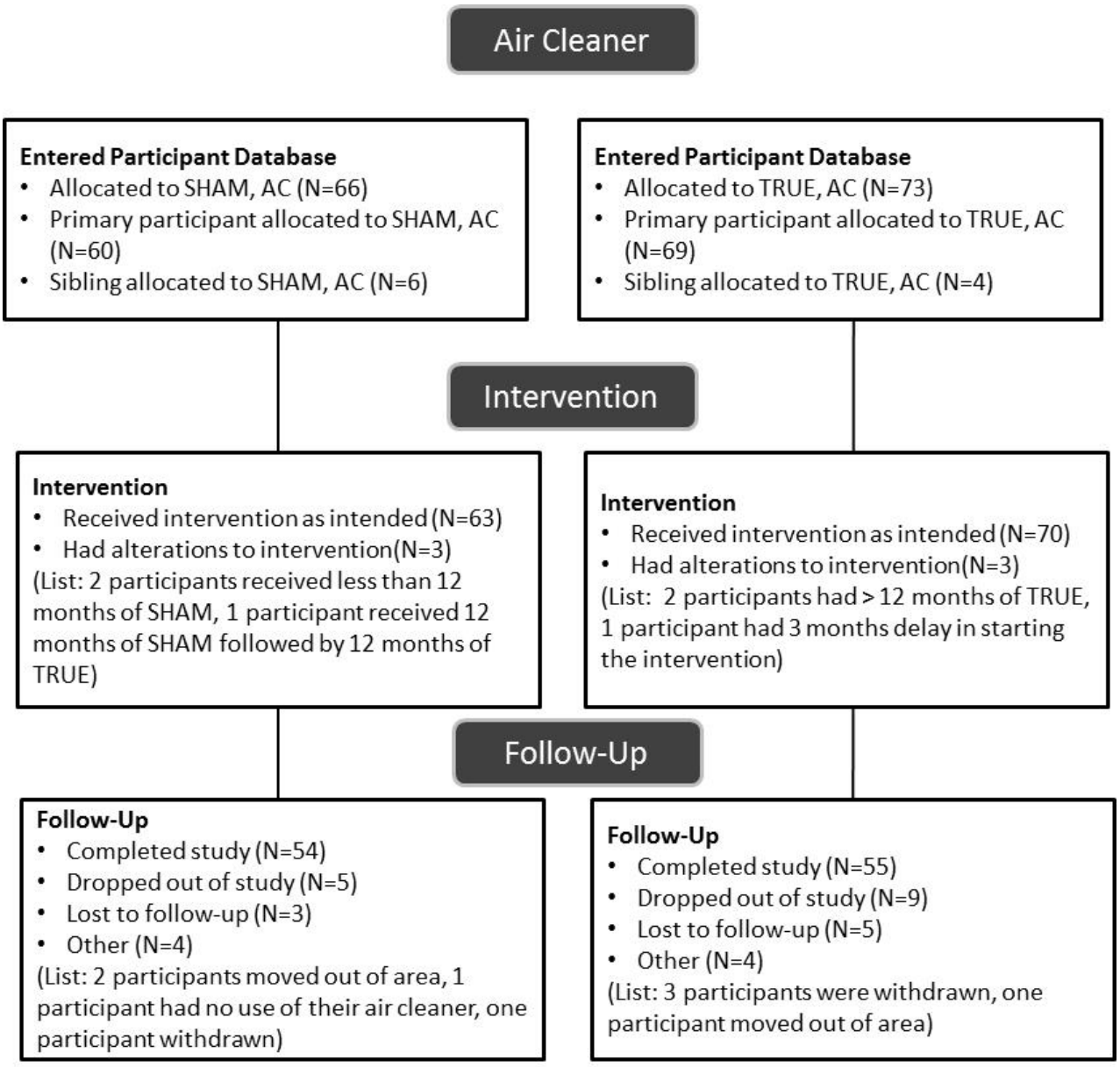


Figure 3.2.2 Flow chart of enrollment, randomization, and follow-up – Air Cleaner.

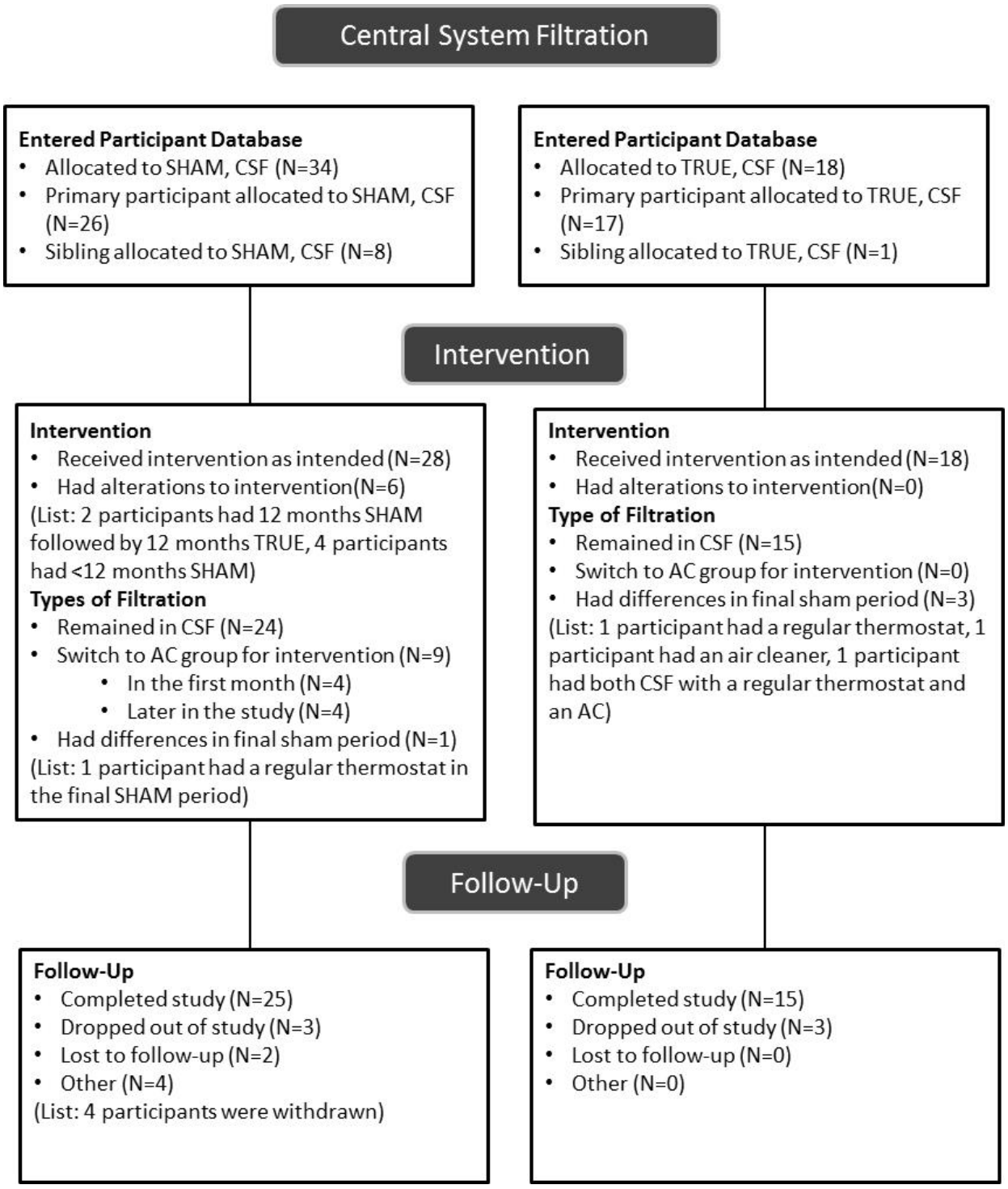


Figure 3.2.3 Flow chart of enrollment, randomization, and follow-up – Central System.

Participants did not complete the study for a variety of reasons. Some participants no longer wanted to participate, in which case it was considered that they dropped out of the study. Participants were withdrawn from the study if staff determined it was not possible for the participant to complete the study under the protocol (e.g., participant purchased a whole house air cleaning system). If they moved out of the area, they were removed from the study. If we were unable to contact them or were otherwise unable to conduct any visits or recall phone interviews for six months, they were considered a loss to follow-up. Finally, if they did not use the intervention, they were removed from the study. The total number of participants completing or not completing the study for any reason is listed in the "Follow-Up" sections of Figure 3.2.2 and Figure 3.2.3. Overall, 78% (149 participants completed the study out of 191 enrolled) of the participants completed the study. Details on the reasons participants did not complete the study are included in Appendix A. We note that some participants not completing the study did participate for a long enough time that their data was useful to the analysis.

A number of the homes originally installed with central system filtration switched to stand-alone air cleaners. These changes are included on Figure 3.2.3, under the section, "Type of Filtration." Specifically, four participants from two households were switched within the first month. These homes received virtually all of their cleaning with stand-alone air cleaners and the indoor air quality data from these homes was analyzed with the stand-alone air cleaner group. In addition, four participants from three households had a portion of their intervention with central system filtration, and a portion with stand-alone air cleaners. Indoor air quality data from the two types of interventions was considered separately. Finally, four participants had alterations in how they received their final sham filtration. These homes were noted, and the indoor air quality data was analyzed with the central system filtration group. Overall, 67% of the homes installed with central system filtration completed the study with central system filtration, and 9% completed the study with an air cleaner in place. More details on the homes that switched from central system filtration can be found in Appendix A.

Some homes had slight alterations to their intervention schedule (when they received true and sham filtration versus the protocol). These changes are included in Figure 3.2.2 and Figure 3.2.3 under the section, "Intervention". Most commonly, homes received their intervention 2 to 3 months late, and began with sham filtration. This occurred for 6 participants. Data from these participants were analyzed with no alterations as the unfiltered air they received prior to receiving the intervention and sham filtration presumably provided similar levels of indoor air quality. Three participants had 12 months of sham filtration followed by 12 months of true filtration, as opposed to the study protocol of six months sham, followed by 12 months of true, followed by 6 months of sham. These alterations are noted and analysis accounted for the actual filtration they received. Two participants received more than 12 months of true filtration. Finally, one participant started the intervention 3 months after their pre-intervention visit, but received the protocol as intended from that point.

In order to track all the various potential alterations, a Participant Status Dataset was created. The following tracking status variables are included for each participant:

- Whether the participant was initially randomized to true or sham for their first six months.
- Whether the participant initially had central system filtration installed or stand-alone air cleaners installed.
- Whether there were any alterations to the timeline for receiving true versus sham filtration.
- Whether there were any alterations to the participant receiving central system filtration versus stand-alone air cleaners.
- If the participant completed the study.
- If the participant moved to a new home during the study.
- If the participant had any visit outside of the prescribed season.

If there were alterations or changes, those were documented with an appropriate response code, with all codes listed in the Participant Status Data Dictionary. The month the participant dropped out along with the last date of collection are included as well.

Although participants were asked if they were going to remain in the same home for the following two years as a condition for being in the study, some of them ended up moving within the study area during the two years of follow-up. The date of the first move is included as a variable in the Participant Status Dataset. For participants with more than two homes, additional information regarding moves is included in a "Moving Notes Field". It is noted that we attempted to conduct an abbreviated Baseline Questionnaire Part 2 for each new home, as described in Section 2.5. Specifically, 19 participants from 17 households moved and data collecting continued in their new home. Other participants moved during the study, but did not continue in the study.

To incorporate all of this data for analysis, status variables for each recall were created. For example, there was a variable for actual true versus sham (3 month visit, the 6 month visit, etc.) There was also a variable that indicated if they started true or sham, from which one could determine the intended true/sham at each time point. The individual variables for each 3 month period provided the actual true versus sham status for that period. Specifically, there were variables for true versus sham, central system filtration versus stand-alone air cleaners, house number, and season. In some cases, the home was unable to complete a specified visit within the targeted timeframe. In some of these cases, we were able to complete the visit, but outside of the target range. These alterations are noted. The season provided easily accessible data on any shifts and visits that resulted in seasonally matched data not following the standard trajectory. All of this information is included in the Participant Status Data Dictionary.

In addition to the status presented in the flowcharts in Figure 3.2.1 through Figure 3.2.3, we also include participation numbers and follow-up by region and type of intervention in Tables 3.2.2 through 3.2.5 below.

Table 3.2.2 Participation and Completion for Air Cleaner Participants in Fresno

Fresno		
	Did not complete	Completed study
Enrolled air cleaner primary participants	17	62
Siblings	2	4
Total	19	66

Table 3.2.3 Households with Central System Filtration (CSF) or Stand-Alone Air Cleaners (AC) in Fresno

	Always in CSF		AC, first month		CSF and AC filtration	
	Completed	Dropped	Completed	Dropped	Completed	Dropped
Enrolled in CSF primary participants	22	4	1	1	1	0
Siblings	5	0	1	1	0	0
Total	27	4	2	2	1	0

Table 3.2.4 Participation and Completion for Air Cleaner Participants in Riverside

Riverside		
	Did not complete	Completed study
Enrolled air cleaner primary participants	9	41
Siblings	2	2
Total	11	43

Table 3.2.5 Households with Central System Filtration or Stand-Alone Air Cleaners in Riverside

Riverside						
	Always in CSF		AC, first month		CSF and AC filtration	
	Completed	Dropped	Completed	Dropped	Completed	Dropped
Enrolled in CSF primary participants	8	5		0	1	0
Siblings	0	1		0	1	0
Total	8	6		0	2	0

3.3 Installation and Follow-up of Central System Filtration

3.3.1 Evaluation of Homes for Central System Filtration

There were several criteria homes had to meet for us to be able to install filtration through the central system, as listed in Section 2.4.2. We conducted inspections of the central system for the first 146 homes during the enrollment visit to determine if the home could have central system

filtration installed. There were many reasons upgrades could not be installed in homes, but they fall into six primary categories:

- Participant did not have a central system.
- Problems with the central system made it infeasible to filter the air.
- House unable to have the IQAir filter system installed (e.g. filter mounted too close to wall).
- House unable to have study thermostat installed (e.g. two thermostats controlling a single central filtration system).
- Participant worried about obtaining permission to make changes to their system since they rented home.
- Participant did not want to run the central system 15 minutes of every hour.

Overall, of the first 146 homes inspected, only 29%, or 43 homes (which included 52 participants), had central system filtration installed. We ceased inspecting homes for possible central system filtration upgrades on July 5, 2014, due to problems that occurred with the study thermostat. The details on why homes could not be upgraded to central system filtration can be found in Appendix A.

3.3.2 Number of components installed in each home

The majority of the homes had a single return-air intake and single thermostat. However, some homes had two return-air intakes and either one or two thermostats. The number of homes with each configuration is presented in Table 3.3.1 below.

Table 3.3.1 Number of homes with 1, 2, or 3 Return-air Intake Units and Thermostats.

	Fresno	Riverside	Total
1 intake, 1 thermostat	20	10	30
2 intakes, 1 thermostat	4	1	5
2 intakes, 2 thermostats	5	2	7
3 intakes, 3 thermostats	1	0	1

3.3.3 Problems faced by homes utilizing central system filtration and follow-up

There were numerous problems with the thermostat utilized in this study. Recall that the study required that the central system run in "fan-only" mode for 15 minutes of every hour. This is called a "clean-air" mode. At the time the study was conducted, there were very few thermostats that were compatible with the wiring typically found in the housing stock of participating households. Unfortunately, the model selected for the study malfunctioned in nine of the 33 homes it was installed in, generally causing the air conditioning to run continuously, with most

of the malfunctions occurring during a heat wave. The thermostat was replaced in all homes with one that ran 20 minutes of every hour, and a number of homes originally scheduled for central air filtration were installed with stand-alone air cleaners instead. Another difficulty when using the central filtration system was that the central system itself may fail while participating household was in the study. In some cases, the study paid to repair the system as it was determined the failure could reasonably be assumed to result from increased wear-and-tear on the system, while in other cases, the study did not pay for the repairs. Finally, as study personnel had no way to determine actual fan use, determining correct electricity reimbursements for central system filtration households was difficult.

Many participants asked to be switched to stand-alone air cleaners, or, because they were still unhappy with their thermostat, asked to have their thermostat switched to yet another model. In total, only 58% of the households that had central system filtration installed completed the study with no alterations. Figures diagraming the changes, difficulties encountered and completion numbers in more detail are available in Appendix A.

3.4 Baseline Questionnaires

As described in Section 2.5, the Baseline Questionnaire Part 1 collected information related to the child's health history as related to asthma and allergies, information about exposures to smoke and pets, and basic demographic information. In addition, it included a Recall Questionnaire altered to ask for hospitalizations, doctor visits, emergency room visits, steroids, and ear and respiratory infections over the past year as opposed to the past three months. The results for the Recall Questionnaire component are included in Section 3.7.1, Baseline Health Measurements. The Baseline Questionnaire Part 1 was asked of every participant in the study, including both siblings if there were two siblings in the same home.

The Baseline Questionnaire Part 2 collected basic information about the home, window usage, the heating and cooling systems, gas appliances, mold and water damage, and flooring. This questionnaire was asked for every home, with the same information being applied to both siblings if there were two siblings in the home.

The Baseline Questionnaires are both located in Appendix B. The Data Dictionary contains the question number, variable name, a brief description of the question, and the variable values for each response option. It also includes any notes related to how information should be coded. In some cases, we wanted to combine information from multiple questions into a single variable, or otherwise present the data collected in a question in a different way. Each created variable is given a variable name, and also a brief descriptive title. Tables B3 and B4 in Appendix B contain lists of the created variables for Baseline Questionnaires Part 1 and 2, respectively. For each variable, we include the descriptive title and a brief description of how they were created. The created variables are also included in the Data Dictionaries, where both the variable name and the brief descriptive title are presented along with information for creating the variable.

For Baseline Questionnaire Part 1, the results are presented for the entire population, as well as for the primary child and siblings separately, where applicable. For questions referring to the household, results are reported by household. There is a series of questions in the questionnaire used to determine the size and number of allergy mattress covers to bring to the home and responses to these questions are not included in the results. For continuous variables, results are presented as being within specified ranges. If the question was answered by all participating households, there is no missing category included. A line for missing was included if there were missing data for the question and likewise for the "don't know/refused" (DK/RF) response option. The results for Baseline Questionnaire Part 1 are in Table B5 in Appendix B. Select results are included in Table 3.4.1 and Table 3.4.2, including race, household income, presence of furry pets and allergies, age of child, and highest education level of parent with the highest level of education.

For Baseline Questionnaire Part 2, information about the homes is presented for the entire set of homes, and often for Fresno and Riverside, separately. Continuous variables are either presented as ranges or specific percentiles are presented. The results for Baseline Questionnaire Part 2 are in Table B6 in Appendix B, with window usage presented in a separate table, Table B7. Select results, including type of housing, age of homes, distance from roadways, presence of gas stove, significant mold, and presence of air conditioning and swamp coolers are included in Table 3.4.3.

A total of 19 participants, from 17 households, moved and continued to provide data while enrolled in the study. Of these, 16 completed the Mover's Questionnaire, located in Appendix B. In cases where questions included in the Mover's Questionnaire are utilized in data analysis, the value from the appropriate home is selected for the analysis. The answers are contained in the mover's data set.

Table 3.4.1 Baseline Questionnaire Part 1 Selected Results – Information about Participants

	Entire Data Set		Primary Children		Enrolled Sibling	
	(n)	(%)	(n)	(%)	(n)	(%)
Childs Race [1,2]						
Hispanic	92	48%	84	49%	8	42%
Black or African American	21	11%	18	10%	3	16%
White	55	29%	49	28%	6	32%
Asian	5	3%	5	3%	0	0%
Native Hawaiian or other Pacific Islander	1	1%	1	1%	0	0%
Mixed	14	7%	13	8%	1	5%
Other: not specified	3	2%	2	1%	1	5%
Grade child enrolled in at start of study[2]						
K-1	38	20%	33	19%	5	26%
2 – 3	68	36%	61	35%	7	37%
4 – 5	58	30%	54	31%	4	21%
6+ UP	26	14%	24	14%	2	11%
Missing	1	1%	0	0%	1	5%
Child had sneezing, runny/blocked nose, itchy/watery eyes around mold in the past 12 months? [3]						
DK[4]	41	21%	37	22%	4	21%
No	66	35%	60	35%	6	32%
Yes	66	35%	59	34%	7	37%
Child had sneezing, runny/blocked nose, itchy/watery eyes around pollen in the past 12 months? [3]						
DK[4]	9	5%	9	5%	0	0%
No	17	9%	16	9%	1	5%
Yes	147	77%	131	76%	16	84%
Pets - All furry/feathered pets (cats, dogs, rodents, birds, rabbits, chickens)						
No furry/feathered pet	74	39%	66	38%	8	42%
Outdoor furry/feathered pet	28	15%	25	15%	3	16%
Indoor furry/feathered pet, does not sleep with child	62	32%	58	34%	4	21%
Indoor furry/feathered pet, sleeps with child	27	14%	23	13%	4	21%
Have indoor furry animals and allergies to furry animals in the last 12 months						
No	143	75%	131	76%	12	63%
Yes	48	25%	41	24%	7	37%

Table 3.4.1, cont.

	Entire Data Set		Primary Children		Enrolled Sibling	
	(n)	(%)	(n)	(%)	(n)	(%)
A doctor or a health care provider has given a written plan for managing child's asthma. Also called asthma action plan.[2]						
DK[4]	3	2%	2	1%	1	5%
No	97	51%	89	52%	8	42%
Yes	91	48%	81	47%	10	53%

[1] Categorized "Other" responses according to census race definitions. If more than one listed, added to the mixed.
[2] The percentages in this category do not add to 100% due to rounding.
[3] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%. There were 18 participants that had never had these symptoms when not sick.
[4] DK = don't know

Table 3.4.2 Baseline Questionnaire Part 1 Selected Results –Information about Households

	Total households	
	(n)	(%)
Respondents race [1]		
Hispanic	81	47%
Black or African American	19	11%
White	57	33%
Asian	6	3%
Mixed	8	5%
Other: not specified	1	1%
Household income		
Less than $23,000	39	23%
Between $23,000 and 46,000	35	20%
Between $46,000 and 70,000	25	15%
More than $70,000	63	37%
DK/RF	9	5%
Missing	1	1%
Primary caregiver's highest grade/school level completed		
1st through 5th grade	3	2%
6th - 8th grade	10	6%
9th - 11th grade	14	8%
GED or 12th grade	24	14%
1 - 3 years of college / technical / voc training / associate	55	32%
4 years of college / technical / voc training / bachelors	35	20%
5+ years of college / technical / voc training / grad degree	30	17%
Missing	1	1%

[1] Categorized "Other" responses according to census race definitions. If more than one race listed, added to the mixed group.

Table 3.4.3 Baseline Questionnaire Part 2 Selected Results

	Population by Residence		Fresno Homes		Riverside Homes		Population by child	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
House Type								
Single Family Home (Detached House)	138	80%	80	74%	58	91%	152	80%
Duplex/Triplex	10	6%	8	7%	2	3%	11	6%
Townhouse/ Row House	4	2%	4	4%	0	0%	5	3%
Low rise apartment or condo (1-3 floors)	15	9%	14	13%	1	2%	17	9%
Mobile Home/Trailer	5	3%	2	2%	3	5%	6	3%
Year home was built								
Older than 1949	18	10%	13	12%	5	8%	18	9%
1950s	16	9%	10	9%	6	9%	18	9%
1960s	13	8%	8	7%	5	8%	14	7%
1970-1976	18	10%	17	16%	1	2%	22	12%
1977-1979	5	3%	3	3%	2	3%	6	3%
1980s	22	13%	13	12%	9	14%	27	14%
1990s	22	13%	14	13%	8	13%	25	13%
2000s	49	28%	21	19%	28	44%	52	27%
2010+	1	1%	1	1%	0	0%	1	1%
Missing	8	5%	8	7%	0	0%	8	4%
How close is nearest freeway, highway, major street								
Immediately in front, behind or beside child's residence	20	12%	15	14%	5	8%	24	13%
One block away, length of football field	39	23%	29	27%	10	16%	45	24%
2-4 blocks away	50	29%	31	29%	19	30%	55	29%
More than 5 blocks away	62	36%	32	30%	30	47%	65	34%
Missing	1	1%	1	1%	0	0%	2	1%
Stove top type								
Gas	122	71%	60	56%	62	97%	132	69%
Electric	50	29%	48	44%	2	3%	59	31%
Oven type								
Gas	86	50%	44	41%	42	66%	93	49%
Electric	84	49%	63	58%	21	33%	96	50%
DK/RF[4]	1	1%	1	1%	0	0%	1	1%
Missing	1	1%	0	0%	1	2%	1	1%

Table 3.4.3, cont.

	Population by Residence		Fresno Homes		Riverside Homes		Population by child	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Have central cooling system								
No	37	22%	22	20%	15	23%	39	20%
Yes	135	78%	86	80%	49	77%	152	80%
Have swamp or desert cooler								
No	164	95%	102	94%	62	97%	181	95%
Yes	8	5%	6	6%	2	3%	10	5%
Have mold currently								
Current mold, not significant	8	5%	5	5%	3	5%	9	5%
Current mold, significant	10	6%	8	7%	2	3%	10	5%
No current mold	154	90%	95	88%	59	92%	172	90%
Had mold in the past								
No past mold	140	81%	84	78%	56	88%	157	82%
Past mold, not significant	8	5%	6	6%	2	3%	9	5%
Past mold, significant	24	14%	18	17%	6	9%	25	13%
Pests [1]								
Mice - Yes	23	13%	15	14%	8	13%	24	13%
Rats - Yes	13	8%	8	7%	5	8%	14	7%
Cockroaches - Yes	47	27%	42	39%	5	8%	55	29%
Cockroaches - DK/RF	1	1%	1	1%	0	0%	1	1%
Ants - Yes	76	44%	43	40%	33	52%	81	42%
Spiders - Yes	87	51%	54	50%	33	52%	96	50%
Bedbugs - Yes	3	2%	2	2%	1	2%	3	2%
Other - Yes	21	12%	16	15%	5	8%	26	14%
Other: Earwigs/pincher bugs (5), water bugs (3), beetles (2), aphids, flies, lice, mosquitos, moths, squirrels, termites, wasps, fleas, potato bugs, not listed								
Yes to problems with mice, rats or cockroaches								
No	107	62%	58	54%	49	77%	117	61%
Mice or rats or cockroaches - Yes	65	38%	50	46%	15	23%	74	39%

Table 3.4.3, cont.

	Population by Residence		Fresno Homes		Riverside Homes		Population by child	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Home within 1/4 mile of source [2, 3]								
Gas Station - Yes	98	57%	66	61%	32	50%	111	58%
Gas Station - Maybe	3	2%	3	3%	0	0%	4	2%
Gas Station - DK	2	1%	0	0%	2	3%	2	1%
Farm - Yes	66	38%	42	39%	24	38%	70	37%
Farm - Maybe	4	2%	3	3%	1	2%	6	3%
Industrial Facility - Yes	27	16%	17	16%	10	16%	31	16%
Industrial Facility - Maybe	6	3%	4	4%	2	3%	8	4%
Industrial Facility - DK	5	3%	5	5%	0	0%	5	3%
Industrial Facility - Missing	1	1%	0	0%	1	2%	1	1%
Railroad - Yes	43	25%	29	27%	14	22%	47	25%
Railroad - Maybe	4	2%	3	3%	1	2%	4	2%
Railroad - DK	1	1%	1	1%	0	0%	1	1%
Drycleaners - Yes	51	30%	32	30%	19	30%	60	31%
Drycleaners - Maybe	9	5%	5	5%	4	6%	10	5%
Drycleaners - DK	5	3%	4	4%	1	2%	5	3%
Bus Truck Depot - Yes	31	18%	19	18%	12	19%	38	20%
Bus Truck Depot - Maybe	5	3%	3	3%	2	3%	5	3%
Construction - Yes	58	34%	30	28%	28	44%	63	33%
Construction - Maybe	5	3%	3	3%	2	3%	5	3%
Construction - DK	2	1%	2	2%	0	0%	2	1%
Waste Sewage Facility - Yes	11	6%	7	6%	4	6%	13	7%
Waste Sewage Facility - Maybe	7	4%	6	6%	1	2%	7	4%
Waste Sewage Facility - DK	5	3%	3	3%	2	3%	5	3%
Restaurant - Yes	50	29%	39	36%	11	17%	59	31%
Close to sources: If yes to any of the above choices								
No	14	8%	4	4%	10	16%	16	8%
Yes	158	92%	104	96%	54	84%	175	92%

Table 3.4.3, cont.

	Population by Residence		Fresno Homes		Riverside Homes		Population by child	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Fireplace								
Does not have fireplace	64	37%	47	44%	17	27%	73	38%
Have fireplace, but use 0 days per year	54	31%	33	31%	21	33%	61	32%
Gas fireplace/woodstove, use >0 day	26	15%	10	9%	16	25%	26	14%
Wood fireplace, use >0 days per year	17	10%	10	9%	7	11%	19	10%
Woodstove/manufactured wood/other, use >0 days per year	11	6%	8	7%	3	5%	12	6%

[1] Assumed any participants that had missing answer for other pests section did not have a problem with other pests and are listed as "No"

[2] One home was missing answers to all the questions. Answers for that home were determined using google maps.

[3] Spanish version of the questionnaire was missing the restaurant question. Distance to restaurant was looked up for all participants (English and Spanish speaking) using google maps.

[4] DK = don't know RF = refused

3.5 Use of Interventions

Calculations were made to determine if the participants were complying with the protocol. As participants were requested to always run the air-cleaners, and were asked to run them at a specified flow-rate, while the participants with a central system filter were requested to run the system for a portion of time, calculation methods were different between the two groups.

The average volumetric flow rate through the two air cleaners over the sampling week was calculated and compared to the desired flow rate of 475 CFM for each home. Participants were categorized as to whether the average volumetric flow rate was above 90%, between 75% and 90%, between 50% and 75%, between 25% and 50%, and below 25%. The portion of homes in each category is presented in Figures 3.5.1 below for the sampling week. Figure 3.5.2 depicts the same information over the 6 months between visits. When the value is less than 1, it may be reduced because the home set the air cleaner at a lower setting than desired or because they turned it off. Compliance was greater during the one week sampling period, as would be expected.

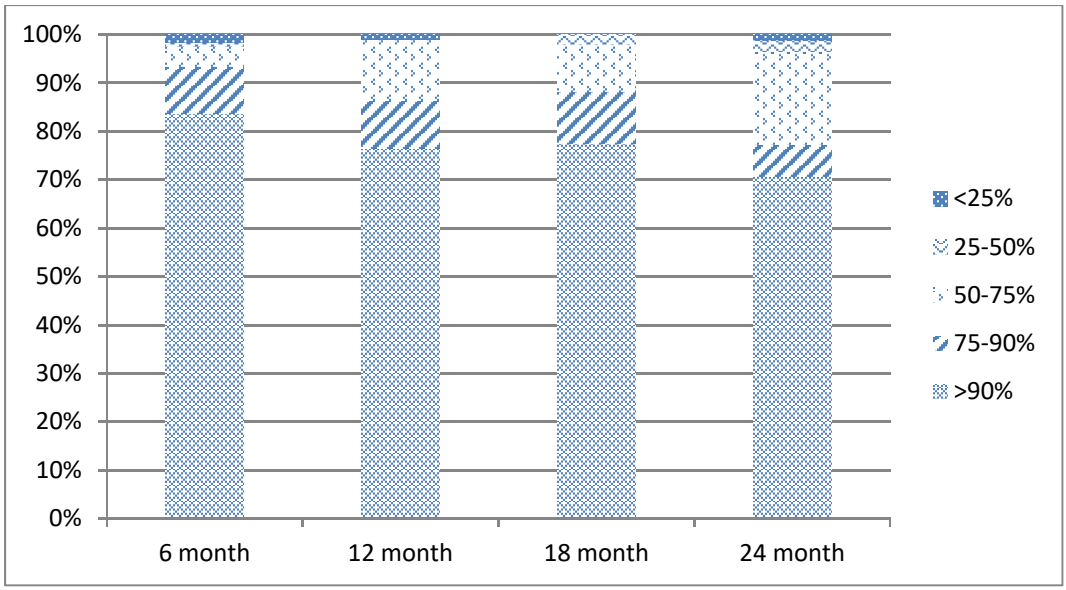


Figure 3.5.1 Fraction of the population that ran the air cleaners in their home at various percent values relative to the desired air flow rate over the sampling week.

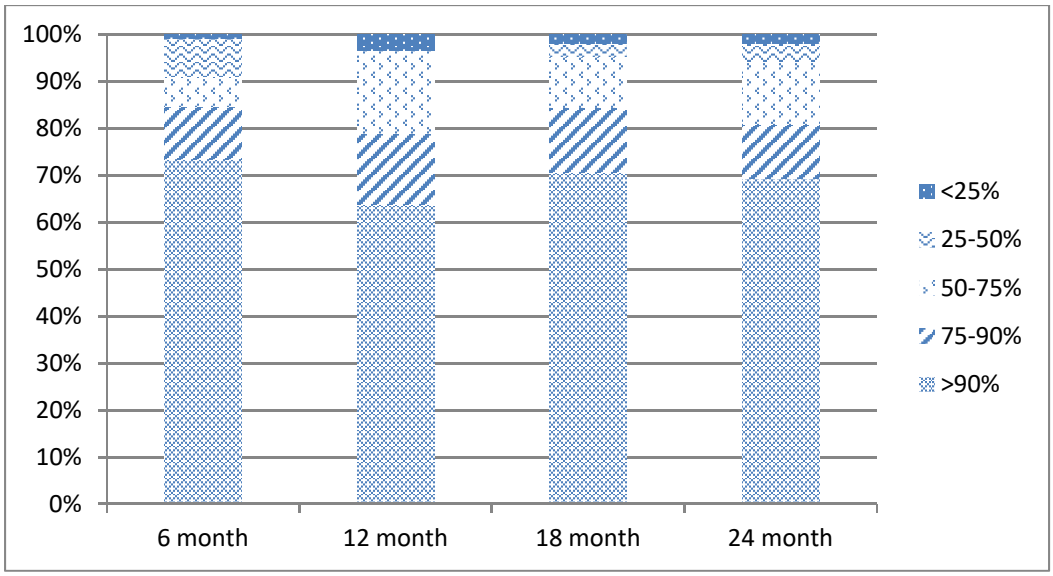


Figure 3.5.2 Fraction of the population that ran the air cleaners in their home at various percent values relative to the desired air flow rate over approximately the 6 months between visits.

It was noted that some of the filters to reduce ozone and VOC's became saturated and released an unpleasant smell early in the study. The smell likely included re-emissions of VOCs, ozone reaction products with VOCs sorbed to the filter, and possibly products of microbial growth, although no microbial growth was visually observed on the filters. In some cases, participating households turned air cleaners off, reflected as a lack of compliance. The holding capacity of the VOC material may have varied based on manufacturing batch. The first batch of air cleaners

appeared to provide better VOC filtration. Of the first 60 households installed, there was only 1 complaint at 6 months, and 9 more complaints occurring between 7 and 12 months. The filters in the second batch of air cleaners received were more problematic. Of the 30 households installed, 6 households reported complaints prior to the 6 month visit, 8 had a complaint or noted a smell at either the 6 month visit or the reminder call for that visit, and 2 homes had at some point had complaints after 6 months. Overall, half the households had a complaint at some point.

Similarly, there were differences in the number of complaints we received for homes that had a TRUE filter installed following SHAM filtration. Of the first 24 homes, only 3 had complaints. For the next 60 homes, 10 had complaints within the first month. There may have been more complaints later but we began replacing filters with a replacement filter that did not appear to have the same problems as no further complaint calls were recorded.

For homes with high-efficiency filtration in central forced air systems, the fraction of time the system fan was running as compared to the desired 20 minutes per hour was calculated, presented for the sampling week in Figure 3.5.3 and for the 3 month period prior to each visit in Figures 3.5.4

The difference in compliance between the sampling week and the three months prior appears to be greater for homes utilizing filtration through the central system as compared to the homes with stand-alone air cleaners. This is likely because homes had to keep the thermostat in the clean-air mode, and frequently thermostats appear to have been taken out of clean-air mode, either intentionally or inadvertently.

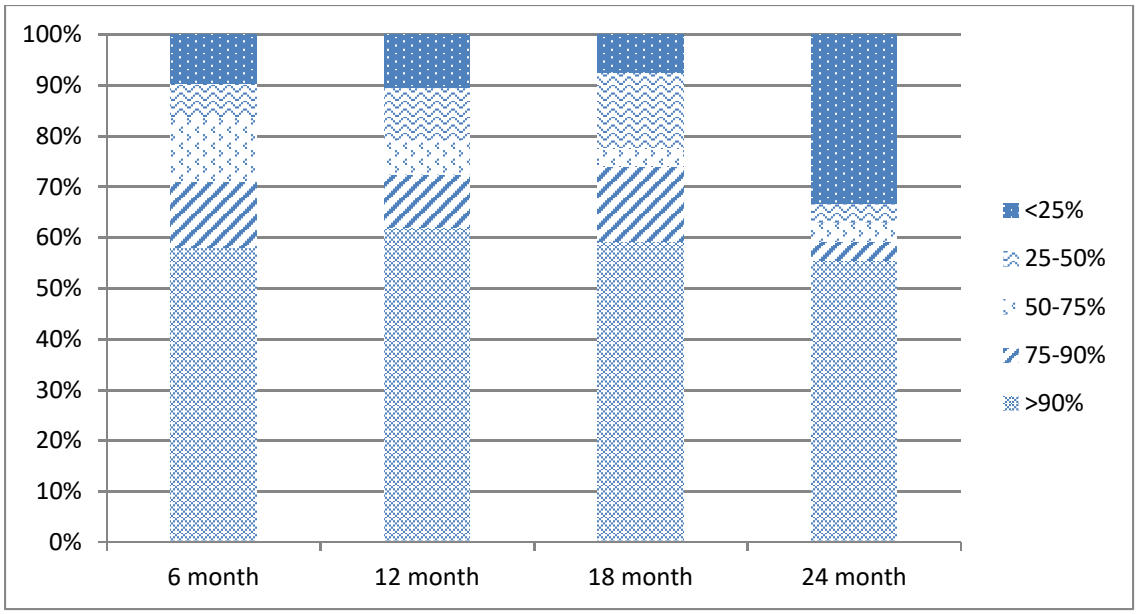


Figure 3.5.3 Fraction of the population that ran their central air system at various percent values relative to the desired air flow rate over the sampling week.

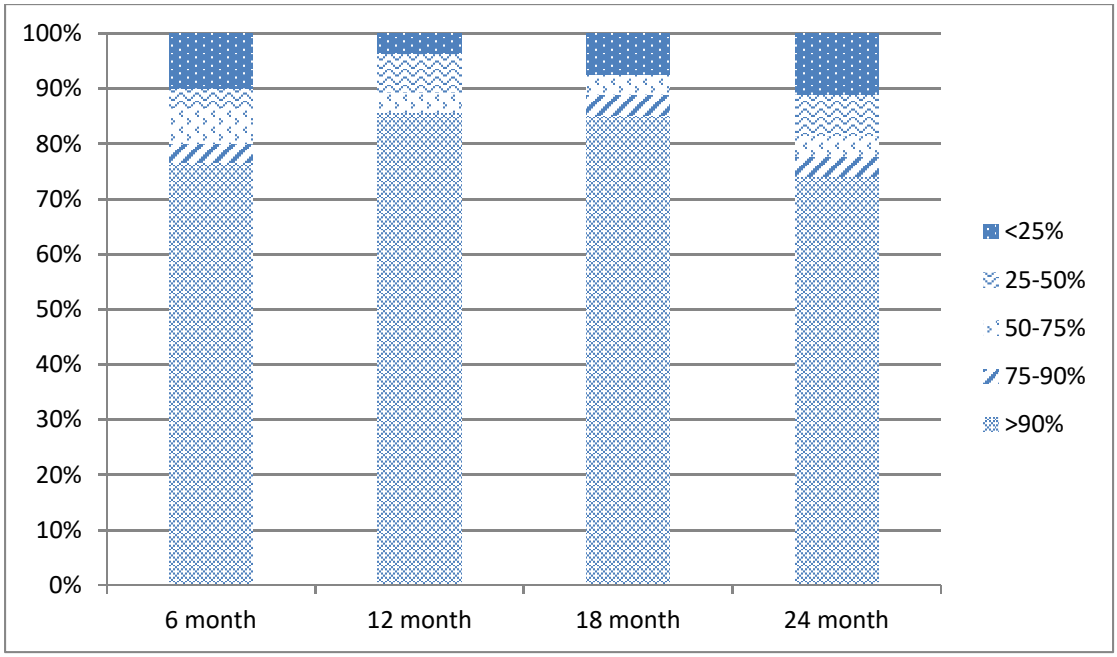


Figure 3.5.4 Fraction of the population that ran their central air system at various percent values relative to the desired air flow rate over approximately the 3 months prior to the visit.

Another relevant comparison between air cleaner and central system filtration homes is the fraction of air cleaned per hour relative to the volume of the home. Table 3.5.1 presents the summary statistics for this parameter. At most percentiles of the distribution, the value is greater

for the homes with filtration through the central system. The values are higher because for many homes, the air flows through the central system is greater than three times the flow rate through the two air cleaners (i.e. greater than 1425 CFM) as indicated in Table 3.5.2. Additionally, some homes ran the central system more than the requested 20 minutes per hour if there were significant heating or cooling demands. It is noted that the homes with central system filtration installed were slightly larger, see Table 3.5.3, but not by enough to offset the other two factors discussed.

Table 3.5.1 Summary Statistics for the Volume of Air Filtered Each Hour, Expressed as Indoor Air Volumes per Hour

Intervention Type	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	50th Pctl	75th Pctl	90th Pctl	Max
Air Cleaner	369	2.3	1.3	0.34	1.1	1.5	2.1	2.8	3.8	7.5
Central System	85	2.8	1.9	0	0.3	1.5	2.7	3.8	4.8	10.6

Table 3.5.2 Distribution of Air Flow Rates in Cubic Feet per Minute (cfm) through the Intake Vents in Central Homes Following Installation of the New Filter

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	50th Pctl	75th Pctl	90th Pctl	Max
Air flow rate through intake	85	2552	1212	560	1033	1800	2426	3398	4165	5548

Table 3.5.3 Distribution of the Square Footage of Homes with Air Cleaners or Central System Filtration Installed

Intervention Type	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	50th Pctl	75th Pctl	90th Pctl	Max
Air Cleaner	369	1861	945	500	931	1156	1610	2378	3102	5426
Central System	85	2315	798	957	1232	1635	2100	2933	3400	4001

3.6 Air Quality Measurements

3.6.1 Air Sampling Completeness and QA/QC Results

QA/QC evaluations were conducted during the course of the study. Three reports were completed by Chuck McDade, who served as the QA/QC officer for the majority of the project. One reported on Dr. McDade's audits of the field work and procedures, one on lab work and procedures, and one evaluating the contamination resulting from the O-rings used in the study. All three reports can be found in Appendix E.

Air sampling data were evaluated in terms of data completeness and results of the QA/QC samples collected.

Prior to evaluation, there were several data checks completed to confirm PM data. Data entry errors were checked and corrected by comparing set up and take down filter numbers, pump box numbers, flow rates, and flow times. Very high and very low flow rates and flow times were checked for errors and corrected if the value was found to be entered incorrectly or written in an obviously incorrect manner (i.e. decimal point in incorrect location).

A list of criteria was developed to remove flawed samples. Samples were removed if:

- On flow or off-flow was below target range.
- The ratio of $PM_{2.5}$ value as measured by PEM compared to value as measured by CI ($PEM_{2.5}$ / $CI_{2.5}$) was greater than 2.
- Sampling time was less than half the nominal time of 5040 minutes.
- O-ring did not meet criteria (Used red O-ring, Atlantic O-ring or black O-ring that was in the sampler for more than 14 days).
- Filter or PUF was damaged.
- Filter or PUF mass value on collected sample was negative or a clear outlier, indicating a gross error, most likely an error with the sampling media being switched.
- Indication that one of the connector tubes had a small hole.
- Other problems as determined by looking over consistency of trends in indoor-outdoor size fraction and review of flags on field logs.

The flow rate through the sampler was measured when the sampler was deployed (on-flow) and at the end of the sampling week (off-flow). If the off-flow was less than 90% of the target value, a flag was generated and the sample volume for that sample was not calculated. The target range for the cascade impactor (CI) off flow was between 4.5 and 5.5 LPM while the target range for PEM off flow was between 1.62 and 1.98 LPM. Seven CI samples and 16 PEM samples had an off flow below the target range and thus the corresponding CI or PEM sampling volume was not calculated. In some cases, the on- or off-flow for the PEM or CI was slightly higher than the target. Sample volumes were calculated for these samples.

Although field staff checked tubing for holes prior to deployment, pump boxes with a hole in the tube were sometimes unintentionally used. Samples collected prior to using these pump boxes were evaluated, looking for low off-flows or a low $PEM_{2.5}$ / $CI_{2.5}$ to identify if any other samples were flawed. These samples were flagged as having a hole in the tubing and the sample volume was not calculated.

The $PM_{2.5}$ concentration was determined by the PEM sampler. However, $PM_{2.5}$ could also be determined from summing the $PM_{0.2}$ and $PM_{0.2\text{-}2.5}$ size fractions from the CI sampler. The ratio of the $PM_{2.5}$ as measured by the PEM to the $PM_{2.5}$ concentration as measured by the CI was calculated (PEM $PM_{2.5}$ / CI $PM_{2.5}$), and the distribution is in Table 3.6.1 below. The reason for the discrepancy is thought to be that the cut-point of the second stage is not as sharp for the

cascade impactor as the PEM, resulting in a portion of the coarse PM not impacting onto the PUF for $PM_{2.5-10}$, but rather being diverted to the $PM_{0.2-2.5}$ PUF. The median value of the ratio was 0.83. The 5th percentile value for samples collected indoors was 0.55 and the 95th percentile value was 0.99. Samples with ratios outside this range were reviewed for or any data entry or other errors (i.e. reviewed field logs, looked for possible filter switches). In a very limited number of instances, the PEM $PM_{2.5}$ / CI $PM_{2.5}$ exceeded a value of 2 and no error could be found. Expert judgement was used to determine if the PEM or CI concentration was in error, and in all cases the PEM concentration was determined to be in error and the data were flagged and the concentration was not calculated.

Table 3.6.1 PEM $PM_{2.5}$/CI $PM_{2.5}$ Ratio Percentiles

	5%	**10%**	**25%**	**50%**	**75%**	**95%**
Indoor	0.55	0.64	0.74	0.83	0.89	0.99
Outdoor	0.59	0.65	0.71	0.84	0.92	0.96

Sampling times were determined by two methods as a data check. First by recording the date and time sampling began and ended and calculating the difference, referred to as the watch time. Second, by recording the total run time on the timer in the pump box at the beginning and end of sampling, and calculating the difference, referred to as the pump elapsed time. As stated in Section 2.6.2, it was noted that some pump box timers seemed to be problematic.

In cases where the pump box timer was determined to be inaccurate and unreliable the watch time difference was used to calculate sampling time, according to criteria below:

- Watch time was used as sampling time if the:
    - Difference between elapsed and watch times was less than 504 minutes (10%) and pump was on when field team arrived at take down.
    - Pump box timer was considered "bad" (see explanation in paragraph below) and pump was on when field team arrived at take down. These samples were manually reviewed.
- Pump box elapsed time difference was used if the:
    - Pump was off when field team arrived at take down.
    - We assumed the pump box may have been turned off and then back on during the sampling week because difference between elapsed time and watch time was greater than 504 minutes and the pump box timer was considered good. These samples were manually reviewed.
- For a few unclear and problematic samples, we determined whether to set sampling time to watch or elapsed time on a case-by-case basis. Any time a manual decision was made, watch or elapsed time was used as sampling time as indicated by the manual decision, overriding anything set by the above criteria. These unclear cases included pump boxes where the timer was completely broken and did not change at all between set up and take down (2 instances),

and where the elapsed time was much higher than watch time and it was determined that elapsed time was recorded incorrectly (6 instances).

Five pump boxes used in the beginning of the study had timers that sporadically did not appropriately record usage. Bad timers were identified as those that had elapsed time values consistently more than 504 minutes lower than watch time values (nominal runtime was 10,080 minutes),with no additional problems, such as being off at the second visit, noted. Bad pump timers were identified and all timers were replaced during the study and thus the date of collection was compared to the date the timer was replaced in the pump box. The sample volume was not calculated if sampling run time was less than 5040 minutes (run less than half the nominal, one week sampling time) because these samples did not represent the average over the week. This occurred 8 times for indoor samples and 14 times for outdoor samples.

As was determined in the "Quality of Assurance Report: O-Ring Assessment" report, concentrations were not calculated if Red or Atlantic O-rings were used, or if Black O-rings remained in the sampler for more than 14 days. Please also see Section 2.6.2.

If the filter or PUF mass values were negative, a search was conducted for a possible switch in the sampling media (e.g. the PUF for the $PM_{0.2\text{-}2.5}$ stage was inadvertently placed in the container for the $PM_{2.5\text{-}10}$ stage and vice versa). This was done by reviewing the on-weights and off-weighs of the sample with negative values and of sampling media that were likely to have been handled on the same day in the original mass spreadsheet sent by the laboratory. The mass value was corrected if this error was found, and the correction noted. In cases with negative mass data where no switch was found, it was noted and the mass value was changed to missing and the concentration was not calculated.

It is noted that in several cases when collecting duplicate samples, there were problems associated with the primary sample, most often the sampler was unplugged. In these cases the duplicate data was substituted for the primary data and the substitution was noted.

Data completeness is indicated in Tables 3.6.2-3.6.8 below. Specifically, Table 3.6.2 includes the total number of samples collected throughout the study. Table 3.6.3 indicates the number of indoor and outdoor samples field staff attempted to collect by visit type. Recall that all collected data was utilized in the analysis, regardless of whether or not the participant completed the study. The number of visits conducted is included for reference. The percent of samples attempted as a percent of active participants is calculated. It is noted that at the 24 month visit, staff did not attempt collection in some homes, either because the participant had moved and thus were in a different home than the seasonally matched 12-month TRUE sample (Recalling that all homes were in SHAM at 24 months), or because they missed their 12 month visit (N=7), or they had valid pre-intervention samples that could be used for the 24 month values for analysis purposes (16). Recall that fewer outdoor samples could be collected because there was not always a location for the sampler or a power supply. It is also noted that in December 2014, there were

insufficient O-rings to operate all samplers, because a replacement O-ring had not yet been identified to enable all samplers to be utilized. Thus we had to forgo collecting some outdoor samples (12 samples).

Table 3.6.2 PM Data Collection

Type of Sample	Number Attempted
Primary Indoor PEM CI Pairs Samples [1]	699
Primary Outdoor PEM CI Pairs Samples [1]	590
Duplicate Samples	49
CI Blank	126
PEM Blank	133

[1] One miscellaneous visit was conducted at 15 months because the participant was moving and it was desired to collect a sample at their original house to compare to previously collected samples. This sample is not included.

Table 3.6.3 Visits Completed and Air Sampling Attempted by Visit Number

Visit Number	Active households	Number of Visits	Indoor samples attempted	Outdoor Samples attempted
	#	# (% of active)	# (% of active)	# (% of active)
Pre	172	172 (100%)	165 (96%)	144 (84%)
6 month	160	158 (99%)	158 (99%)	126 (79%)
12 month	150	146 (97%)	142 (95%)	123 (82%)
18 month	139	138 (99%)	130 (94%)	110 (79%)
24 month	136	136 (100%)	104 (76%)	87 (64%)

The reasons staff did not attempt indoor air sampling at some visits are listed in Table 3.6.4. Apart from the samples intentionally not collected at 24 months, the most common reason for not collecting the data was that the participant had a "single visit", in other words staff only went to the home once, often because participants kept rescheduling and the visit was less than one week from the date staff moved operations to the other region. It is noted that following the discovery of the O-ring problem with samples collected in the first month of the study, December 2013, pre-intervention air samples were not collected but the project continued to enroll participants until the problem was solved (5 households).

Table 3.6.4 Reasons Indoor Air Sampling Not Attempted

Reason No PM Done	Number
Air Sampling at 24 months not attempted, good pre-intervention data available as a substitute	16
Air Sampling at 24 months not attempted, no 12 months or moved	7
Samples not collected in Jan 2014 due to O-ring contamination issue	5
Phone Call Visit	3
Single Visit, Unplanned	15
Visit Not Conducted	7
Other Reason [1]	5

[1] Other reasons air sampling was not done include no electricity in home at time of visit (1), participant said pump box gives her allergies (1 participant, 3 samples not attempted), home visit not scheduled due to a shooting at a nearby home on a previous visit (1).

Table 3.6.5 includes the number of valid samples by sample type and visit number. As the majority of the pre-intervention $PM_{0.2}$ and $PM_{2.5}$ samples collected with the PEM were not valid due to the O-ring problems, there is a low percent of valid samples for pre-intervention visits. The number of samples affected by O-rings is listed in Table 3.6.6.

Table 3.6.5 Number of Valid Samples by Sample Type and Visit Number

	Indoor				Outdoor			
Visit Number	**PEM $PM_{2.5}$**	**CI $PM_{0.2}$**	**CI $PM_{0.2-2.5}$**	**CI $PM_{2.5-10}$**	**PEM $PM_{2.5}$**	**CI $PM_{0.2}$**	**CI $PM_{0.2-2.5}$**	**CI $PM_{2.5-10}$**
	# (% of sample collection attempted) (% of active households)				# (% of sample collection attempted) (% of active households)			
Pre	35 (21%) (20%)	31 (19%) (18%)	158 (96%) (92%)	157 (95%) (91%)	25 (17%) (15%)	26 (18%) (15%)	133 (92%) (77%)	133 (92%) (77%)
6 month	123 (78%) (73%)	127 (80%) (76%)	154 (97%) (92%)	154 (97%) (92%)	96 (76%) (57%)	98 (78%) (58%)	121 (96%) (72%)	121 (96%) (72%)
12 month	140 (99%) (88%)	141 (99%) (88%)	141 (99%) (88%)	142 (100%) (89%)	117 (95%) (73%)	121 (97%) (74%)	119 (97%) (74%)	118 (96%) (74%)
18 month	123 (95%) (79%)	128 (98%) (83%)	128 (98%) (83%)	128 (98%) (83%)	104 (95%) (67%)	110 (96%) (68%)	106 (96%) (68%)	106 (96%) (68%)
24 month	103 (99%) (72%)	102 (98%) (71%)	102 (98%) (71%)	103 (99%) (72%)	78 (90%) (54%)	87 (97%) (58%)	84 (97%) (58%)	87 (97%) (58%)

Table 3.6.6 Primary Samples Collected with Bad O-rings

	Indoor # bad O-ring		Outdoor # bad O-ring	
Visit Number	**PEM $PM_{2.5}$**	**CI $PM_{0.2}$**	**PEM $PM_{2.5}$**	**CI $PM_{0.2}$**
Pre	128	132	117	116
6 month	28	27	25	23
12 month	0	0	0	0
18 month	0	0	0	0
24 month	0	0	0	0

The fraction of valid data can also be ascertained in Tables 3.6.7 and 3.6.8. These tables list the number of samples with valid data for all size fractions, along with the number of samples with partially valid data. Table 3.6.7 includes samples collected prior to 9/4/2014, the date after which black O-rings were no longer used and Table 3.6.8 includes samples collected after that date.

Table 3.6.7 Primary Samples Collected Prior to 9/4/2014[1]

	Indoor	Outdoor
Total Attempted	180	154
Total Collected [2]	180	154
All Size Fractions Good	14	7
Collected with 2 bad O-rings, both PUF values good	144	126
Collected with 2 bad O-rings, one or both PUF values missing	6	9
Collected with 1 bad O-ring, remaining filter and PUF values good	13	8
Collected with 1 bad O-ring, one or more remaining values missing	1	3
Other problem [3]	1	1

[1] This date was selected because it was the last date black O-rings were used in the study

[2] Includes bad O-rings

[3] Neither indoor nor outdoor sample volumes were calculated because samplers ran less than half the time

Table 3.6.8 Primary Samples Collected After 9/4/2014[1]

	Indoor	Outdoor
Total Attempted	520	437
Total Collected [2]	519	434
All Size Fractions Good	499	406
3 Good Filter/Pufs	14	16
2 Good Filter/Pufs	0	0
1 Good Filter/Pufs	0	3
0 Good Filter/Pufs	6	9

[1] No black O-rings were used after this date

[2] Number of collected primary samples includes data that is not valid

The reasons for invalid samples were determined and listed in Table 3.6.9. It is noted that in some cases samples are deliberately included in the table twice. For example, the sample may have been collected with a bad O-ring, but the sampling time may also have been less than half the nominal time, rendering the PUF samples invalid as well.

Table 3.6.9 Samples Not Valid and Not Used in Analysis

Sample not valid / not collected	Indoor	Outdoor
Sampling media not sent to laboratory [1]	5	8
Pump box low run time [2]	8	14
Bad CI O-ring	159	139
Bad PEM O-ring	156	142
Low CI off flow [3]	1	5
Low PEM off flow [4]	5	4
Hole in CI tubing	0	1
Hole in PEM tubing	0	8
Problem with filter or PUF [5]	3	2
Other problem [6]	9	4

[1] Sampling media not sent to laboratory – pump box flooded (2), problem with sampler (1), could not get the right on flow (1), PUF/filter lost (2), PUFs not sent in December 2013 due to concern of contamination (7 pairs of PUFs from CI sampler)

[2] Pump box ran half the nominal time (less than 5040 minutes)

[3] Does not include low off flow due to hole in CI tubing

[4] Does not include low off flow due to hole in PEM tubing

[5] Collected, but problem with filter or PUF - loaded incorrectly (4), filter damaged (1)

[6] Mass was negative and no switch was found (8), PEM $PM_{2.5}$/CI $PM_{2.5}$ greater than 2 (3), Mass value very high, determined to be an outlier (1), taken down after a day due to severe cockroach contamination in the home and a concern that cockroaches would enter pump box (1).

There were 58 instances where all the data were valid, but still flagged. Some of the reasons data were flagged but left valid were the pump timer not being accurate the watch time was used (12), switched duplicate and primary samples (6), sampling media switch occurred and was manually fixed in SAS (1), did not have on flow and utilized off flow value as on flow (1), CI on-flow above the intended range (5), PEM on-flow above the intended range (1), PEM off-flow above the intended range (2), potential filter problem identified by lab, such as filter separating from ring (3), a bit of PUF material remained in the dish (27).

Ozone Samples Collected

Ozone samples were collected for a limited time period during the late summer and early fall of 2014 and 2015. It was assumed that there would be a number of homes that had a sample collected in both the true and sham periods. Unfortunately, we did not consider the fact that a greater portion of homes were in true filtration in these time periods. A total of 112 indoor samples were collected, of which 106 resulted in valid concentrations. Likewise, a total of 103

outdoor samples were collected, of which 96 resulted in valid concentrations. In total, 94 homes had a valid indoor concentration, with 12 homes having two samples. Of these indoor samples, 67 samples were collected with true air cleaner filtration, 21 samples were collected with sham filtration, 9 samples were collected with true central filtration, and 9 samples were collected with sham central filtration. Overall, 91% of indoor samples had a corresponding outdoor sample.

Reflectance Samples Collected

Reflectance was measured before and after deploying a filter into the field. To measure data completeness, the data was merged with valid PEM concentrations and the fraction of those with both pre- and post- reflectance was determined. Of the 525 indoor $PM_{2.5}$ PEM concentrations, 505 (96%) have both pre- and post- reflectance (Table 3.6.10). Of the samples without both measures, sometimes the pre- value was inadvertently not determined (6 filters), sometimes the post- value was inadvertently not determined (32 filters). The outcome for reflectance is the indoor/outdoor ratio. For pre-intervention samples, there are 35 measures, for measurements taken with true filtration, there are 266 measures, and for measurements taken with sham filtration, there are 224 measures.

Table 3.6.10. Number of Samples that have a PEM Concentration and also have Pre and Post Reflectance

	Indoor	**Outdoor**	**Both Indoor and Outdoor**
No Pre Reflectance, Have Post Reflectance	4	2	6
Have Pre Reflectance, No Post Reflectance	16	16	32
Have Both Pre Reflectance and Post Reflectance	505	403	926

Evaluation of Blanks

Blanks were collected throughout the study. As previously discussed, blanks collected at the beginning of the study only remained in the sampler for 1 or 2 days, and thus were not representative of actual sampling conditions. The mass on the blanks is summarized in three tables.

- Table 3.6.11 – Blanks collected for samplers with Harvard or Viton O-rings.
- Table 3.6.12 – Blanks collected for samples with black O-rings that remained in the sampler for between 7 and 14 days.
- Table 3.6.13 – PUF Blanks collected for red O-rings, Atlantic O-rings, or black O-rings that remained in the sampler for over 14 days.

These three types of blanks are relevant to compare to actual sample values listed in the study. All resulted in acceptable results.

Please refer to report "Quality of Assurance Report: O-Ring Assessment" in Appendix E for discussion of blanks collected not representative of data used in the data analysis.

Table 3.6.11 Summary Statistics of Mass Change (mg) on Blank Samples Collected with Harvard and Viton O-rings (Excludes Red Atlantic O-rings and Black O-rings)

	N	Mean	Std Dev	Min	10^{th} Pctl	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	90^{th} Pctl	Max
CI Filter Mass	76	-0.002	0.006	-0.015	-0.009	-0.006	-0.001	0.002	0.004	0.025
CI $PM_{0.2-2.5}$ PUF Mass	76	-0.001	0.014	-0.103	-0.014	-0.003	0.002	0.005	0.008	0.014
CI $PM_{2.5-10}$ PUF Mass	75	0.002	0.016	-0.024	-0.012	-0.003	0.001	0.006	0.01	0.116
PEM Filter Mass	75	-0.003	0.005	-0.015	-0.01	-0.007	-0.002	0.001	0.002	0.012

Table 3.6.12 Summary Statistics of Mass Change (mg) on Blank Samples Collected with Black O-rings that Remained in the Sampler between 7 and 14 Days

	N	Mean	Std Dev	Min	10^{th} Pctl	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	90^{th} Pctl	Max
CI Filter Mass	22	0.023	0.032	0	0.001	0.004	0.012	0.029	0.067	0.135
CI $PM_{0.2-2.5}$ PUF Mass	19	0.004	0.015	-0.016	-0.013	-0.01	-0.002	0.018	0.025	0.033
CI $PM_{2.5-10}$ PUF Mass	19	0.005	0.013	-0.02	-0.009	-0.007	0.004	0.019	0.024	0.025
PEM Filter Mass	18	0.013	0.026	-0.006	-0.003	-0.001	0.004	0.011	0.075	0.08

Table 3.6.13 Summary Statistics of Mass Change (mg) on Blank PUF Collected with Red O-rings, Atlantic O-rings, or Black O-rings that Remained in the Sampler More than 14 Days

	N	Mean	Std Dev	Min	10^{th} Pctl	25^{th} Pctl	50^{th} Pctl	75^{th} Pctl	90^{th} Pctl	Max
CI $PM_{0.2-2.5}$ PUF Mass	20	-0.002	0.011	-0.024	-0.011	-0.009	-0.005	0.005	0.016	0.019
CI $PM_{2.5-10}$ PUF Mass	20	-0.005	0.01	-0.021	-0.013	-0.012	-0.009	-0.001	0.014	0.02

Blank samples were also collected for ozone and the values for the mass of NO_3, the reaction product measured to calculate ozone concentrations, are presented in Table 3.6.14.

Table 3.6.14 Summary Statistics of Mass of NO_3 (µg) on Blank Ozone Filters

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
NO_3 mass (µg)	16	0.714	0.344	0.252	0.317	0.529	0.687	0.851	0.98	1.72

Blank measures were taken for reflectance and values for the estimated mass of elemental carbon are presented in Table 3.6.15. There are fewer blank measurements for reflectance than for PEM samples. If there were not enough pre-reflected filters when loading samplers, the preference was to use pre-reflected filters for actual samples and use one without pre-reflectance for the blank PEM sample.

Table 3.6.15 Summary Statistics for Reflectance on Blank PEM Filters

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Elemental Carbon (µg)	98	-0.06	0.32	-0.74	-0.44	-0.28	-0.10	0.07	0.45	0.84

Evaluation of Duplicates

Duplicate samples were collected 49 times (includes both indoor and outdoor duplicates). Unfortunately, data could not be used for all sample pairs. Specifically, for 7 PEM samples and 8 $PM_{0.2}$ samples, the concentrations were not calculated because of the O-ring used or time the black O-ring was in the sampler. The concentrations of particles collected on PUF substrates (PUF concentrations) were calculated in these cases. There were additional sample pairs for which one or more type of concentration could not be compared. Specifically, both samples in a pump box were filled with water after a severe rainstorm (1), pump box ran less than half the time (3), PEM flow below target range (1) and a hole in PEM tubing (2). Summary statistics are presented in Table 3.6.16. The percent difference was calculated between the two concentrations. The mean and 75th percentile values were both less than 10% for all sample types except the $PM_{0.2}$ concentration. The 90th percentile all differed by less than 20%. There was one sample pair with very poor precision.

Table 3.6.16 Duplicate Percent Difference Percentiles

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	50th Pctl	75th Pctl	90th Pctl	Max
$PM_{2.5}$ conc.	31	9.1%	15.2%	0.2%	1%	2.3%	4.3%	8.2%	13.2%	75%
$PM_{0.2}$ conc.	35	12.7%	16.4%	1.3%	2.8%	4.6%	8.4%	14.6%	17.7%	87.3%
CI $PM_{0.2\text{-}2.5}$ conc.	42	5.9%	9.1%	0.0%	0.5%	1.7%	3.6%	6%	11.9%	56.5%
CI $PM_{2.5\text{-}10}$ conc.	42	9.2%	18%	0.2%	1.3%	2.9%	6.1%	8.9%	14.1%	119%

Duplicate ozone samples were collected if the house had an ozone sample and PM was calculated in duplicate, resulting in only 10 duplicate samples. Of these, 4 were outdoor samples and had relative percent differences of blank corrected values of 0.6%, 2.7%, 3%, and 9.4%. The indoor concentrations were often near or below the limit of detection. The percent differences were 0.0%, 2.9%, 3.7%, 10.6%, 22.3%, and 406%. For the sample pairs with 10.6% and 22.3% differences, the actual blank corrected ozone concentration was less than 0.2 ppb. For the sample pair with 406% difference, the actual concentration difference was less than 1.5 ppb.

Duplicate reflectance values were collected during the study. The summary statistics for the percent differences are presented in Table 3.6.17. Some of the reflectance duplicates have high percent differences. Most of these are associated with samples with very low predicted elemental carbon. Specifically, the highest three percent differences are associated with a mass of less than 1μg EC.

Table 3.6.17 Reflectance Duplicate Percent Difference Percentiles

Percentiles	**N**	**Mean**	**Std Dev**	**Min**	**10^{th} Pctl**	**25^{th} Pctl**	**Median**	**75^{th} Pctl**	**90^{th} Pctl**	**Max**
Conc, only if have $PM_{2.5}$	34	27%	0.177	0.30%	1.0%	4.3%	9.3%	16%	45%	123%

3.6.2 Summary Statistics for Indoor and Outdoor PM

The distribution of indoor concentrations was lowest for samples taken with true filtration, as seen in Table 3.6.18, which presents summary statistics for indoor $PM_{0.2}$, $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ as measured by the cascade impactor, as well as summed $PM_{2.5}$ and PM_{10} values, and $PM_{2.5}$ as measured by the PEM, for both the pre-intervention, as well as for the true and sham periods. The mean values reported in the summary statistics tables are all arithmetic values. Histograms of the distribution of $PM_{0.2}$, $PM_{2.5}$ and PM_{10} at pre-intervention, during true, and during sham can also be seen in Figures 3.6.1, 3.6.2, and 3.6.3 respectively. These tables and figures also indicate that the distributions of pre-intervention indoor PM concentrations were higher than concentrations measured in the sham period.

Table 3.6.18 Indoor PM Concentration Summary Statistics with Concentrations in µg/m^3

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ – PRE	35	13.8	11.8	2.6	3.9	7.0	10.1	17.2	28.9	57.1
$PM_{2.5}$ – SHAM	224	8.3	6.9	1.8	3.2	4.4	6.3	9.8	14.9	62.5
$PM_{2.5}$ – TRUE	266	4.6	4.5	0.2	1.4	2.2	3.6	5.6	8.1	47.9
$PM_{0.2}$ - PRE	31	4.3	2.7	0.9	1.3	2.0	3.6	5.7	8.6	10.6
$PM_{0.2}$ – SHAM	230	2.8	1.9	0.5	1.2	1.7	2.2	3.2	4.9	14.3
$PM_{0.2}$ – TRUE	269	1.6	1.6	0.2	0.5	0.8	1.2	1.8	2.9	16.9
PM_{10} - PRE	31	20.0	10.1	5.7	9.5	14.3	19.2	22.8	33.2	44.2
PM_{10} - SHAM	229	14.9	9.4	3.3	6.7	8.7	12.6	18.1	25.0	72.0
PM_{10} - TRUE	268	10.3	6.5	1.8	4.5	6.3	8.9	12.1	17.3	58.9
$PM_{0.2\text{-}2.5}$ PRE	158	8.7	6.1	1.5	3.5	4.4	7.3	10.3	15.5	35.9
$PM_{0.2\text{-}2.5}$ SHAM	239	6.8	5.6	1.2	2.6	3.7	5.3	8.2	12.7	55.4
$PM_{0.2\text{-}2.5}$ TRUE	287	4.1	3.3	0.5	1.5	2.3	3.3	4.8	7.1	31.9
$PM_{2.5\text{-}10}$ PRE	157	7.6	4.1	1.9	3.1	4.5	7.0	9.4	13.5	25.4
$PM_{2.5\text{-}10}$ SHAM	240	5.3	3.4	0.9	2.2	2.9	4.4	6.8	9.4	28.1
$PM_{2.5\text{-}10}$ TRUE	288	4.7	3.1	1.0	2.0	2.6	3.9	5.9	7.9	26.8
$PM_{2.5}$ – PRE	19	18.1	13.9	3.1	5.1	8.5	14.2	27.4	40.8	57.1
$PM_{2.5}$ – SHAM	140	8.8	8.1	1.8	2.9	4.3	6	11.2	17.4	62.5
$PM_{2.5}$ – TRUE	164	5.1	5.4	0.2	1.3	2.3	3.6	6	8.9	47.9
$PM_{0.2}$ - PRE	15	5.4	2.8	1.3	1.9	3.3	5	8.3	9.7	10.6
$PM_{0.2}$ – SHAM	143	2.9	2.1	0.7	1.1	1.7	2.2	3.7	5	14.3
$PM_{0.2}$ – TRUE	167	1.8	1.9	0.2	0.5	0.8	1.3	2.2	3.1	16.9
PM_{10} - PRE	15	25.1	11.1	11	14.6	18	19.6	33.2	43.6	44.2
PM_{10} - SHAM	143	15.6	10.5	3.3	6.7	8.4	13	19.4	26.9	72
PM_{10} - TRUE	166	11.1	7.3	1.8	4.4	6.7	9.4	14.1	18.2	58.9
$PM_{0.2\text{-}2.5}$ PRE	95	9.1	7.4	1.5	3.2	4.1	6.7	10.8	22.1	35.9
$PM_{0.2\text{-}2.5}$ SHAM	152	7.2	6.7	1.2	2.4	3.4	5.2	8.7	14.6	55.4
$PM_{0.2\text{-}2.5}$ TRUE	184	4.4	3.9	0.5	1.4	2.3	3.3	5.3	7.9	31.9
$PM_{2.5\text{-}10}$ PRE	95	7.8	4.4	1.9	3.2	4.5	6.9	10.1	13.8	25.4
$PM_{2.5\text{-}10}$ SHAM	152	5.4	3.2	1	2.2	2.9	4.4	7.2	9.9	19.4
$PM_{2.5\text{-}10}$ TRUE	185	4.9	3.2	1	2.1	2.9	4.1	6.2	8.8	26.8

Table 3.6.18, Cont.

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ – PRE	16	8.8	5.7	2.6	2.8	4.1	7.8	10.1	18.6	24
$PM_{2.5}$ – SHAM	84	7.5	4.2	2.3	3.5	4.5	6.6	8.5	12.5	26.3
$PM_{2.5}$ – TRUE	102	3.9	2.2	0.4	1.5	2.1	3.6	5	6.8	12.3
$PM_{0.2}$ - PRE	16	3.2	2.2	0.9	1.1	1.6	2.8	3.8	5.9	9.1
$PM_{0.2}$ – SHAM	87	2.5	1.6	0.5	1.2	1.6	2.2	2.9	4.2	9.6
$PM_{0.2}$ – TRUE	102	1.3	0.7	0.2	0.5	0.7	1.2	1.7	2	4.5
PM_{10} - PRE	16	15.2	6.3	5.7	7	9.9	15.3	19.8	25.6	25.9
PM_{10} - SHAM	86	13.6	6.9	4.5	7.2	8.7	12	16.5	21	45.8
PM_{10} - TRUE	102	8.9	4.7	2.2	4.7	5.9	8.1	10.7	13.7	36.6
$PM_{0.2\text{-}2.5}$ PRE	63	8.1	3.3	2.3	4.1	5.9	8.1	9.7	12.4	17.6
$PM_{0.2\text{-}2.5}$ SHAM	87	6.1	3	1.8	3	3.8	5.8	7.9	10.1	17.1
$PM_{0.2\text{-}2.5}$ TRUE	103	3.4	1.7	0.6	1.6	2.2	3.1	4.4	5.8	9
$PM_{2.5\text{-}10}$ PRE	62	7.4	3.6	2.1	2.9	4.8	7.3	9.2	12	19.7
$PM_{2.5\text{-}10}$ SHAM	88	5.1	3.7	0.9	2	2.9	4.5	5.9	8.8	28.1
$PM_{2.5\text{-}10}$ TRUE	103	4.2	2.9	1	1.9	2.5	3.6	5.3	6.6	24.1

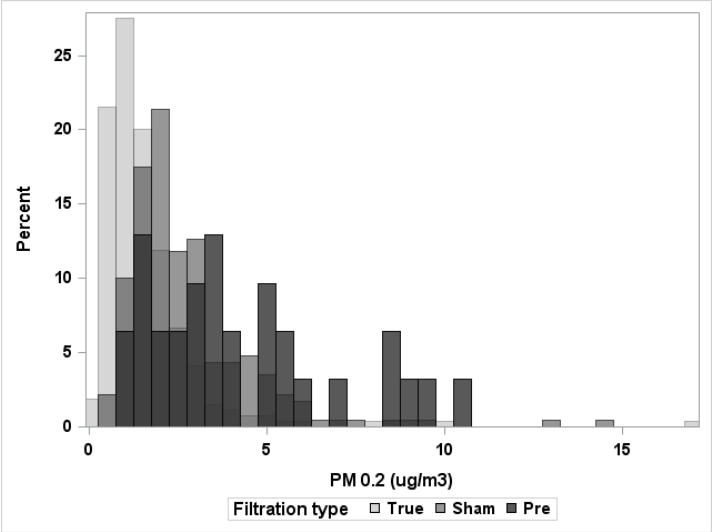


Figure 3.6.1: Distribution of $PM_{0.2}$ concentrations ($\mu g/m^3$) for pre-intervention, true and sham periods.

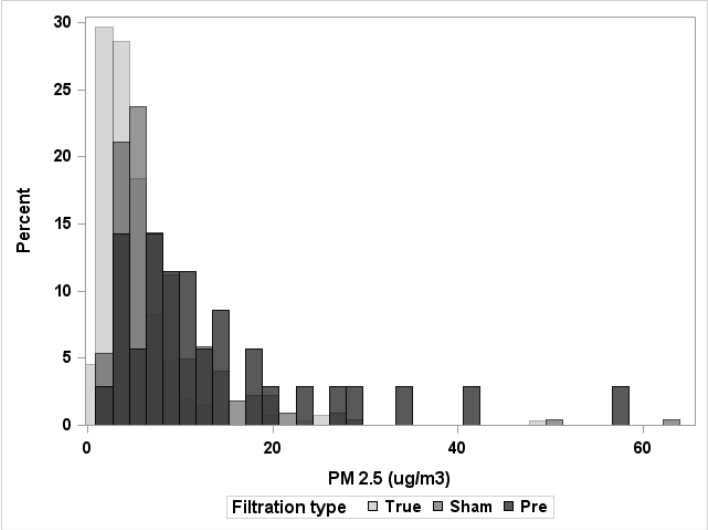


Figure 3.6.2: Distribution of $PM_{2.5}$ concentrations ($\mu g/m^3$) for pre-intervention, true and sham periods.

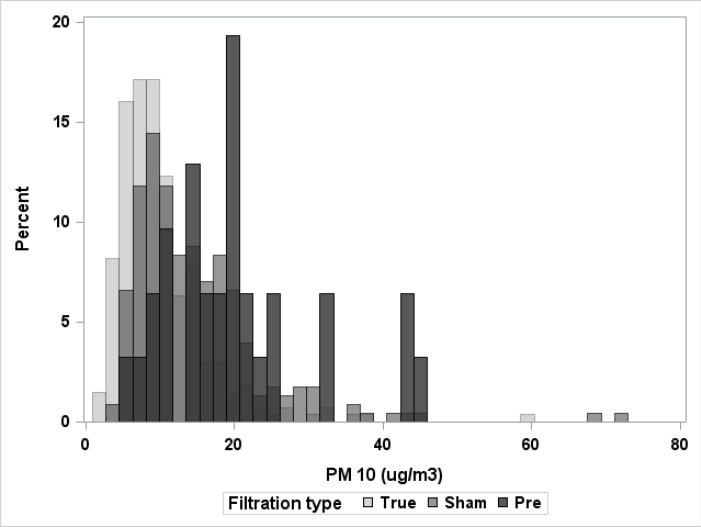


Figure 3.6.3: Distribution of PM_{10} concentrations ($\mu g/m^3$) for pre-intervention, true and sham periods.

An alternative way to evaluate indoor air quality is through the ratio of the indoor concentration to the outdoor concentration, as this measure accounts for differences in indoor concentrations due to infiltration of outdoor air. Table 3.6.19 presents the indoor/outdoor (I/O) ratios for the same size fractions and time periods. Histograms of the distribution of I/O $PM_{0.2}$, I/O $PM_{2.5}$ and I/O PM_{10} at pre-intervention, during true, and during sham can also be seen in Figures 3.6.4, 3.6.5, and 3.6.6, respectively. As with the indoor concentrations, the I/O rations are lowest when the home has true filtration. The data for $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ are the most complete and

representative for the pre-intervention measures, and for those size fractions we see that pre-intervention levels are higher than levels measured with sham filtration.

Table 3.6.19 Indoor/Outdoor Concentration Summary Statistics

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ - PRE	24	0.88	0.57	0.30	0.42	0.50	0.69	0.95	1.84	2.70
$PM_{2.5}$ - SHAM	169	0.85	0.63	0.17	0.35	0.50	0.72	0.95	1.47	4.44
$PM_{2.5}$ - TRUE	214	0.46	0.43	0.03	0.13	0.22	0.36	0.57	0.82	3.71
$PM_{0.2}$ - PRE	21	0.90	0.49	0.33	0.37	0.58	0.79	1.10	1.56	2.33
$PM_{0.2}$ - SHAM	180	0.92	0.63	0.12	0.30	0.53	0.77	1.07	1.63	4.77
$PM_{0.2}$ - TRUE	220	0.49	0.42	0.05	0.16	0.23	0.38	0.62	0.93	3.21
PM_{10} - PRE	21	0.58	0.22	0.27	0.30	0.42	0.57	0.72	0.85	1.03
PM_{10} - SHAM	179	0.66	0.39	0.15	0.28	0.41	0.57	0.77	1.15	2.41
PM_{10} - TRUE	218	0.42	0.25	0.09	0.18	0.25	0.36	0.52	0.70	1.63
$PM_{0.2\text{-}2.5}$ PRE	131	0.91	0.55	0.26	0.45	0.59	0.78	1.07	1.29	4.39
$PM_{0.2\text{-}2.5}$ SHAM	189	0.72	0.49	0.17	0.31	0.43	0.60	0.83	1.23	3.55
$PM_{0.2\text{-}2.5}$ TRUE	235	0.42	0.31	0.05	0.16	0.23	0.36	0.51	0.71	2.61
$PM_{2.5\text{-}10}$ PRE	130	0.71	0.57	0.14	0.24	0.38	0.59	0.80	1.26	4.19
$PM_{2.5\text{-}10}$ SHAM	190	0.61	0.50	0.05	0.18	0.28	0.48	0.74	1.23	3.16
$PM_{2.5\text{-}10}$ TRUE	235	0.48	0.38	0.06	0.17	0.24	0.38	0.59	0.88	3.00
$PM_{2.5}$ - PRE	10	0.87	0.54	0.42	0.43	0.55	0.62	0.93	1.85	1.86
$PM_{2.5}$ - SHAM	108	0.81	0.59	0.17	0.29	0.48	0.69	0.91	1.47	4.33
$PM_{2.5}$ - TRUE	130	0.46	0.51	0.03	0.11	0.19	0.33	0.56	0.92	3.71
$PM_{0.2}$ - PRE	8	0.9	0.4	0.38	0.38	0.66	0.8	1.14	1.65	1.65
$PM_{0.2}$ - SHAM	113	0.94	0.69	0.12	0.3	0.47	0.76	1.13	1.88	4.77
$PM_{0.2}$ - TRUE	133	0.51	0.49	0.05	0.13	0.22	0.36	0.64	1.02	3.21
PM_{10} - PRE	8	0.61	0.19	0.36	0.36	0.44	0.6	0.75	0.92	0.92
PM_{10} - SHAM	113	0.69	0.45	0.15	0.25	0.39	0.58	0.83	1.27	2.41
PM_{10} - TRUE	132	0.43	0.27	0.09	0.17	0.25	0.36	0.52	0.75	1.63
$PM_{0.2\text{-}2.5}$ PRE	77	0.89	0.58	0.26	0.45	0.58	0.74	1	1.29	4.39
$PM_{0.2\text{-}2.5}$ SHAM	122	0.71	0.52	0.17	0.28	0.4	0.58	0.79	1.34	3.55
$PM_{0.2\text{-}2.5}$ TRUE	146	0.42	0.35	0.05	0.14	0.2	0.34	0.47	0.75	2.61
$PM_{2.5\text{-}10}$ PRE	76	0.81	0.68	0.17	0.27	0.38	0.64	0.9	1.58	4.19
$PM_{2.5\text{-}10}$ SHAM	122	0.69	0.58	0.05	0.18	0.27	0.49	0.87	1.42	3.16
$PM_{2.5\text{-}10}$ TRUE	147	0.53	0.43	0.06	0.18	0.27	0.41	0.62	1.06	3

Table 3.6.19, Cont.

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ - PRE	14	0.89	0.61	0.3	0.37	0.45	0.77	0.97	1.44	2.7
$PM_{2.5}$ - SHAM	61	0.93	0.71	0.17	0.39	0.55	0.75	0.96	1.46	4.44
$PM_{2.5}$ - TRUE	84	0.47	0.28	0.05	0.2	0.27	0.44	0.6	0.76	1.96
$PM_{0.2}$ - PRE	13	0.9	0.55	0.33	0.37	0.56	0.79	1.03	1.56	2.33
$PM_{0.2}$ - SHAM	67	0.87	0.52	0.15	0.36	0.57	0.78	1.01	1.41	3.14
$PM_{0.2}$ - TRUE	87	0.47	0.28	0.12	0.18	0.29	0.41	0.58	0.89	1.84
PM_{10} - PRE	13	0.56	0.24	0.27	0.27	0.4	0.54	0.72	0.85	1.03
PM_{10} - SHAM	66	0.6	0.27	0.16	0.32	0.44	0.53	0.72	0.87	1.72
PM_{10} - TRUE	86	0.41	0.21	0.11	0.2	0.26	0.36	0.52	0.69	1.26
$PM_{0.2\text{-}2.5}$ PRE	54	0.93	0.53	0.27	0.44	0.61	0.83	1.07	1.54	3.26
$PM_{0.2\text{-}2.5}$ SHAM	67	0.73	0.43	0.18	0.41	0.47	0.65	0.83	1.15	3.3
$PM_{0.2\text{-}2.5}$ TRUE	89	0.43	0.22	0.1	0.2	0.27	0.39	0.54	0.66	1.54
$PM_{2.5\text{-}10}$ PRE	54	0.58	0.32	0.14	0.2	0.29	0.54	0.68	1.08	1.52
$PM_{2.5\text{-}10}$ SHAM	68	0.46	0.23	0.1	0.18	0.29	0.45	0.56	0.75	1.29
$PM_{2.5\text{-}10}$ TRUE	88	0.41	0.25	0.08	0.14	0.22	0.34	0.56	0.73	1.24

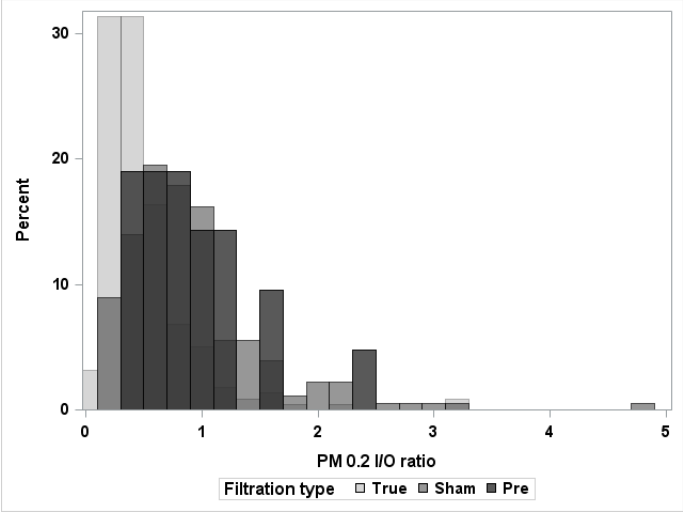


Figure 3.6.4: Distribution of $PM_{0.2}$ I/O ratios for pre-intervention, true and sham periods.

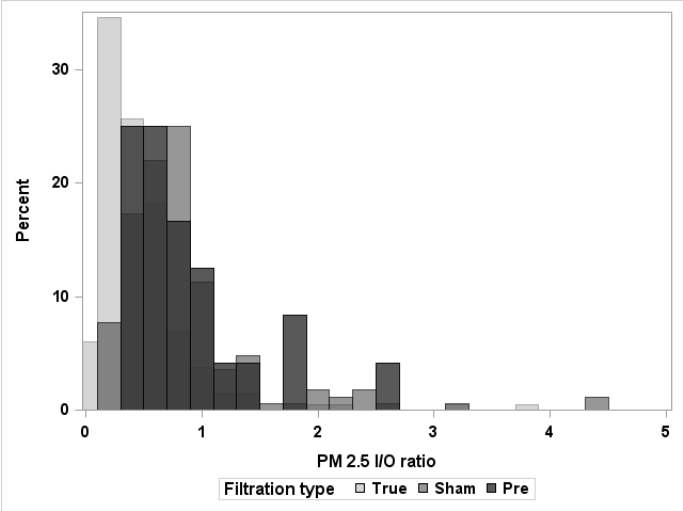


Figure 3.6.5: Distribution of $PM_{2.5}$ I/O ratios for pre-intervention, true and sham periods.

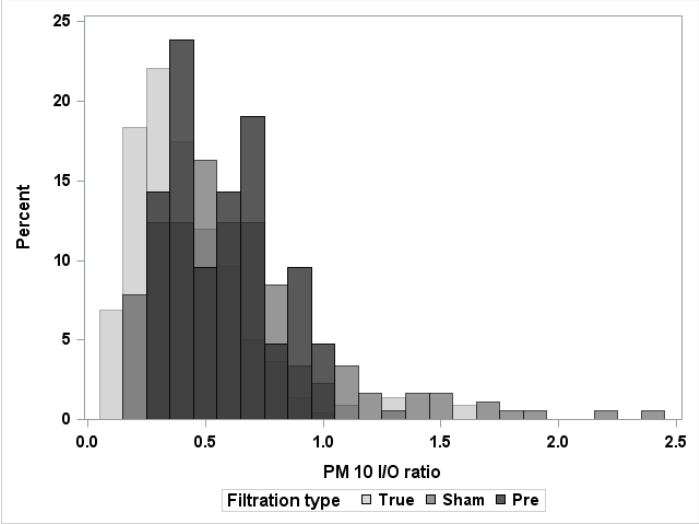


Figure 3.6.6: Distribution of PM_{10} I/O ratios for pre-intervention, true and sham periods.

Outdoor concentrations in both the Riverside and Fresno regions are presented in Tables 3.6.20 and 3.6.21. Outdoor concentrations were also plotted versus time for both the Riverside and Fresno regions for $PM_{0.2}$, $PM_{2.5}$, $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ in Figures 3.6.7-3.6.14. The components $PM_{0.2\text{-}2.5}$ and $PM_{2.5\text{-}10}$ were included since we have a richer dataset for these size fractions for the earlier time periods.

Table 3.6.20 Outdoor PM Concentration Summary Statistics Fresno, Concentrations in µg/m^3

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ – Pre-Intervention	11	19.2	16.8	7.3	8.0	9.0	10.3	23.1	50.2	53.0
$PM_{2.5}$ – During Study	245	12.8	10.5	1.9	5.3	7.0	9.3	14.5	22.3	65.9
$PM_{0.2}$ - Pre-Intervention	13	5.6	3.2	0.1	2.2	4.1	4.6	8.2	10.4	10.8
$PM_{0.2}$ – During Study	251	3.7	1.9	0.9	1.9	2.4	3.2	4.4	6.3	13.1
PM_{10} - Pre-Intervention	13	36.9	15.1	19.0	23.1	25.6	34.4	40.2	61.4	70.3
PM_{10} – During Study	251	26.5	12.9	9.6	13.3	17.2	23.5	33.7	42.3	84.4
$PM_{0.2\text{-}2.5}$ - Pre-Intervention	79	9.4	6.2	3.0	4.5	5.4	8.1	10.9	16.6	42.7
$PM_{0.25\text{-}2.5}$ – During Study	273	11.5	8.0	3.2	5.0	6.6	8.9	13.3	21.7	50.2
$PM_{2.5\text{-}10}$ - Pre-Intervention	78	11.5	6.0	1.7	3.8	6.5	10.9	15.9	19.6	29.7
$PM_{2.5\text{-}10}$ During Study	273	11.5	7.5	1.5	3.9	5.9	9.9	16.2	20.7	49.6

Table 3.6.21 Outdoor PM Concentration Summary Statistics Riverside, concentrations in µg/m^3

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
$PM_{2.5}$ - Pre-Intervention	14	9.0	1.5	6.5	7.5	7.9	8.6	11.0	11.1	11.4
$PM_{2.5}$ – During Study	151	8.8	2.5	3.8	5.8	7.1	8.4	10.5	12.6	14.4
$PM_{0.2}$ - Pre-Intervention	13	3.6	1.0	2.2	2.3	2.6	3.6	4.2	4.5	5.7
$PM_{0.2}$ – During Study	157	3.0	1.0	1.0	1.7	2.3	2.8	3.5	4.5	5.5
PM_{10} - Pre-Intervention	13	26.9	5.4	20.1	20.2	24.8	25.9	29.0	35.0	38.6
PM_{10} – During Study	156	23.2	6.8	10.6	15.5	18.4	22.2	27.4	33.0	48.0
$PM_{0.2\text{-}2.5}$ - Pre-Intervention	54	9.2	2.3	3.7	6.1	7.5	9.5	10.8	12.2	13.4
$PM_{0.25\text{-}2.5}$ – During Study	158	8.6	2.4	3.6	5.9	6.8	8.1	10.5	12.1	13.8
$PM_{2.5\text{-}10}$ - Pre-Intervention	55	13.6	3.5	5.4	9.4	11.4	13.8	15.4	16.1	23.3
$PM_{2.5\text{-}10}$ During Study	157	11.7	4.5	3.4	7.0	9.0	10.7	13.8	18.1	28.8

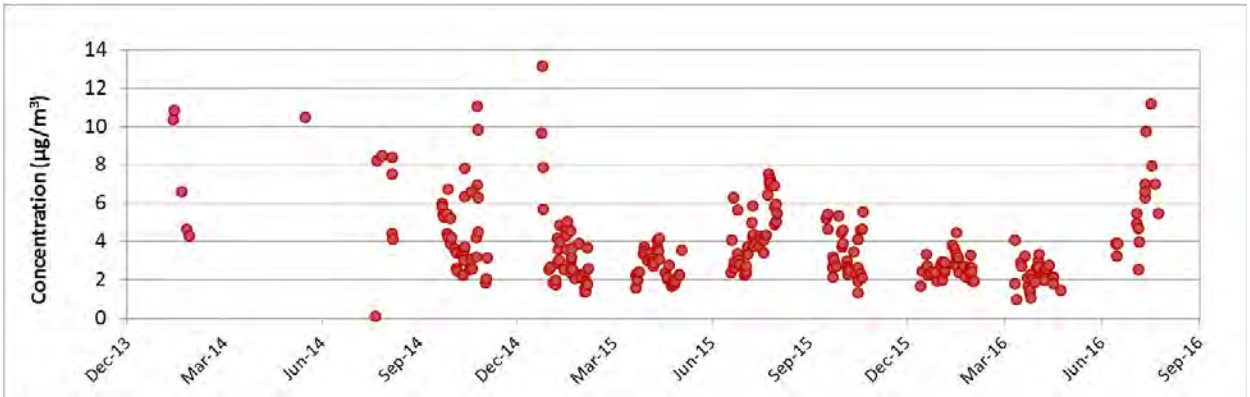


Figure 3.6.7 Distribution of $PM_{0.2}$ outdoor concentrations in Fresno plotted versus the first day of the sampling period.

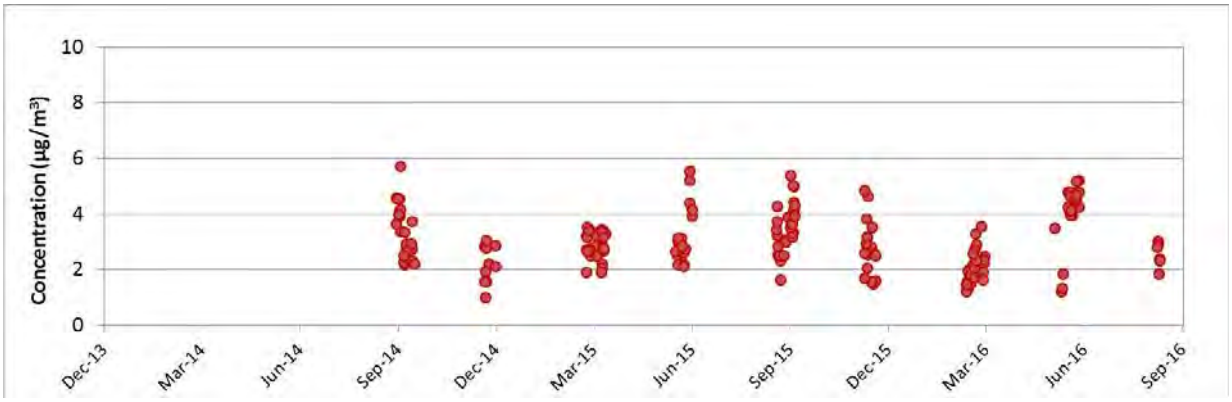


Figure 3.6.8 Distribution of $PM_{0.2}$ outdoor concentrations in Riverside plotted versus the first day of the sampling period.

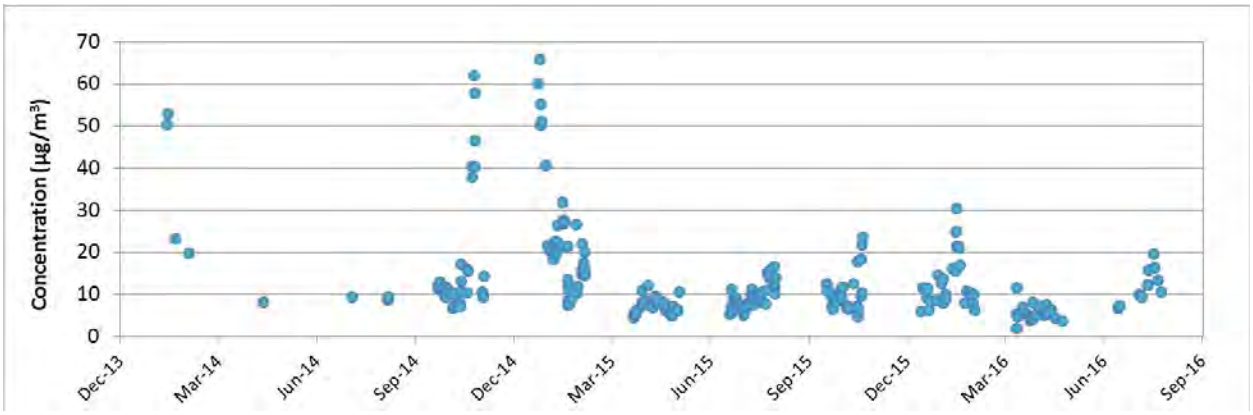


Figure 3.6.9 Distribution of $PM_{2.5}$ outdoor concentrations in Fresno plotted versus the first day of the sampling period.

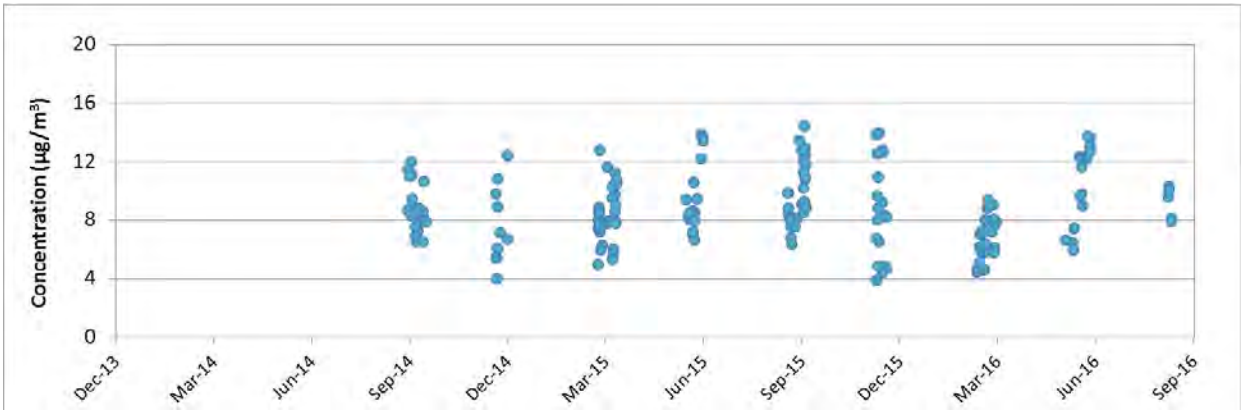


Figure 3.6.10 Distribution of $PM_{2.5}$ outdoor concentrations in Riverside plotted versus the first day of the sampling period.

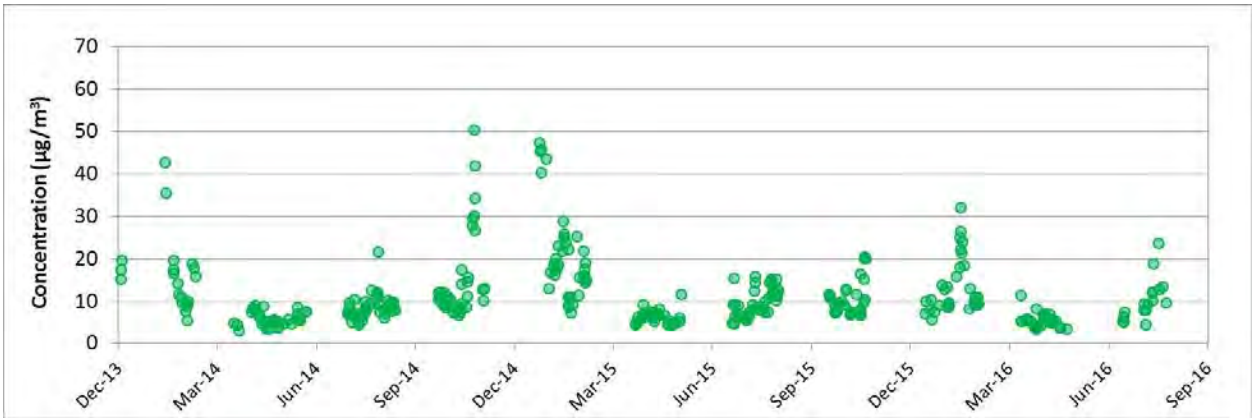


Figure 3.6.11 Distribution of $PM_{0.2\text{-}2.5}$ outdoor concentrations in Fresno plotted versus the first day of the sampling period.

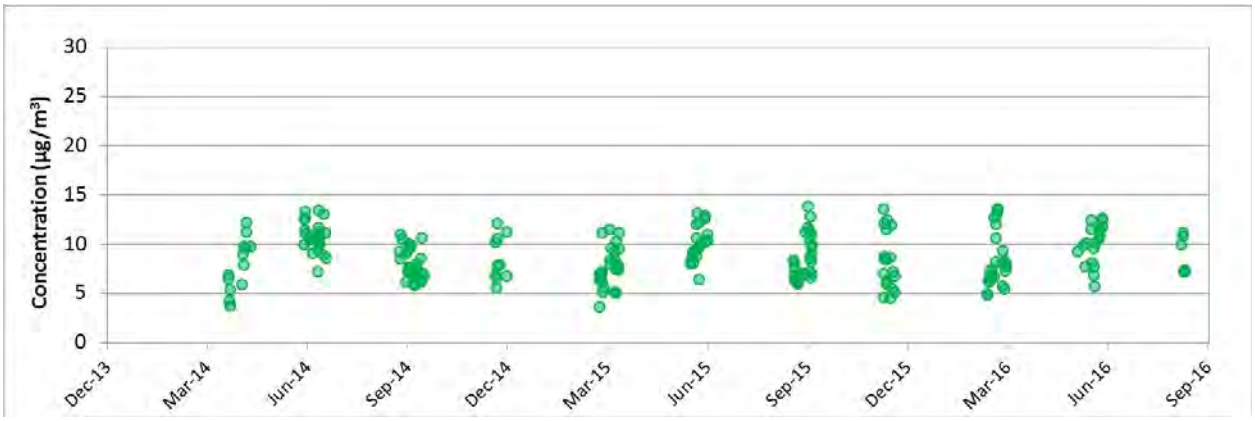


Figure 3.6.12 Distribution of $PM_{0.2\text{-}2.5}$ outdoor concentrations in Riverside plotted versus the first day of the sampling period.

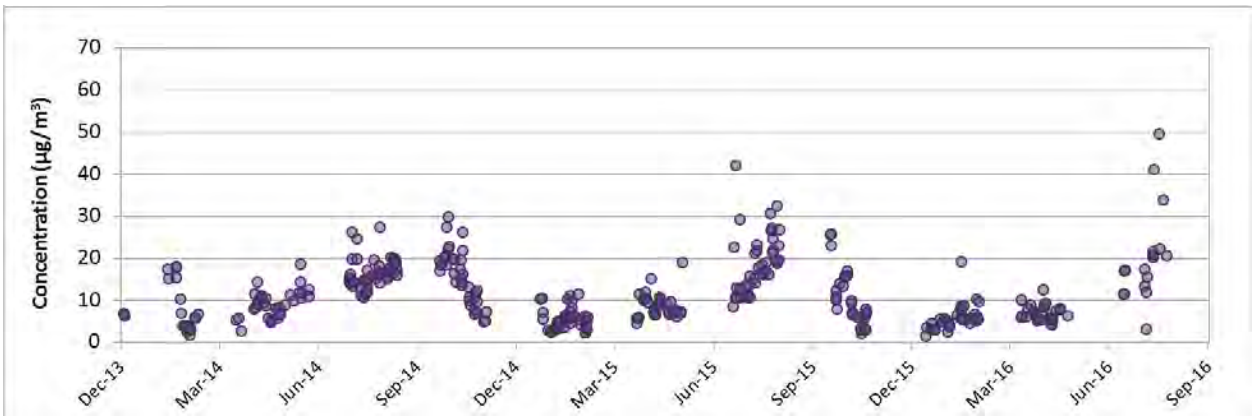


Figure 3.6.13 Distribution of $PM_{2.5-10}$ outdoor concentrations in Fresno plotted versus the first day of the sampling period.

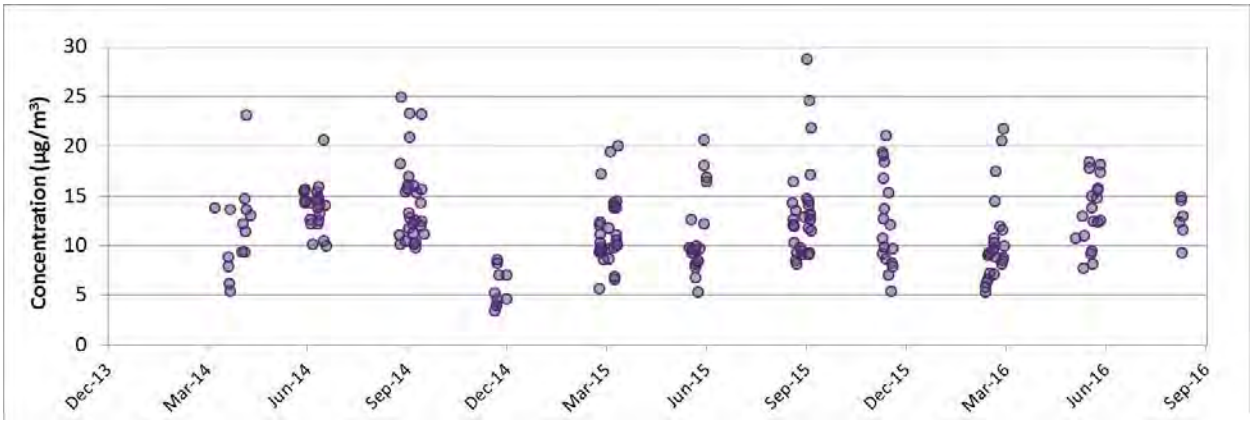


Figure 3.6.14 Distribution of $PM_{2.5-10}$ outdoor concentrations in Riverside plotted versus the first day of the sampling period.

The cumulative distributions for indoor concentrations of all size fractions measured in both the true and sham periods for homes with stand-alone filtration are shown in Figure 3.6.15, with the distributions for homes with central filtration in Figure 3.6.16. Visual inspection of these distributions indicate that there is a significant reduction in the indoor concentrations with air-cleaners for all size fractions. In particular, for a given size fraction, the "True" curve is to the left of the "Sham" curve, indicating that for any given percentile, PM concentrations measured with true filtration are lower than PM concentrations measured with sham filtration. For homes with central filtration, the reductions are not as great, with virtually no difference for the size fraction $PM_{2.5-10}$. Similar tables for the I/O ratios are presented in Figures 3.6.17 and 3.6.18.

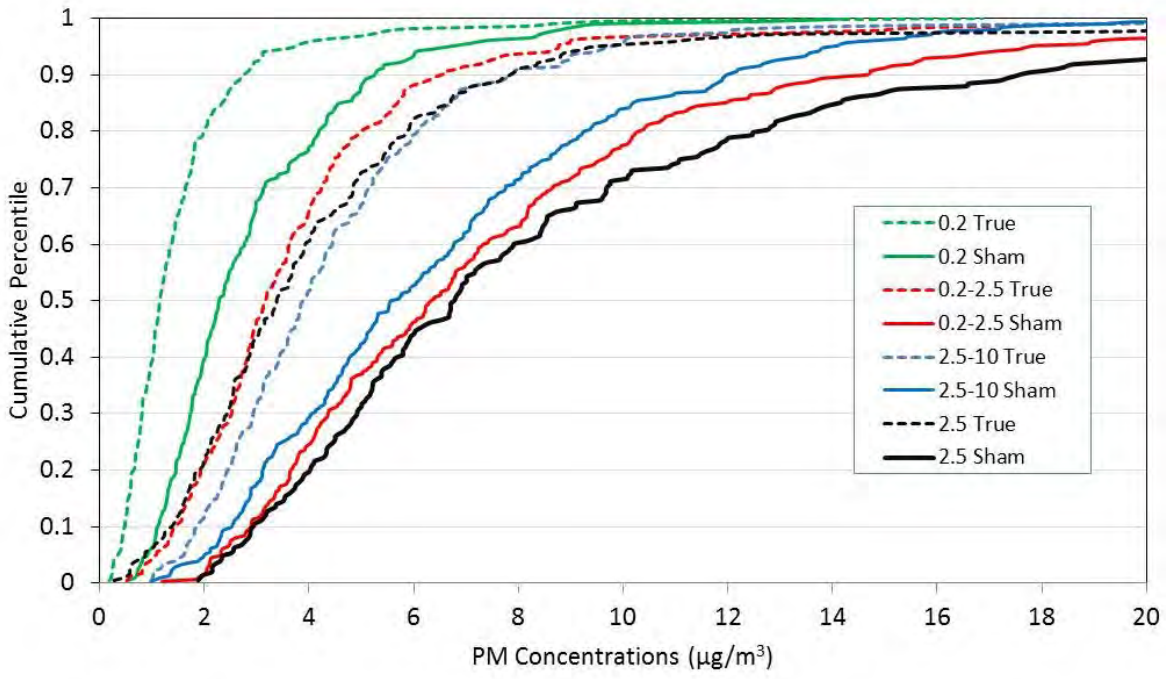


Figure 3.6.15 Distribution of indoor concentrations with and without air cleaners.

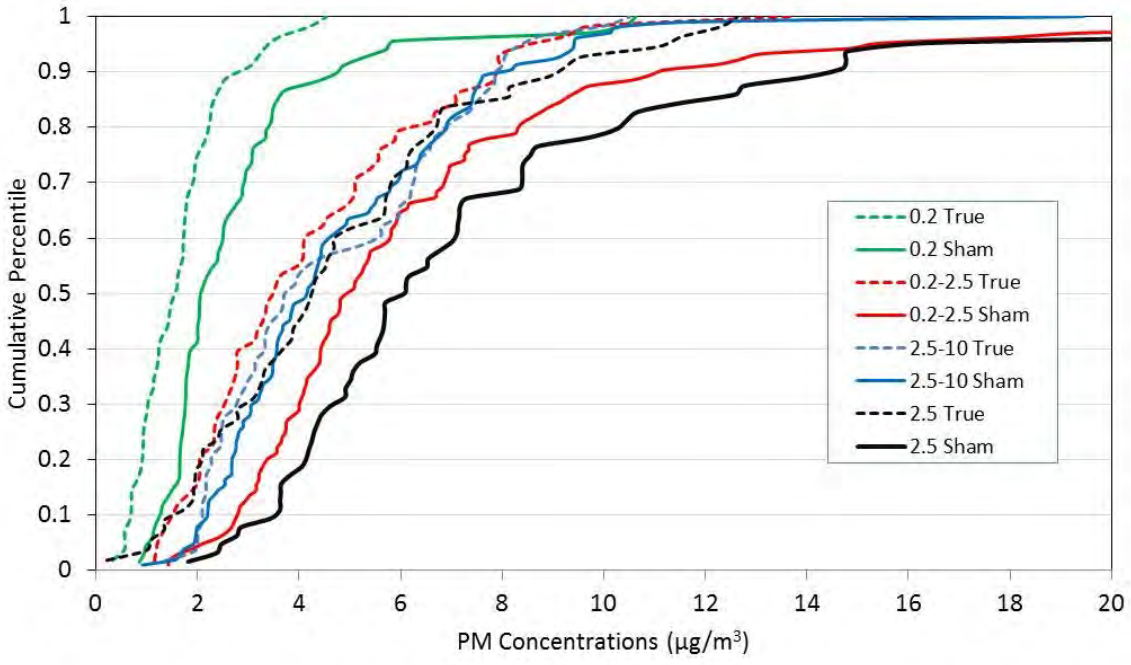


Figure 3.6.16 Distribution of indoor concentrations with and without central filtration.

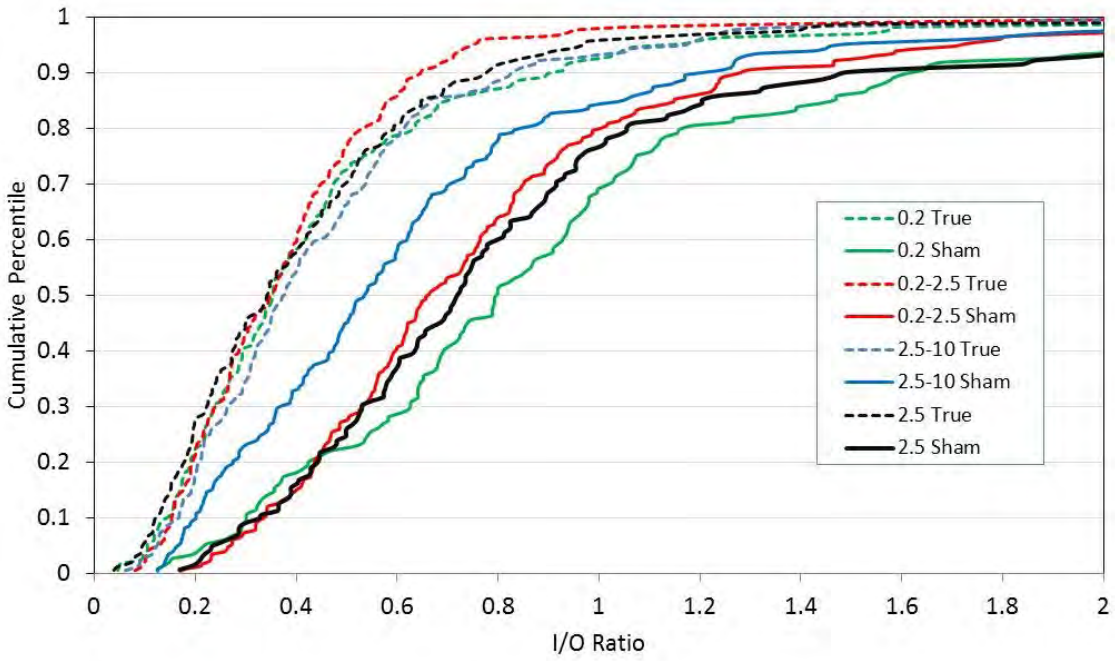


Figure 3.6.17 Distribution of I/O ratios with and without stand-alone filtration.

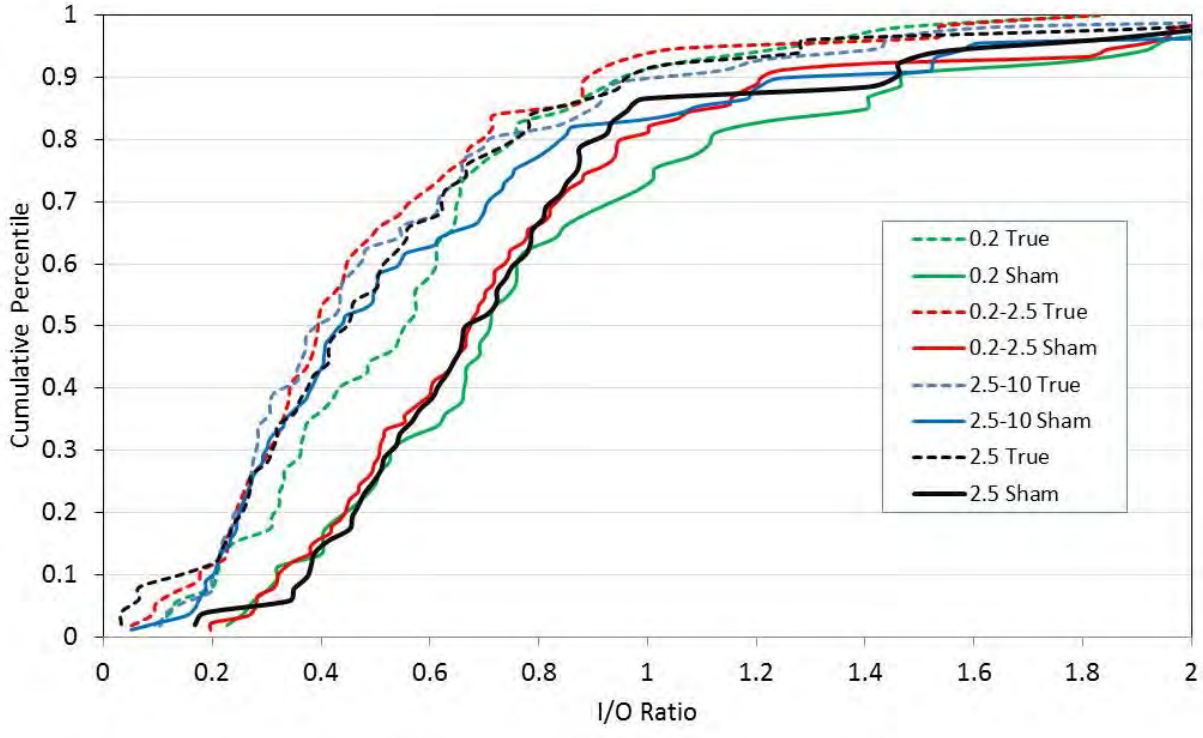


Figure 3.6.18 Distribution of I/O ratios with and without central filtration.

3.6.4 Summary Statistics for Indoor and Outdoor Reflectance

The vast majority of indoor/outdoor reflectance values were less than 1, as is to be expected. Approximately 6% of the initial indoor reflectance calculations yielded negative values (measurements with good indoor and outdoor PEM concentrations only). Negative indoor reflectance values were substituted with the smallest positive reflectance value of 0.0001 (6^{th} percentile was 0.000107). Reflectance is determined by measuring the amount of light reflected from the filter before and after it is used. If there is very little black carbon deposited on the filter, the pre- and post-readings are very similar. Since there is uncertainty in each reading, sometimes the post-reading is slightly lower than the pre-reading as a result of measurement error. All outdoor reflectance values were positive. Reflectance indoor/outdoor (I/O) ratios were recalculated using the corrected indoor reflectance values, and the corrected I/O ratios were used in the summary statistics and analyses.

The median I/O values were higher for samples collected during periods with sham filtration than samples collected during periods with true filtration. For homes with air cleaners, the median value of the I/O ratio was 0.43 and the 75^{th} percentile value was 0.71 and for homes with central filtration, the median value was 0.51 and the 75^{th} percentile value was 0.70, Table 3.6.22. The distribution of I/O ratios collected during periods with true filtration were lower, with a median value of 0.15 and 75^{th} percentile value of 0.35 in homes with air cleaners and a median value of 0.20 and 75^{th} percentile value of 0.46 in homes with central filtration.

Table 3.6.22 Summary Statistics for Reflectance Measurements, Indoor and Outdoor Concentrations are in units of μg EC/m^3

Filtration Status	Intervention Type	Conc. and I/O ratios	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Sham	**Air Cleaner**	**Indoor**	165	0.33	0.52	1E-04	0.04	0.1	0.18	0.41	0.67	5.35
		Outdoor	117	0.55	0.35	0.12	0.18	0.32	0.49	0.66	1.03	1.89
		I/O Ratio	117	0.64	1.03	0.0003	0.13	0.26	0.43	0.71	0.96	9.86
	Central Filtration	**Indoor**	55	0.37	0.53	1E-04	0.06	0.09	0.2	0.39	0.75	2.55
		Outdoor	48	0.45	0.3	0.08	0.12	0.18	0.44	0.58	0.88	1.43
		I/O Ratio	47	0.72	0.83	0.0008	0.13	0.3	0.51	0.7	1.41	4.15
True	**Air Cleaner**	**Indoor**	205	0.17	0.37	1E-04	1E-04	0.03	0.07	0.17	0.37	3.43
		Outdoor	161	0.58	0.32	0.07	0.23	0.34	0.5	0.79	1.03	1.7
		I/O Ratio	160	0.39	1.27	0.0001	0.0006	0.07	0.15	0.35	0.67	15.02
	Central Filtration	**Indoor**	54	0.19	0.35	1E-04	0.01	0.03	0.08	0.22	0.4	2.3
		Outdoor	48	0.48	0.35	0.09	0.13	0.25	0.36	0.59	1.15	1.5
		I/O Ratio	48	0.46	1.21	0.0004	0.0009	0.07	0.2	0.46	0.72	8.38
Pre	**Air Cleaner**	**Indoor**	24	0.5	0.41	0.1	0.15	0.16	0.38	0.75	1.14	1.64
		Outdoor	20	0.66	0.45	0.2	0.28	0.41	0.52	0.71	1.16	2.18
		I/O Ratio	17	0.95	1.27	0.25	0.26	0.38	0.62	0.72	2.19	5.57
	Central Filtration	**Indoor**	2	0.43	0.16	0.31	0.31	0.31	0.43	0.54	0.54	0.54
		Outdoor	3	0.55	0.1	0.47	0.47	0.47	0.52	0.66	0.66	0.66
		I/O Ratio	2	0.74	0.11	0.66	0.66	0.66	0.74	0.82	0.82	0.82

3.6.4 Summary Statistics for Indoor and Outdoor Ozone

Ozone concentrations were calculated by the laboratory, based on the number of days the sample was exposed, as provided by our study team to the laboratory. Concentrations were blank corrected by batch. This process resulted in a small number of negative values and extremely low concentrations. All negative values (N=12) and values below 0.1 ppb (N=3) were converted to be equal to 0.1 ppb. All of these low values were from samples collected indoors.

Overall, indoor ozone concentrations were relatively low, as were indoor/outdoor (I/O) ratios, Tables 3.6.23 and 3.6.24. The values were the highest for the air cleaners with sham filtration, with a median value of 4.0 ppb and a 75th percentile value of 8.9 ppb. The values for sham central filtration were slightly lower, with a median value of 1.0 ppb and a 75th percentile value of 1.5 ppb. With sham central filtration, the air was still circulating through a filter which likely caused the ozone to be eliminated. The distribution of concentrations measured during periods with true filtration and sham filtration was virtually the same for homes with central filtration, with a median value of 1.2 ppb and 75th percentile value of 1.4 ppb. There was not expected to be a difference between true and sham filtration with a central system because both provided

flow through a filter, as neither the true or sham filter included a carbon filter media. The concentrations during true filtration in homes with stand-alone air cleaners that did include a specific VOC and ozone filter resulted in lower concentrations than those measured during periods of sham filtration. The median concentration was 0.98 ppb, with a 75th percentile value of 4.4 ppb. It is noted that the 75th percentile value was actually higher than in homes with central filtration. Similar trends were reflected in the indoor/outdoor distributions. Due to the small sample size and lack of matching homes, it is difficult to make robust conclusions from this data.

Table 3.6.23. Summary Statistics for Primary Blank Corrected Ozone Concentrations

Filtration Status	Intervention Type	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Indoor											
Sham	Air Cleaner	21	5.1	5.3	0.1	0.5	0.8	4.0	8.9	12	19.4
	Central Filtration	9	1.3	1.7	0.1	0.1	0.3	1.0	1.5	5.7	5.7
True	Air Cleaner	67	3.3	4.5	0.1	0.1	0.3	1.0	4.4	9.8	17.9
	Central Filtration	9	1.9	2.3	0.2	0.2	0.8	1.2	1.4	7.7	7.7
Outdoor											
Sham	Air Cleaner	19	30.2	6.7	19.5	21.4	25.2	28.7	37.3	40.9	41.9
	Central Filtration	9	31.4	7.6	19.2	19.2	25.4	33.3	36.5	43.3	43.3
True	Air Cleaner	60	36.0	8.3	15.6	24.3	31.2	36.3	41.6	44.9	54.6
	Central Filtration	8	37.2	6.7	26.1	26.1	31.9	39.0	42.6	44.6	44.6

Table 3.6.24. Summary Statistics for Primary Indoor/Outdoor Blank Corrected Ozone Concentration Ratios

Filtration Status	Intervention Type	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Sham	Air Cleaner	19	0.16	0.20	0.003	0.008	0.02	0.06	0.28	0.42	0.74
	Central Filtration	9	0.05	0.06	0.003	0.003	0.01	0.03	0.06	0.19	0.19
True	Air Cleaner	60	0.11	0.16	0.002	0.003	0.008	0.03	0.15	0.37	0.57
	Central Filtration	8	0.07	0.09	0.02	0.02	0.03	0.03	0.05	0.30	0.30

3.6.6 Summary Statistics for Indoor Air Quality Questions on Symptom Diary and Recall Questionnaire

Table 3.6.25 shows the number of participants that completed the symptom diaries during the sampling air-week throughout the study. Information is only included for the sampling week

because these variables are used as covariates for the indoor air quality. The reasons that the symptom diaries were not completed are listed in Table 3.6.26.

Table 3.6.25 Symptom Diary Data Completeness Chart

Visit Number [1]	Active Households	Number of Air Sampling Visits	Have Symptom Diary Data
Pre	172	165	158
6 month	160	158	152
12 month	150	142	138
18 month	139	130	127
24 month	136	104	100

[1] One miscellaneous visit was done at 15 months because the participant was moving and we wanted to collect a sample at their original house to compare to previously collected samples. The symptom diary was completed 2 weeks earlier and thus is not included in the data.

Table 3.6.26 Missing Symptom Diary Data

Missing Symptom Diary Data Reasons	Number
SD lost	11
Participant dropped out at TD so SD not collected	4
Back side of SD wasn't filled out	4
SD wasn't collected	2
TD wasn't completed	1
SD not filled out	1
Air sampling done at 15 months as a miscellaneous visit, symptom diary completed 2 weeks earlier	1

The summary statistics for the indoor air quality questions on the symptom diaries are shown in Table 3.6.27. For each diary, the number of days an action occurred was summed. Data is presented for all sampling weeks, with the exception of the created variable summing all burning sources, which is broken into the sampling weeks in the pre-intervention period and the sampling weeks during the study so the behavior between the two periods can be compared. The summary statistics for the number of days any windows in the home were open for more than 2 hours during the sampling week at pre-intervention are shown in Table 3.6.28 and for the sampling weeks during study in Table 3.6.29. Windows were open slightly more often during the pre-intervention period than during the study itself. Households were marked as having windows generally open if windows were 6-7 days open during sampling week in all but one symptom diary or 6-7 days open in all symptom diaries but those completed in winter (December – February). Households were marked as having windows generally closed if windows were open 0-1 day during sampling week in all but one symptom diary. All other households with 3 or more completed symptom diaries were marked as having mixed window usage. Figure 3.6.19 shows percentage of households that generally keep the windows open, closed or mixed window activity during sampling week in households with 3 or more completed diaries.

Table 3.6.27 Symptom Diary Summary Statistics (Number of Days during a Sampling Week)

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Bedroom door kept open	674	4.1	3.3	0	0	0	6.5	7	7	7
Anyone smoke in the home	675	0.1	0.5	0	0	0	0	0	0	7
Frying or sautéing on a stove	674	2.1	2.1	0	0	0	2	3	5	7
Have a fire, use a wood burning stove, or burn candles or incense in the home	674	0.7	1.6	0	0	0	0	0	3	7
Sum of days anyone smoked, frying/ sautéing, have a fire or wood burning stove. – Pre-Intervention	157	3.0	2.8	0	0	1	2	5	7	14
Sum of days anyone smoked, frying/ sautéing, have a fire or wood burning stove. – During Study	516	2.8	2.9	0	0	0	2	4.5	7	17
Use cleaning products or spray air freshener in the home	675	2.4	2.6	0	0	0	1	4	7	7

Table 3.6.28 Any Windows in the Home Open for More than 2 Hours, Pre-Intervention (number of days per week)

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Winter (Dec-Feb)	27	2.3	2.7	0	0	0	1	4	7	7
Spring (March-May)	42	4.2	2.9	0	0	1	5	7	7	7
Summer (June-Aug)	60	3.5	2.9	0	0	0	3.5	7	7	7
Fall (Sep-Nov)	29	1.9	2.6	0	0	0	0	3	7	7

Table 3.6.29 Any Windows in the Home Open for More than 2 Hours, During Study (number of days per week)

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Winter (Dec-Feb)	138	2.1	2.9	0	0	0	0	5	7	7
Spring (March-May)	133	3.0	2.9	0	0	0	3	7	7	7
Summer (June-Aug)	132	2.7	3.0	0	0	0	1	7	7	7
Fall (Sep-Nov)	114	2.7	3.0	0	0	0	1	7	7	7

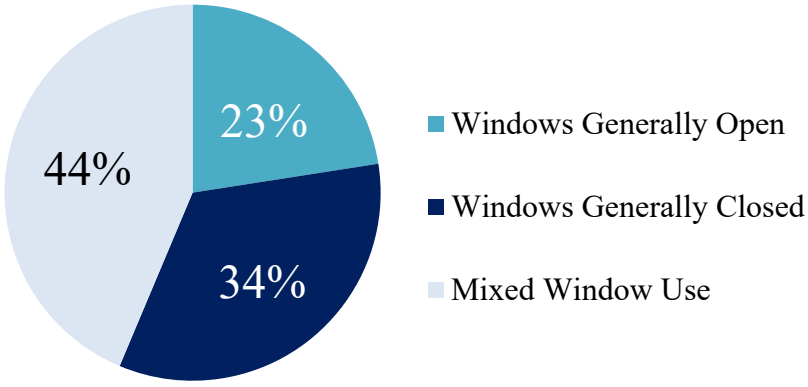


Figure 3.6.19 Window usage patterns in households with 3 or more completed diaries.

To determine if reports of mold, mildew, or water damage tended to occur repeatedly at a limited number of homes or if they were distributed across the homes, we determined the number of diaries reporting either of these conditions, both among all homes and limiting results only to homes with 6 or more diaries in Table 3.6.30. The majority of homes never or rarely had problems, while a smaller fraction of the population reported consistent problems. Another question was if participants had had any wood smoke in the neighborhood due to wood burning during the past 3 months. This was reported more frequently in winter, as seen in Table 3.6.31.

Table 3.6.30 Number of Recalls Indicating Mold, Mildew or Water Damage

Number of recalls indicating mold, mildew or water damage	All homes	Homes with 6 or more recalls
0	29%	26%
1	34%	33%
2	9%	10%
3	8%	7%
4	2%	3%
5	5%	6%
6	2%	3%
7	4%	5%
8	5%	6%
9	1%	1%

Table 3.6.31 Wood Smoke in the Neighborhood in the Last 3 Months

Month Recall was Completed	% of homes with "Yes" to wood smoke in the neighborhood
January	40%
February	45%
March	20%
April	28%
May	29%
June	22%
July	18%
August	22%
September	18%
October	23%
November	32%
December	35%

3.6.6 Evaluation of PM Concentration versus Predictors

Correlation coefficients were calculated between continuous candidate covariates and PM concentrations (for all size fractions) and are presented in Tables 3.6.32-3.6.34, with significant correlations in bold face type ($p<0.05$) and correlations with a p-value between 0.05 and 0.1 indicated in italic type. For concentrations measured in homes with true filtration with portable air cleaners, indoor concentrations were always significantly correlated with outdoor concentrations of the same size fraction, and oftentimes correlated with other size fractions as well. While the magnitude of the correlation coefficients for the size fractions under $PM_{2.5}$ were similar for central air homes the relationship was not always significant because of the smaller sample size. The magnitude of correlation coefficients for $PM_{2.5}$ and $PM_{0.2\text{-}2.5}$ were slightly higher for measurements taken during the SHAM period, as might be expected because without filtration, particles of outdoor origin are likely to be a significant contributor to indoor concentrations.

Table 3.6.32 Spearman Correlations between Both Indoor PM and I/O Ratios and Covariates Collected in Homes with Air Cleaners during True Filtration Periods (N Varies From 162 to 230, Depending on the Involved Variables)

	Outdoor PM 0.2 (μg/m^3)	**Outdoor PM 2.5 (μg/m^3)**	**Outdoor PM 0.2-2.5 (μg/m^3)**	**Outdoor PM 2.5-10 (μg/m^3)**	**Filtration Use Ratio[a]**	**Year Home was built**
PM 0.2 (μg/m^3)	**0.150**	**0.192**	**0.238**	0.025	**-0.177**	**-0.145**
PM 2.5 (μg/m^3)	*0.127*	**0.227**	**0.280**	0.000	**-0.199**	**-0.189**
PM 0.2-2.5 (μg/m^3)	0.104	**0.263**	**0.386**	-0.041	**-0.195**	**-0.274**
PM 2.5-10 (μg/m^3)	**0.207**	0.024	*0.121*	**0.293**	**-0.166**	**-0.326**
PM 0.2 I/O ratio	**-0.341**	*-0.128*	-0.010	**-0.220**	*-0.149*	-0.048
PM 2.5 I/O ratio	**-0.219**	**-0.327**	**-0.209**	0.004	*-0.149*	-0.100
PM 10 I/O ratio	**-0.372**	**-0.331**	**-0.211**	**-0.297**	**-0.226**	**-0.199**

[a] Proportion of filtered air volume or time normalized to the intended filtration air volume or time.

Table 3.6.33 Spearman Correlations between Indoor PM and I/O Ratios and Covariates Collected in Homes with Central Filtration during True Filtration Periods (N Varies From 47 to 58, Depending on the Involved Variables)

	Outdoor PM 0.2 (μg/m^3)	**Outdoor PM 2.5 (μg/m^3)**	**Outdoor PM 0.2-2.5 (μg/m^3)**	**Outdoor PM 2.5-10 (μg/m^3)**	**Filtration Usage Ratio**	**Year Home was built**
PM 0.2 (μg/m^3)	*0.251*	0.116	0.123	0.155	**-0.377**	-0.135
PM 2.5 (μg/m^3)	0.215	0.221	*0.234*	0.068	**-0.309**	-0.051
PM 0.2-2.5 (μg/m^3)	*0.235*	*0.233*	**0.294**	0.044	*-0.254*	-0.146
PM 2.5-10 (μg/m^3)	0.060	0.088	0.079	0.077	-0.204	-0.158
PM 0.2 I/O ratio	*-0.236*	-0.142	-0.126	-0.158	**-0.455**	-0.101
PM 2.5 I/O ratio	-0.092	*-0.266*	*-0.270*	0.081	**-0.528**	0.012
PM 10 I/O ratio	-0.209	-0.174	-0.159	-0.226	**-0.379**	-0.099

Table 3.6.34 Spearman Correlations Between Indoor PM and I/O Ratios and Covariates Collected in Homes During Sham Periods (N Varies From 164 To 239, Depending on the Involved Variables)

	Outdoor PM 0.2 (μg/m^3)	**Outdoor PM 2.5 (μg/m^3)**	**Outdoor PM 0.2-2.5 (μg/m^3)**	**Outdoor PM 2.5-10 (μg/m^3)**	**Filtration Usage Ratio**	**Year Home was built**
PM 0.2 (μg/m^3)	**0.201**	**0.354**	**0.398**	-0.048	**-0.179**	**-0.140**
PM 2.5 (μg/m^3)	**0.177**	**0.349**	**0.414**	-0.027	**-0.171**	*-0.129*
PM 0.2-2.5 (μg/m^3)	**0.207**	**0.363**	**0.442**	0.018	**-0.180**	**-0.168**
PM 2.5-10 (μg/m^3)	**0.213**	**0.151**	**0.154**	**0.257**	*-0.116*	**-0.332**
PM 0.2 I/O ratio	**-0.517**	-0.103	0.035	**-0.526**	**-0.228**	-0.027
PM 2.5 I/O ratio	**-0.297**	**-0.366**	**-0.256**	-0.117	**-0.177**	-0.142
PM 10 I/O ratio	**-0.369**	**-0.167**	-0.113	**-0.424**	**-0.195**	**-0.181**

For categorical variables, the least squares log geometric mean values of concentrations in periods of true filtration for both homes with air cleaners and central filtration, as well as in periods of sham filtration for each given category are presented in Table 3.6.35. If the mean value for a given category was significantly different ($p<0.05$) than the baseline category, the value of the mean is in bold text. For borderline significance ($0.05\leq p<0.1$), the mean value is in italics. Analyses were conducted on log transformed values. The baseline category is always the last one listed, indicated with an asterisk. Significant indoor concentration differences were seen for many size fractions between windows almost always open and rarely open for concentrations measured during periods of true filtration with air cleaners, but not for central air filtration. For concentrations measured during periods with sham filtration, there was a significant difference for $PM_{2.5-10}$, and a borderline significant difference for PM_{10}. The number of days on which indoor combustion occurred often resulted in significant differences between categories for concentrations measured during true filtration in homes with central air.

Table 3.6.35 Least Squares Log Geometric Mean Values [and Standard Errors] resulting from ANOVA analysis for each category. Mean values must be exponentiated to determine least squares mean adjusted geometric mean concentrations

	$PM_{0.2}$	$PM_{2.5}$	PM_{10}	$PM_{0.2-2.5}$	$PM_{2.5-10}$	$PM_{0.2}$ I/O	$PM_{2.5}$ I/O	PM_{10} I/O
Window Usage								
Air Cleaner True Filtration	p=0.04	p=0.06	p=0.004	p=0.02	p=0.0005	p=0.06	p=0.02	p=0.008
Windows almost always open	**0.35 [0.09]**	**1.41 [0.1]**	**2.36 [0.07]**	**1.36 [0.08]**	**1.6 [0.07]**	**-0.84 [0.1]**	**-0.86 [0.11]**	**-0.87 [0.08]**
Windows sometimes open	0.07 [0.11]	1.13 [0.12]	2.08 [0.08]	1.12 [0.09]	1.30 [0.08]	-1.07 [0.13]	-1.22 [0.13]	-1.15 [0.09]
*Windows rarely open	0.08 [0.07]	1.14 [0.07]	2.09 [0.05]	1.10 [0.06]	1.29 [0.05]	-1.16 [0.08]	-1.23 [0.08]	-1.15 [0.06]
HVAC True Filtration	p=0.5	p=0.9	p=0.9	p=0.9	p=0.9	p=0.5	p=0.5	p=0.7
Windows almost always open	0.50 [0.15]	1.43 [0.2]	2.24 [0.14]	1.25 [0.16]	1.36 [0.14]	-0.56 [0.17]	-0.65 [0.24]	-0.73 [0.16]
Windows sometimes open	0.38 [0.14]	1.38 [0.19]	2.24 [0.13]	1.24 [0.15]	1.43 [0.13]	-0.78 [0.16]	-0.92 [0.23]	-0.92 [0.16]
*Windows rarely open	0.28 [0.11]	1.32 [0.15]	2.25 [0.11]	1.33 [0.12]	1.43 [0.11]	-0.77 [0.13]	-1.02 [0.19]	-0.86 [0.13]
All Homes Sham Filtration	p=0.7	p=0.7	p=0.2	p=0.5	p=0.01	p=0.3	p=0.4	p=0.7
Windows almost always open	0.84 [0.07]	1.93 [0.08]	*2.64 [0.07]*	1.76 [0.08]	1.66 [0.07]	-0.35 [0.09]	-0.27 [0.09]	-0.58 [0.08]
Windows sometimes open	0.89 [0.08]	1.86 [0.09]	2.48 [0.08]	1.64 [0.09]	1.34 [0.09]	-0.16 [0.11]	-0.42 [0.1]	-0.54 [0.09]
*Windows rarely open	0.80 [0.05]	1.85 [0.05]	2.50 [0.05]	1.67 [0.05]	1.44 [0.05]	-0.34 [0.06]	-0.40 [0.06]	-0.62 [0.05]
Sum of Days Anyone Smoked, Fried/Sautéed, Burned Fire								
Air Cleaner True Filtration	p=0.3	p=0.2	p=0.3	p=0.3	p=0.6	p=0.04	p=0.2	p=0.09
Significant (5 days or more)	0.29 [0.1]	1.33 [0.11]	2.24 [0.08]	*1.3 [0.09]*	1.4 [0.08]	**-0.81 [0.12]**	-1.00 [0.12]	*-0.97 [0.09]*
Moderate (3-4 days)	0.19 [0.11]	1.32 [0.11]	2.23 [0.08]	1.18 [0.09]	1.43 [0.08]	-1.02 [0.11]	-1.03 [0.12]	*-0.99 [0.08]*
*Not Significant (2 days or less)	0.09 [0.07]	1.12 [0.07]	2.11 [0.05]	1.12 [0.06]	1.35 [0.05]	-1.17 [0.08]	-1.22 [0.08]	-1.16 [0.06]
HVAC True Filtration	p=0.06	p=0.3	p=0.02	p=0.02	p=0.04	p=0.4	p=0.3	p=0.2
Significant (5 days or more)	**0.55 [0.12]**	1.52 [0.16]	**2.42 [0.11]**	1.51 [0.13]	**1.54 [0.11]**	-0.61 [0.14]	-0.73 [0.2]	-0.73 [0.14]
Moderate (3-4 days)	0.49 [0.18]	1.52 [0.24]	**2.46 [0.16]**	*1.47 [0.19]*	**1.67 [0.17]**	-0.60 [0.21]	-0.68 [0.29]	-0.67 [0.2]
*Not Significant (2 days or less)	0.18 [0.1]	1.20 [0.14]	2.04 [0.1]	1.07 [0.11]	1.24 [0.09]	-0.84 [0.13]	-1.10 [0.18]	-1.00 [0.12]
All Homes Sham Filtration	p=0.2	p=0.3	p=0.3	p=0.2	p=0.6	p=0.2	p=0.8	p=0.5
Significant (5 days or more)	*0.94 [0.08]*	1.99 [0.08]	2.62 [0.07]	1.80 [0.08]	1.54 [0.08]	-0.15 [0.1]	-0.31 [0.09]	-0.50 [0.09]
Moderate (3-4 days)	0.81 [0.08]	1.86 [0.09]	2.49 [0.08]	1.66 [0.09]	1.43 [0.09]	-0.37 [0.1]	-0.36 [0.1]	-0.62 [0.09]
*Not Significant (2 days or less)	0.79 [0.05]	1.83 [0.05]	2.51 [0.05]	1.65 [0.05]	1.48 [0.05]	-0.34 [0.06]	-0.39 [0.06]	-0.62 [0.05]

Table 3.6.35, cont.

	$PM_{0.2}$	$PM_{2.5}$	PM_{10}	$PM_{0.2-2.5}$	$PM_{2.5-10}$	$PM_{0.2}$ I/O	$PM_{2.5}$ I/O	PM_{10} I/O
Distance to Roadway								
Air Cleaner True Filtration	p=0.3	p=0.2	p=0.08	p=0.09	p=0.2	p=0.7	p=0.6	p=0.8
<2 blocks (1 block = 360 ft)	0.22 [0.08]	*1.31 [0.09]*	**2.23 [0.06]**	**1.25 [0.07]**	1.42 [0.06]	-1.06 [0.1]	-1.12 [0.1]	-1.04 [0.07]
2-4 blocks	0.19 [0.09]	1.25 [0.1]	2.2 [0.07]	1.19 [0.08]	1.43 [0.07]	-0.96 [0.11]	-1.03 [0.11]	-1.06 [0.08]
*5+ blocks	0.06 [0.08]	1.09 [0.09]	2.05 [0.06]	1.04 [0.07]	1.28 [0.06]	-1.09 [0.09]	-1.17 [0.09]	-1.11 [0.07]
HVAC True Filtration	p=0.0005	p=0.006	p=<0.0001	p=<0.0001	p=0.001	p=0.06	p=0.07	p=0.02
<2 blocks (1 block = 360 ft)	**0.44 [0.14]**	1.39 [0.19]	**2.42 [0.12]**	**1.52 [0.13]**	**1.55 [0.13]**	-0.77 [0.17]	-1.03 [0.24]	-0.82 [0.16]
2-4 blocks	**0.72 [0.12]**	**1.78 [0.17]**	**2.59 [0.11]**	**1.62 [0.12]**	**1.69 [0.11]**	**-0.4 [0.15]**	**-0.44 [0.22]**	**-0.51 [0.14]**
*5+ blocks	0.08 [0.1]	1.07 [0.14]	1.92 [0.09]	0.92 [0.1]	1.14 [0.09]	-0.88 [0.12]	-1.09 [0.17]	-1.06 [0.11]
All Homes Sham Filtration	p=0.02	p=0.008	p=0.0007	p=0.002	p=0.006	p=0.5	p=0.07	p=0.04
<2 blocks (1 block = 360 ft)	**0.96 [0.06]**	**2.00 [0.07]**	**2.68 [0.06]**	**1.84 [0.06]**	**1.59 [0.06]**	-0.28 [0.09]	*-0.26 [0.08]*	**-0.44 [0.07]**
2-4 blocks	*0.88 [0.07]*	**1.98 [0.07]**	**2.60 [0.06]**	**1.78 [0.07]**	**1.54 [0.07]**	-0.22 [0.09]	**-0.26 [0.08]**	-0.57 [0.07]
*5+ blocks	0.72 [0.06]	1.73 [0.07]	2.38 [0.06]	1.53 [0.06]	1.32 [0.06]	-0.35 [0.07]	-0.47 [0.07]	-0.69 [0.06]
Age of Home								
Air Cleaner True Filtration	p=0.004	p=0.0005	p=<0.0001	p=<0.0001	p=<0.0001	p=0.2	p=0.05	p=0.02
Home Built 1977 or Later	**0.03 [0.07]**	**1.05 [0.07]**	**2.01 [0.05]**	**1.01 [0.05]**	**1.25 [0.05]**	-1.11 [0.07]	*-1.2 [0.07]*	**-1.15 [0.05]**
*Home Built Before 1977	0.32 [0.08]	1.43 [0.08]	2.35 [0.06]	1.38 [0.06]	1.54 [0.05]	-0.95 [0.09]	-0.97 [0.1]	-0.95 [0.07]
HVAC True Filtration	p=0.6	p=0.3	p=0.9	p=0.9	p=0.6	p=0.7	p=0.3	p=0.96
Home Built 1977 or Later	0.39 [0.09]	1.43 [0.12]	2.24 [0.08]	1.28 [0.09]	1.39 [0.08]	-0.69 [0.1]	-0.82 [0.14]	-0.84 [0.1]
*Home Built Before 1977	0.3 [0.14]	1.19 [0.19]	2.27 [0.14]	1.29 [0.15]	1.47 [0.13]	-0.77 [0.17]	-1.11 [0.24]	-0.85 [0.16]
All Homes Sham Filtration	p=0.1	p=0.1	p=0.006	p=0.1	p=0.001	p=0.8	p=0.3	p=0.4
Home Built 1977 or Later	0.79 [0.05]	1.83 [0.05]	**2.46 [0.04]**	1.64 [0.05]	**1.37 [0.05]**	-0.28 [0.06]	-0.37 [0.06]	-0.6 [0.05]
*Home Built Before 1977	0.91 [0.06]	1.96 [0.07]	2.65 [0.06]	1.77 [0.06]	1.63 [0.06]	-0.3 [0.08]	-0.28 [0.08]	-0.53 [0.07]
Air Conditioning								
Air Cleaner True Filtration	p=0.2	p=0.04	p=0.001	p=0.006	p=<0.0001	p=1	p=0.007	p=0.002
Swamp Cooler	0.43 [0.2]	*1.55 [0.21]*	**2.49 [0.15]**	**1.49 [0.16]**	**1.7 [0.13]**	-0.85 [0.21]	-1.05 [0.21]	-0.95 [0.15]
Neither Central Nor Swamp	0.27 [0.11]	*1.4 [0.12]*	**2.36 [0.08]**	**1.36 [0.1]**	**1.68 [0.08]**	-0.86 [0.13]	-0.75 [0.13]	-0.79 [0.09]
*Central AC	0.11 [0.06]	1.14 [0.06]	2.08 [0.04]	1.09 [0.05]	1.27 [0.04]	-1.11 [0.07]	-1.21 [0.07]	-1.16 [0.05]
All Homes Sham Filtration	p=0.2	p=0.2	p=0.007	p=0.03	p=<0.0001	p=0.09	p=0.03	p=0.003
Swamp Cooler	1 [0.15]	2.02 [0.17]	**2.82 [0.14]**	1.86 [0.17]	**1.97 [0.16]**	-0.2 [0.19]	-0.2 [0.18]	**-0.27 [0.16]**
Neither Central Nor Swamp	0.94 [0.08]	2.03 [0.09]	**2.69 [0.08]**	1.89 [0.09]	**1.71 [0.08]**	-0.1 [0.1]	-0.13 [0.1]	**-0.39 [0.09]**
*Central AC	0.81 [0.04]	1.85 [0.05]	**2.48 [0.04]**	1.65 [0.05]	**1.38 [0.04]**	-0.35 [0.05]	-0.42 [0.05]	**-0.66 [0.05]**

Table 3.6.35, cont.

	$PM_{0.2}$	$PM_{2.5}$	PM_{10}	$PM_{0.2-2.5}$	$PM_{2.5-10}$	$PM_{0.2}$ I/O	$PM_{2.5}$ I/O	PM_{10} I/O
Presence of a Gas Stove								
Air Cleaner True Filtration	p=0.6	p=1	p=0.1	p=0.5	p=0.1	p=0.07	p=0.05	p=0.9
Electric Stove	0.12 [0.09]	1.22 [0.1]	2.25 [0.07]	1.21 [0.08]	1.46 [0.07]	*-1.24 [0.12]*	**-1.33 [0.12]**	-1.09 [0.09]
Gas Stove	0.17 [0.06]	1.21 [0.06]	2.12 [0.04]	1.15 [0.05]	1.34 [0.04]	-0.99 [0.06]	-1.05 [0.07]	-1.07 [0.05]
HVAC True Filtration	p=0.9	p=0.8	p=0.4	p=0.4	p=0.5	p=0.7	p=0.5	p=0.5
Electric Stove	0.39 [0.16]	1.33 [0.21]	2.36 [0.15]	1.4 [0.16]	1.51 [0.14]	-0.65 [0.2]	-1.08 [0.29]	-0.73 [0.19]
*Gas Stove	0.36 [0.09]	1.38 [0.11]	2.21 [0.08]	1.25 [0.09]	1.38 [0.08]	-0.73 [0.1]	-0.85 [0.14]	-0.87 [0.09]
All Homes Sham Filtration	p=0.9	p=0.7	p=0.2	p=0.4	p=0.03	p=0.8	p=0.7	p=0.2
Electric Stove	0.85 [0.07]	1.92 [0.08]	2.62 [0.07]	1.77 [0.07]	1.61 [0.07]	-0.27 [0.09]	-0.31 [0.09]	-0.5 [0.08]
*Gas Stove	0.84 [0.04]	1.89 [0.05]	2.52 [0.04]	1.69 [0.05]	1.43 [0.04]	-0.3 [0.06]	-0.35 [0.05]	-0.61 [0.05]

Notes: Pairwise contrasts with the reflectance category indicated with an * were performed for each of the other categories with typeface used to represent statistical significance as follows:

$p < 0.05$, bold
$0.05 \leq p < 0.10$, italics
* reference category

p values in the first cell pertain to the F-test of the omnibus NULL Hypothesis that the log geometric mean values are the same in all three groups.

Indoor concentrations tended to be higher in homes 4 blocks or less as compared to more than 5 blocks of a roadway, although the homes closest to the roadway (<2 blocks) were not necessarily the group with the highest concentrations. Many of the differences were significant or borderline significant.

For measurements taken with true filtration in air cleaner homes, homes built in 1977 or later tended to have lower concentrations than older homes, with the differences being significant for all size fractions. For homes with central air systems, concentrations were similar between older and newer homes. For measurements taken with sham filtration, PM_{10} and $PM_{2.5-10}$ were significantly higher in older homes. For measurements taken during periods with true filtration in homes with air cleaners, both homes with swamp coolers and homes without central AC had higher particle concentrations than homes with central AC, with the difference typically being significant. Concentrations measured during periods of sham filtration typically were lower in homes with central air conditioning, although the differences often did not reach significance. Comparisons could not be made for homes with central filtration as all of those homes had central AC.

There were no statistically significant differences for indoor concentrations for presence of gas stoves, although the I/O ratios were moderately significant or significantly different for the smaller size fractions for measurements collected during periods with true filtration in homes with air cleaners.

3.6.7 Objective 1: Evaluation of Indoor PM Reductions

Objective 1 investigated the relationships between filtration type and indoor PM measurements ($PM_{0.2}$, $PM_{2.5}$, and PM_{10}) as well as indoor/outdoor PM and reflectance ratios. Indoor and outdoor PM measurements were sampled over the course of a week at study months 6, 12, 18, and 24. Pre-installation measurements were substituted in for missing measurements at study month 24 (during the sham filtration period). PM measurements had a log-normal distribution and so log-normal mixed effects models were used to model these data. All models specified the household ID as a random effect and included covariates city and season. In addition to the primary analysis or true versus sham conditions, an analysis was also completed to compare pre-intervention measurements with measurements collected in both true and sham periods.

All measured indoor PM concentrations (i.e., $PM_{0.2}$, $PM_{2.5}$, and PM_{10}) were significantly higher during sham compared with true filtration periods (all $p<0.0001$). The geometric means of $PM_{0.2}$ concentrations during sham and true filtration periods were 2.31 $\mu g/m^3$ [2.12, 2.50] and 1.20 $\mu g/m^3$ [1.09, 1.33], respectively (Table 3.6.36); mean $PM_{2.5}$ concentrations were 6.64 $\mu g/m^3$ [6.08, 7.25] during sham and 3.46 $\mu g/m^3$ [3.11, 3.84] during true filtration; and mean PM_{10} concentrations were 12.68 $\mu g/m^3$ [11.74, 13.69] and 8.74 $\mu g/m^3$ [8.09, 9.45]. The numbers in the brackets represent the corresponding 95% confidence intervals (CI).

The mean differences in log-transformed indoor PM concentrations were statistically significant between the sham period as compared to the true filtration period for all size fractions evaluated, $PM_{0.2}$ (adjusted mean sham versus true difference (β)=0.65 [95% CI: 0.55, 0.75], p<0.0001), $PM_{2.5}$ (β=0.65 [0.55, 0.75], p<0.0001), PM_{10} (β=0.37 [0.30, 0.44], p<0.0001), $PM_{0.2-2.5}$ (β=0.52 [0.44, 0.59], p<0.0001) and $PM_{2.5-10}$ (β=0.10 [0.03, 0.16], p=0.003) as shown in Table 3.6.37.

Having the intervention through the central system or an air cleaner significantly impacted the degree of improvement of the air for all size fractions (p<0.05), with greater improvements in indoor air quality in homes with air cleaners than through the central system. Indoor concentrations were higher during sham compared with true filtration for nearly all size fractions ($PM_{0.2}$, $PM_{2.5}$, PM_{10}, and $PM_{0.2-2.5}$) regardless if the home had filtration through air cleaners or through the central system (Tables 3.6.38 and 3.6.39). One exception was $PM_{2.5-10}$; in homes with air cleaners, $PM_{2.5-10}$ levels were significantly higher in sham than in true filtration, but in homes with central systems, $PM_{2.5-10}$ concentrations did not differ by filtration status.

Because the outcome variable was log-transformed, β can also be interpreted as the logarithm of the adjusted sham:true ratio of geometric means, and the inverse-logarithm of β, exp(β) is thus the sham:true ratio of geometric means. Alternatively, we can express the true:sham geometric mean ratio as exp(-β). We can express the proportional change in geometric mean concentrations due to using true filtration as exp(β) – 1, and the percentage change as 100*[exp(β) – 1]. Similarly, we can express these percentage changes as "reductions", using the formula -100*[exp(-β) – 1], presented in Table 3.6.40 and 3.6.41).

Looking at the values from the Table 3.6.40, it is clear that the differences are greater for the smaller size fractions with a 48% drop in concentration for $PM_{0.2}$ as compared to 31% drop in concentration for PM_{10} considering the compact size fractions, a 41% drop was observed for $PM_{0.2-2.5}$, while only a 10% drop was observed for $PM_{2.5-10}$. This trend is also observed considering only the homes with central system filtration or only the homes with air cleaners. The percent decreases were much greater for homes with air cleaners (see "Air Cleaner vs. Central differences in Sham vs True Differences" row in Table 3.6.39). For $PM_{0.2}$, there was a 34% decrease in the concentration with central filtration as compared to a 52% decrease with air cleaners (Table 3.6.40).

Table 3.6.36 Geometric Means (GM) of $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) by filtration type

	$PM_{0.2}$		$PM_{2.5}$		PM_{10}		$PM_{0.2-2.5}$		$PM_{2.5-10}$	
Filtration type	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**
Pre	3.46	2.73, 4.37	10.81	8.43, 13.88	17.70	14.90, 21.03	7.51	6.88, 8.21	6.50	5.96, 7.09
Sham	2.31	2.12, 2.50	6.64	6.08, 7.25	12.68	11.74, 13.69	5.54	5.12, 6.00	4.35	3.97, 4.75
True	1.20	1.09, 1.33	3.46	3.11, 3.84	8.74	8.09, 9.45	3.30	3.03, 3.60	3.95	3.64, 4.28

Table 3.6.37 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) for filtration type in the log-normal mixed-effects model

	$PM_{0.2}$			$PM_{2.5}$			PM_{10}			$PM_{0.2-2.5}$			$PM_{2.5-10}$		
Filtration type	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Pre vs. Sham	0.40	0.17, 0.64	0.001	0.49	0.23, 0.75	0.0003	0.33	0.16, 0.51	0.0002	0.30	0.21, 0.39	<.0001	0.40	0.33, 0.48	<.0001
Pre vs. True	1.05	0.81, 1.30	<.0001	1.14	0.88, 1.41	<.0001	0.71	0.52, 0.89	<.0001	0.82	0.72, 0.93	<.0001	0.50	0.42, 0.58	<.0001
Sham vs. True	0.65	0.55, 0.75	<.0001	0.65	0.55, 0.75	<.0001	0.37	0.30, 0.44	<.0001	0.52	0.44, 0.59	<.0001	0.10	0.03, 0.16	0.003

Table 3.6.38 Geometric Means (GM) of $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

		$PM_{0.2}$		$PM_{2.5}$		PM_{10}		$PM_{0.2-2.5}$		$PM_{2.5-10}$	
Filtration type	**Filtration system**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**
Sham	Air cleaner	2.42	2.18, 2.67	6.96	6.27, 7.73	13.34	12.18, 14.62	5.69	5.17, 6.25	4.48	4.04, 4.97
Sham	Central	2.14	1.90, 2.41	6.25	5.40, 7.24	11.35	9.81, 13.12	5.16	4.42, 6.02	3.96	3.32, 4.74
True	Air cleaner	1.17	1.04, 1.30	3.39	3.01, 3.82	8.62	7.90, 9.41	3.19	2.90, 3.51	3.86	3.52, 4.23
True	Central	1.41	1.18, 1.68	3.92	3.13, 4.92	9.48	7.98, 11.27	3.84	3.17, 4.66	4.36	3.63, 5.23
Pre	Air Cleaner	-	-	-	-	-	-	7.82	7.07, 8.65	6.88	6.23, 7.61
Pre	Central	-	-	-	-	-	-	6.70	5.54, 8.10	5.46	4.66, 6.40

Table 3.6.39 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

	$PM_{0.2}$			$PM_{2.5}$			PM_{10}			$PM_{0.2-2.5}$			$PM_{2.5-10}$		
Filtration type	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Air Cleaner: Sham vs True	0.73	0.62, 0.84	<.0001	0.72	0.61, 0.83	<.0001	0.44	0.36, 0.52	<.0001	0.58	0.49, 0.67	<.0001	0.15	0.08, 0.22	<.0001
Central System: Sham vs True	0.42	0.23, 0.61	<.0001	0.47	0.25, 0.68	<.0001	0.18	0.04, 0.32	0.01	0.29	0.14, 0.45	0.0003	-0.10	-0.22, 0.03	0.14
Air Cleaner vs Central difference in Sham vs True differences	0.31	0.09, 0.53	0.01	0.25	0.01, 0.50	0.04	0.26	0.10, 0.42	0.002	0.28	0.10, 0.47	0.002	0.24	0.10, 0.39	<.0001
Air Cleaner: Pre vs Sham	-	-	-	-	-	-	-	-	-	0.32	0.22, 0.42	<.0001	0.43	0.35, 0.51	<.0001
Central System: Pre vs Sham	-	-	-	-	-	-	-	-	-	0.26	0.06, 0.46	0.01	0.32	0.15, 0.49	0.0003
Air Cleaner vs Central difference in Pre vs Sham differences	-	-	-	-	-	-	-	-	-	0.06	-0.16, 0.28	0.61	0.11	-0.08, 0.30	0.26
Air Cleaner: Pre vs True	-	-	-	-	-	-	-	-	-	0.90	0.79, 1.01	<.0001	0.58	0.50, 0.66	<.0001
Central System: Pre vs True	-	-	-	-	-	-	-	-	-	0.56	0.31, 0.81	<.0001	0.22	0.06, 0.39	0.01
Air Cleaner vs Central difference in Pre vs True differences	-	-	-	-	-	-	-	-	-	0.34	0.07, 0.62	0.01	0.35	0.17, 0.54	0.0002

Table 3.6.40 Percent reduction in adjusted geometric mean indoor PM concentrations for each size fraction for both the whole population and by intervention type.

	$PM_{0.2}$	$PM_{2.5}$	PM_{10}	$PM_{0.2-2.5}$	$PM_{2.5-10}$
All Homes: Sham vs. True	**48%**	**48%**	**31%**	**41%**	**10%**
Central Filtration Homes: Sham vs. True	**34%**	**37%**	**16%**	**25%**	-
Air cleaner Homes: Sham vs. True	**52%**	**51%**	**36%**	**44%**	**14%**

Notes: Reductions calculated for statically significant differences are in bold while those from marginally significant differences are in italics. If concentrations were virtually the same, no number is presented.

The same statistical approach was utilized to compare levels between pre-intervention and both sham and true measurements, and we discuss the differences for $PM_{0.2-2.5}$ and $PM_{2.5-10}$ because these size fractions had most complete data sets. Pre-installation levels were significantly higher than sham levels for both size fractions; $PM_{0.2-2.5}$ (β=0.30 [0.21, 0.39], $p<0.0001$) and $PM_{2.5-10}$ (β=0.40 [0.33, 0.48], $p<0.0001$) (Table 3.6.37). While we expected indoor levels to be higher pre-intervention than in sham for homes with filtration though the central system due to the increased circulation through the sham filter, we also found higher levels with the air cleaner homes. In fact, there were statistically significant differences between concentrations collected during the pre-intervention periods and the sham periods for both air cleaners $PM_{0.2-2.5}$ (β=0.32 [0.22, 0.42], $p<0.0001$) and $PM_{2.5-10}$ (β=0.43 [0.35, 0.51], $p<0.0001$) and central systems $PM_{0.2-2.5}$ (β=0.26 [0.06, 0.46], $p=0.01$) and $PM_{2.5-10}$ (β=0.32 [0.15, 0.49], $p<0.01$). The air cleaner vs. central system difference in the pre-installation vs. sham log geometric mean differences were not statistically significant, indicating that the type of filtration system in the home did not change the effect of sham filtration on the indoor PM levels of any fraction size examined (Table 3.6.39).

Pre-installation levels were significantly higher than true levels for both size fractions; $PM_{0.2-2.5}$ (β=0.82 [0.72, 0.93], $p<0.0001$) and $PM_{2.5-10}$ (β=0.50 [0.42, 0.58], $p<0.0001$) (Table 3.6.37). The differences between the pre-intervention and true levels were greater than the differences between sham and true levels. There were statistically significant differences between concentrations collected during the pre-intervention periods and the true periods for both air cleaners $PM_{0.2-2.5}$ (β=0.90 [0.79, 1.01], $p<0.0001$) and $PM_{2.5-10}$ (β=0.58 [0.50, 0.66], $p<0.0001$) and central systems $PM_{0.2-2.5}$ (β=0.56 [0.31, 0.81], $p<0.0001$) and $PM_{2.5-10}$ (β=0.22 [0.06, 0.39], $p<0.0001$). The air cleaner vs. central system difference in the pre-installation vs. sham log geometric mean differences were statistically significant (Table 3.6.39).

The percent decrease between both pre and sham and pre and true concentrations was also calculated (Table 3.6.41). Here we see there was a greater decrease between pre and sham values for the larger component of PM, ($PM_{2.5-10}$) with a 33% decrease in the geometric mean as compared to the smaller component, ($PM_{0.2-2.5}$) with a 26% decrease. However, comparing

decreases between pre and true conditions, we still see a greater drop with the smaller size fraction (56% as compared to 39%). Considering the two interventions separately, the % decreases from pre to sham were similar, with negligible differences by filtration system in the pre vs. sham log geometric mean differences for the fraction sizes considered (Table 3.6.39).

Table 3.6.41 Percent reduction in adjusted geometric mean indoor PM concentration between Pre vs. true or sham values for $PM_{0.2-2.5}$ and $PM_{2.5-10}$, for both the whole population and by intervention type.

	$PM_{0.2-2.5}$	**$PM_{2.5-10}$**
All Homes		
Pre vs. Sham	**26%**	**33%**
Pre vs. True	**56%**	**39%**
Air Cleaner Homes		
Pre vs. Sham	**27%**	**35%**
Pre vs. True	**59%**	**44%**
Central Filtration Homes		
Pre vs. Sham	**23%**	**27%**
Pre vs. True	**43%**	**20%**

Notes: Reductions calculated for statically significant differences are in bold while those from marginally significant differences are in italics, while non-significant differences are in plain text.

Outdoor levels were compared to determine if they differed between pre-, true, and sham periods for $PM_{0.2-2.5}$ and $PM_{2.5-10}$ size fractions. There were no significant differences between pre- and sham or compared with true filtration for $PM_{0.2-2.5}$; however, outdoor $PM_{0.2-2.5}$ levels were slightly lower in sham than in true filtration and reached statistical significance (β= - 0.06 [-0.12, -0.01], p=0.03) There were no significant differences for $PM_{2.5-10}$. These analysis were conducted with the estimated outdoor values in cases where actual ones were not available. There were no statistically significant differences when only actual measured concentrations were included. Details are presented in Appendix F.2

To account for the impact of varying outdoor concentrations on indoor levels, analyses were also conducted on log-transformed I/O ratios for $PM_{0.2}$, $PM_{2.5}$, and PM_{10}. The I/O ratios during the sham period were significantly higher compared with the true filtration period for all size fractions, $PM_{0.2}$ (β=0.67 [0.55, 0.79], p<0.0001), $PM_{2.5}$ (β=0.70 [0.57, 0.82], p<0.0001) and PM_{10} (β=0.41 [0.32, 0.50], p<0.0001) (Table 3.6.42). The difference was slightly less for PM_{10} than the other size fractions. Geometric means are included in Table 3.6.43.

As with the indoor concentrations, I/O ratios were lower during true filtration in homes with air cleaners than in homes with filtration through the central system, with statistically significant

differences for $PM_{0.2}$ (air cleaner vs. central system difference in sham vs true differences: β=0.34 [0.06, 0.62], p=0.02) and PM_{10} (0.28 [0.06, 0.50], p=0.01), but not reaching statistical significance for $PM_{2.5}$ (0.26 [-0.06, 0.57], p=0.11) (Table 3.6.44). The differences between the true and sham periods were always greater for the homes air cleaners than for homes with filtration through the central system, although the differences were significantly different for the I/O $PM_{0.2}$ and I/O PM_{10} values only. Geometric mean least squares mean values are included in Table 3.6.45.

The percent decreases in the value of the indoor/outdoor ratio between sham and true periods were calculated and are presented in Table 3.6.46. Decreases were basically the same for the $PM_{0.2}$ and $PM_{2.5}$ size fraction (49% and 50% respectively) and were lower for PM_{10} (34%), mirroring the trend for indoor concentrations. There were greater reductions in the I/O ratio for homes with air cleaners as compared to those with central filtration (PM0.2=53%, $PM_{2.5}$=54%, PM_{10}=38%) vs ($PM_{0.2}$=34%, $PM_{2.5}$=41%, PM_{10}=18%).

Table 3.6.42 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} I/O ratios for filtration type in the log-normal mixed-effects model

	I/O $PM_{0.2}$			I/O $PM_{2.5}$			I/O PM_{10}		
Filtration type	**β**	**95% CI**	**Pr > |t|**	**B**	**95% CI**	**Pr > |t|**	**β**	**95% CI**	**Pr > |t|**
Sham vs. True	0.67	0.55, 0.79	<.0001	0.70	0.57, 0.82	<.0001	0.41	0.32, 0.50	<.0001
Pre vs. Sham	0.05	-0.18, 0.28	0.65	0.11	-0.01, 0.43	0.07	0.08	-0.07, 0.23	0.29
Pre vs. True	0.72	0.48, 0.96	<.0001	0.90	0.67, 1.14	<.0001	0.48	0.33, 0.64	<.0001

Table 3.6.43 Geometric Means (GM) of $PM_{0.2}$, $PM_{2.5}$, and PM_{10} I/O ratios by filtration type

	I/O $PM_{0.2}$		I/O $PM_{2.5}$		I/O PM_{10}	
Filtration type	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**
Pre	0.79	0.63, 0.99	0.87	0.71, 1.08	0.59	0.51, 0.69
Sham	0.75	0.69, 0.81	0.71	0.64, 0.78	0.55	0.51, 0.59
True	0.38	0.35, 0.43	0.35	0.32, 0.40	0.37	0.34, 0.40

Table 3.6.44 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} I/O ratios for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

	I/O $PM_{0.2}$			I/O $PM_{2.5}$			I/O PM_{10}		
Filtration type	**β**	**95% CI**	**Pr > |t|**	**β**	**95% CI**	**Pr > |t|**	**β**	**95% CI**	**Pr > |t|**
Air Cleaner: Sham vs True	0.76	0.63, 0.89	<.0001	0.78	0.65, 0.91	<.0001	0.48	0.39, 0.58	<.0001
Central: Sham vs True	0.42	0.17, 0.66	0.001	0.52	0.24, 0.81	0.0004	0.20	0.00, 0.40	0.04
Air Cleaner vs Central difference in Sham vs True differences	0.34	0.06, 0.62	0.02	0.26	-0.06, 0.57	0.11	0.28	0.06, 0.50	0.01

Table 3.6.45 Geometric Means (GM) of $PM_{0.2}$, $PM_{2.5}$, and PM_{10} I/O ratios for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

		I/O $PM_{0.2}$		I/O $PM_{2.5}$		I/O PM_{10}	
Filtration type	**Filtration system**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**
Sham	Air cleaner	0.76	0.68, 0.84	0.72	0.64, 0.81	0.56	0.51, 0.62
Sham	Central	0.74	0.65, 0.84	0.70	0.60, 0.82	0.53	0.46, 0.60
True	Air cleaner	0.36	0.32, 0.40	0.34	0.30, 0.38	0.35	0.32, 0.38
True	Central	0.48	0.39, 0.59	0.42	0.32, 0.55	0.43	0.35, 0.52

Table 3.6.46 Percent reduction in I/O PM Ratios for each size fraction for both the whole population and by intervention type. Reductions calculated for statically significant differences are in bold

	$PM_{0.2}$	**$PM_{2.5}$**	**PM_{10}**
Sham vs. True All Homes	**49%**	**50%**	**34%**
Sham vs. True Central Filtration Homes	**34%**	**41%**	**18%**
Sham vs. True Air cleaner Homes	**53%**	**54%**	**38%**

The analyses below explored whether any of the following factors (moderators) influenced the Sham vs. True Filtration differences in indoor air pollution or the Air Cleaner vs. Central System difference in the Sham vs. True differences:

- Days per week windows were open >2 hours: almost always [6-7 days], sometimes [2-5 days] vs. rarely [<2 days].
- Smoking indoors, frying/sautéing, and/or burning fire (wood, candles, incense) as sources of PM (presented as sum of days per week of each source, maximum 21 days): significant source [5+ days], moderate [3-4 days] vs. not significant [<3 days].
- Year the home was built: Before 1977 vs. 1977 or later.
- Presence of gas stove in the home.
- Proximity to roadway: Analysis conducted for both <2 blocks (<720 ft), 2-4 blocks, 5+ blocks as well as <5 blocks vs. 5+ blocks.
- Filtration utilization (proportion of volume normalized to what asked to use), continuous.
- Outdoor PM concentrations, continuous (indoor $PM_{0.2}$ and $PM_{2.5}$ only).
- Filtration fraction (fraction of the volume of air in the home that is cleaned every hour) (indoor $PM_{0.2}$ and $PM_{2.5}$ only).

The base model for these analyses included main effect terms filtration type (sham vs. true) and filtration system (air cleaner vs. central), an interaction term filtration type x filtration system, and covariates season and city, with household ID as the random variable. The interaction analyses below explored whether additional factors further modified the filtration type and indoor air pollution relationship with 3-way interaction terms included in these models. The outcome variables used in these analyses are log-transformed indoor $PM_{0.2}$, $PM_{2.5}$, and $PM_{0.2\text{-}2.5}$. Model results are presented as adjusted mean differences (β coefficients) and 95% confidence intervals (CI) and geometric means (GM) or geometric mean ratios with corresponding 95% CI. (As described above, geometric mean ratios result from applying the inverse log transformation to β.) All moderators are discussed below, with additional details in Appendix F.3.

Interaction terms with *P* values less than 0.20 were considered broadly significant. Associations between the filtration status (or another exposure) and indoor air pollution measurements were further evaluated and described at the various levels of any moderating factors identified as broadly significant based on this definition. For pair-wise comparisons at a particular level of the moderating factor (or combination of factors), *P* values greater than 0.05 but less than 0.20 were described as approaching significance or marginally significant whereas *P* values less than 0.05 indicated statistical significance at the α=0.05 level. Given the likely possibility of low power in analyses with interaction terms (especially those containing 3-way interaction terms), the usual statistical significance thresholds were slackened. (Trading off a higher type-1 error rate in exchange for a lower type-2 error rate is commonly done when evaluating interaction terms, given the low statistical power available for such analyses.) Despite this loosened definition of significance, all results with *P* values greater than 0.05 should be interpreted with caution.

Window usage, age of the home, filtration utilization, and outdoor concentrations were the only factors from the list that modified the effects of filtration status and filtration system on indoor air pollution, as determined by the broadly significant for the 3-way interaction term that included filtration status in the cross-product ($p<0.20$).

Window usage, or the number of days windows were open >2 hours per week, was categorized as almost always open (>5 days per week), sometimes open (2-5 days per week), or rarely open (<2 days per week). During both sham and true filtration periods, 26-29% of households reported almost always having windows open >2 hours, 19-22% of households sometimes opened windows, and 50-55% households rarely opened windows. In Table 3.6.47, we present sham vs. true contrasts for each type of filtration system in subgroups defined by window usages, as well as pairwise comparisons in these contrasts among levels of the window usage variable.

The magnitude of the estimated differences in indoor log-transformed $PM_{0.2}$ concentrations between sham and true filtration was greater in homes that opened windows more frequently, and this trend was observed in homes with air cleaners as well as central filtration systems (Table 3.6.47). In homes with air cleaners, the differences in indoor $PM_{0.2}$ concentrations between sham

and true filtration were greater in homes that rarely (β=0.76 [0.61, 0.91], p<0.0001) or sometimes opened windows (0.82 [0.56, 1.08], p<0.0001) than in homes that always opened windows (0.55 [0.34, 0.77], p<0.0001), as expected, with the comparison of mean differences approaching significance for homes that always versus rarely opened windows (-0.21 [-0.48, 0.07], p=0.14). A similar trend was observed in homes with central filtration although the mean differences between sham and true filtration were smaller at each category of window usage. Specifically, the differences in indoor $PM_{0.2}$ concentrations between sham and true filtration were as follows: 0.50 [0.30, 0.70] (p<0.0001) in homes that rarely opened windows, 0.53 [0.12, 0.95] (p=0.01) in homes that sometimes opened windows, and 0.19 [-0.21, 0.60] (p=0.35) in homes that always opened windows; and the comparison of mean differences approached significance for homes that always versus rarely opened windows (-0.31 [-0.75, 0.14], p=0.18). It should be noted that the subset of homes with central filtration systems was smaller than homes with air cleaners, therefore, affecting the power to detect significant differences in this analysis.

Results for indoor $PM_{2.5}$ concentrations also revealed numerically greater reductions in indoor $PM_{2.5}$ during true versus sham filtration when windows were rarely vs. always open, with the difference in improvement approaching significance for air cleaner homes (always vs. rarely open: -0.20 [-0.48, 0.08], p=0.15) but not central system homes (-0.21 [-0.79, 0.36], p=0.47) though trending in the expected direction (Table 3.6.47). Specifically, in homes with air cleaners, the differences in indoor $PM_{2.5}$ between sham and true filtration were as follows: 0.75 [0.59, 0.90] (p<0.0001) in homes that rarely opened windows, 0.75 [0.48, 1.01] (p<0.0001) in homes that sometimes opened windows, and 0.54 [0.32, 0.77] (p<0.0001) in homes that always opened windows. In homes with central filtration, the sham vs. true differences in indoor $PM_{2.5}$ were smaller in magnitude compared to homes with air cleaners at corresponding window usage categories, with 0.57 [0.24, 0.90] (p=0.001) in homes that rarely opened windows, 0.38 [-0.03, 0.80] (p=0.07) in homes that sometimes opened windows, and 0.36 [-0.11, 0.83] (p=0.13) in homes that always opened windows. All of these results, along with those for $PM_{0.2-2.5}$, can be seen in Table 3.6.47. The geometric means of indoor PM concentrations for each filtration type x filtration system x window usage combination are listed in Table 3.6.41. From this table, one can also see that the indoor PM concentrations were higher the more frequently the windows were open during true filtration in homes with air cleaners and central filtration systems. When evaluating these contrasts in contrasts, though, we do not seen much evidence for statistically significant heterogeneity in treatment effects by window usage, as most p-values are above 0.20.

The age of the home was another moderating factor for the relationship between filtration status and indoor air pollution measures. The age of the home was divided into two categories: homes built before 1977 and homes build in 1977 or later. Homes built prior to 1977 tend to have higher air exchange rates than newer homes, and thus it is anticipated that filtration should be more effective in newer homes. During both sham and true filtration, 39-40% of homes were built before 1977 and 60-61% of homes were built in 1977 or later. Specifically, the 3-way interaction term: filtration type × presence of central filtration × age of home was statistically significant for

both $PM_{0.2-2.5}$ (p=0.02) and $PM_{2.5}$ (p=0.01), indicating that the combined effects of sham vs. true filtration and of using an air cleaner vs. central filtration on indoor concentrations varied depending on whether the home was built before or after 1977. Although significant differences in indoor $PM_{0.2}$ were detected for the sham vs. true filtration comparisons, they did not vary significantly with the age of the home. In homes with air cleaners, we saw the expected trend of a greater difference in log mean PM levels between sham and true filtration (with lower mean indoor PM observed during true filtration) in homes built in 1977 or later as compared to homes built before 1977, although these differences only reached significance for $PM_{0.2-2.5}$ (β= -0.18 [95% CI: -0.36, 0.00], p=0.05) (Table 3.6.49). In contrast, among homes with central filtration, the difference between true and sham was greater in the older homes, which was not expected, but only reached significance for $PM_{2.5}$ (0.47 [0.04, 0.91], p=0.03). For all size fractions, in homes with air cleaners during true filtration, the indoor concentrations were lower in newer homes. All of these results are in Table 3.6.49 and more details, including the geometric means for all filtration type × presence of central filtration × age of home combinations, are included in Appendix F3.

Table 3.6.47 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) for each level of the filtration type x filtration system x window usage interaction term in the log-normal mixed-effects model

	$PM_{0.2}$			$PM_{2.5}$			$PM_{0.2-2.5}$		
Contrast	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Always open, Air Cleaner: Sham vs True	0.55	0.34, 0.77	<.0001	0.54	0.32, 0.77	<.0001	0.43	0.24, 0.61	<.0001
Sometimes open, Air Cleaner: Sham vs True	0.82	0.56, 1.08	<.0001	0.75	0.48, 1.01	<.0001	0.58	0.37, 0.79	<.0001
Rarely open, Air Cleaner: Sham vs True	0.76	0.61, 0.91	<.0001	0.75	0.59, 0.90	<.0001	0.62	0.49, 0.74	<.0001
Always open, Central: Sham vs True	0.19	-0.21, 0.60	0.35	0.36	-0.11, 0.83	0.13	0.35	-0.02, 0.72	0.07
Sometimes open, Central: Sham vs True	0.53	0.12, 0.95	0.01	0.38	-0.03, 0.80	0.07	0.26	-0.08, 0.59	0.14
Rarely open, Central: Sham vs True	0.50	0.30, 0.70	<.0001	0.57	0.24, 0.90	0.001	0.35	0.15, 0.55	0.001
Air Cleaner: Always vs Rarely open difference in Sham vs True differences	-0.21	-0.48, 0.07	0.14	-0.20	-0.48, 0.08	0.15	-0.19	-0.42, 0.04	0.11
Central: Always vs Rarely open difference in Sham vs True differences	-0.31	-0.75, 0.14	0.18	-0.21	-0.79, 0.36	0.47	0.00	-0.42, 0.41	0.99
Always open: Air Cleaner vs. Central difference in Sham vs True differences	0.14	-0.10, 0.81	0.12	0.18	-0.34, 0.70	0.49	0.08	-0.33, 0.49	0.70
Sometimes open: Air Cleaner vs. Central difference in Sham vs True differences	0.28	-0.21, 0.77	0.26	0.36	-0.13, 0.85	0.15	0.32	-0.08, 0.73	0.11
Rarely open: Air Cleaner vs. Central difference in Sham vs True differences	0.26	0.00, 0.51	0.05	0.18	-0.19, 0.54	0.35	0.27	0.03, 0.50	0.03
Always vs. Rarely open difference in Air Cleaner vs. Central difference in Sham vs True differences	0.10	-0.42, 0.62	0.70	0.01	-0.62, 0.64	0.98	-0.19	-0.65, 0.28	0.43
Sometimes vs. Rarely open difference in Air Cleaner vs. Central difference in Sham vs True differences	0.03	-0.53, 0.58	0.93	0.19	-0.46, 0.83	0.57	0.06	-0.43, 0.55	0.82

Table 3.6.48 Geometric Means (GM) of $PM_{0.2}$, $PM_{2.5}$ and $PM_{0.2\text{-}2.5}$ concentrations for each level of the filtration type x filtration system x window usage interaction term in the log-normal mixed-effects model

			$PM_{0.2}$		$PM_{2.5}$		$PM_{0.2\text{-}2.5}$	
Filtration type	**Filtration system**	**Window usage**	**GM**	**95% CI**	**GM**	**95% CI**	**GM**	**95% CI**
Sham	Air cleaner	Almost always open	2.35	2.02, 2.74	6.86	5.87, 8.01	5.88	5.13, 6.74
Sham	Air cleaner	Sometimes open	2.69	2.20, 3.30	7.32	5.97, 8.97	6.04	4.95, 7.36
Sham	Air cleaner	Rarely open	2.25	1.98, 2.56	6.49	5.69, 7.40	5.31	4.69, 6.01
Sham	Central System	Almost always open	2.02	1.48, 2.76	6.35	4.39, 9.17	5.24	3.73, 7.36
Sham	Central System	Sometimes open	2.47	1.93, 3.16	5.98	4.58, 7.80	4.69	3.71, 5.93
Sham	Central System	Rarely open	2.08	1.82, 2.38	6.29	5.28, 7.50	5.03	4.20, 6.02
True	Air cleaner	Almost always open	1.35	1.14, 1.61	3.98	3.31, 4.79	3.84	3.29, 4.48
True	Air cleaner	Sometimes open	1.19	0.98, 1.45	3.47	2.85, 4.21	3.38	2.93, 3.90
True	Air cleaner	Rarely open	1.06	0.90, 1.23	3.07	2.60, 3.63	2.87	2.51, 3.27
True	Central System	Almost always open	1.67	1.28, 2.17	4.43	3.28, 5.97	3.70	2.85, 4.81
True	Central System	Sometimes open	1.45	1.02, 2.06	4.07	2.80, 5.91	3.63	2.67, 4.94
True	Central System	Rarely open	1.26	1.03, 1.55	3.55	2.60, 4.85	3.55	2.87, 4.38

Table 3.6.49 Contrasts in log geometric mean $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations ($\mu g/m^3$) for each level of the filtration type x filtration system x age of home interaction term in the log-normal mixed-effects model

	$PM_{0.2}$			$PM_{2.5}$			$PM_{0.2-2.5}$		
Contrast	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Before 1977, Air Cleaner: Sham vs True	0.67	0.49, 0.86	<.0001	0.60	0.43, 0.77	<.0001	0.47	0.34, 0.59	<.0001
1977 or later, Air Cleaner: Sham vs True	0.76	0.61, 0.92	<.0001	0.79	0.63, 0.96	<.0001	0.65	0.52, 0.78	<.0001
Before 1977, Central: Sham vs True	0.52	0.28, 0.77	<.0001	0.81	0.45, 1.16	<.0001	0.47	0.25, 0.69	<.0001
1977 or later, Central: Sham vs True	0.37	0.13, 0.61	0.003	0.34	0.09, 0.58	0.01	0.25	0.05, 0.45	0.01
Air Cleaner: Before 1977 vs 1977 or later difference in Sham vs True differences	-0.09	-0.33, 0.15	0.45	-0.19	-0.43, 0.05	0.12	-0.18	-0.36, 0.00	0.05
Central: Before 1977 vs 1977 or later difference in Sham vs True differences	0.15	-0.19, 0.50	0.39	0.47	0.04, 0.91	0.03	0.23	-0.07, 0.52	0.14
Before 1977: Air Cleaner vs Central differences in Sham vs True differences	0.15	-0.16, 0.46	0.34	-0.21	-0.60, 0.19	0.31	-0.01	-0.26, 0.25	0.97
1977 or later: Air Cleaner vs Central differences in Sham vs True differences	0.39	0.11, 0.68	0.01	0.46	0.15, 0.76	0.003	0.40	0.16, 0.64	0.001
Before 1977 vs. 1977 or later difference in Air Cleaner vs. Central difference in Sham vs True difference	-0.24	-0.66, 0.17	0.25	-0.66	-1.16, -0.17	0.01	-0.41	-0.76, -0.05	0.02

The mean filtration use ratio (proportion of filtered air volume or time normalized to the intended filtration air volume or time, discussed as "time" for simplicity in this document) was the same (Mean = 0.98; Median = 1) during both sham and true filtration, as expected. The ratio of time the filtration system was used compared to the amount of time asked modified the association between filtration status and indoor PM concentrations for all size fractions considered, as determined by the significant 2-way interaction terms filtration status x filtration use ratio ($p \leq 0.05$ for $PM_{0.2}$ and $PM_{2.5}$). However, use ratio did not significantly change the combined effects of filtration type and filtration system on indoor PM levels as indicated by the 3-way interaction term (filtration type x filtration system x use ratio). Use ratios of 1 (mean levels) and 0.75 were used to illustrate the moderating effect of use ratio on the relationship between filtration type and indoor PM.

In homes with central filtration, log-transformed indoor $PM_{0.2}$ concentrations were higher on average by 0.37 during sham compared with the true filtration period where the hypothetical home ran their filtration system 100% of the amount of time asked (i.e., use ratio = 1) (β=0.37 [0.17, 0.57], p=0.0004) (Table 3.6.50). By comparison, in hypothetical homes that ran their filtration system 75% of the amount of time asked (i.e., use ratio = 0.75), the sham-true difference in log geometric mean levels of $PM_{0.2}$ was 0.29 [0.04, 0.55] (p=0.02). The difference in the mean differences comparing sham and true filtration in hypothetical homes that ran their filtration system 75% (0.29 [0.04, 0.55]) versus 100% of the time asked (0.37 [0.17, 0.57]) was marginally significant (-0.07 [-0.18, 0.03], p=0.16), indicating that using the intervention more yielded better air quality results.

In homes with air cleaners, log-transformed indoor $PM_{0.2}$ concentrations were higher by 0.74 during sham compared with the true filtration period where the hypothetical home ran their filtration system 100% of the amount of time asked (0.74 [0.63, 0.85], p<0.0001). While in hypothetical homes that ran their filtration system 75% of the time asked, the mean difference between sham and true filtration was 0.61 [0.42, 0.80] (p<0.0001). The difference in mean differences comparing sham and true filtration in homes that ran their filtration system 75% (0.61 [0.42, 0.80]) versus 100% of the time asked (0.74 [0.63, 0.85]) was marginally statistically significant (-0.13 [-0.31, 0.05], p=0.15), indicating that using the intervention more yielded better air quality results.

Results were very similar for $PM_{2.5}$, also included in Table 3.6.50. Although the majority of homes had a filtration use ratio between 0.95 and 1.05, there were homes in the other value ranges.

Table 3.6.50 Contrasts in log geometric mean $PM_{0.2}$ and $PM_{2.5}$ concentrations for *selected values* of the filtration use ratio (a continuous variable) in the log-normal mixed-effects model with interaction term filtration type × filtration system × use ratio

	$PM_{0.2}$			$PM_{2.5}$		
Filtration type	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Use ratio = 0.75, Air Cleaner: Sham vs True	0.61	0.42, 0.80	<.0001	0.58	0.37, 0.79	<.0001
Use ratio = 1.00, Air Cleaner: Sham vs True	0.74	0.63, 0.85	<.0001	0.74	0.63, 0.84	<.0001
Use ratio = 0.75, Central: Sham vs True	0.29	0.04, 0.55	0.02	0.31	0.06, 0.57	0.02
Use ratio = 1.00, Central: Sham vs True	0.37	0.17, 0.57	0.0004	0.39	0.18, 0.61	0.0003
Air Cleaner: Use ratio = 0.75 vs 1.00 difference in Sham vs True differences	-0.13	-0.31, 0.05	0.15	-0.16	-0.35, 0.03	0.10
Central: Use ratio = 0.75 vs 1.00 difference in Sham vs True differences	-0.07	-0.18, 0.03	0.16	-0.08	-0.18, 0.01	0.09
Use ratio = 0.75: Air Cleaner vs. Central difference in Sham vs True differences	0.32	0.00, 0.63	0.05	0.27	-0.06, 0.60	0.11
Use ratio = 1.00: Air Cleaner vs. Central difference in Sham vs True differences	0.37	0.14, 0.60	0.002	0.34	0.10, 0.58	0.01
Use ratio = 0.75 vs. 1.00 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.05	-0.26, 0.15	0.60	-0.08	-0.29, 0.13	0.48

There were some significant interactions on indoor levels with the corresponding outdoor levels, although the differences were not always in the anticipated direction. The mean outdoor $PM_{0.2}$ concentrations were slightly higher during the true period ($PM_{0.2}$ Geometric Mean [GM] = 3.31 [SD = 1.56] and Median = 3.12; $PM_{2.5}$ GM = 10.28 [1.75] and Median=8.94) compared with the sham period ($PM_{0.2}$ GM = 3.05 [1.60] and Median = 2.87; $PM_{2.5}$ GM = 9.21 [1.75] and Median = 8.85) (details in Appendix F3). Outdoor $PM_{0.2}$ levels modified both the effect of sham versus true filtration and the effect of using an air cleaner versus central filtration on the indoor $PM_{0.2}$ concentrations (p=0.002). Stated differently, the slope of the continuous independent variable (outdoor $PM_{0.2}$ concentrations) – or the amount of change in indoor $PM_{0.2}$ concentrations for each unit increase in outdoor $PM_{0.2}$ concentrations – varied depending on the combination of the filtration period (sham or true filtration) and filtration system in the home (central filtration or air cleaner).

Outdoor $PM_{0.2}$ concentrations of 3 (50^{th} percentile) and 8 (95^{th} percentile) $\mu g/m^3$ were used to illustrate the modifying effect of outdoor $PM_{0.2}$ concentrations on the relationship between filtration type and indoor $PM_{0.2}$ concentrations in homes with central filtration and separately in homes with air cleaners. For homes with outdoor $PM_{0.2}$ concentrations of 3 $\mu g/m^3$, we compared log-transformed $PM_{0.2}$ concentrations during sham compared with true filtration: for central systems, the contrast was β=0.39 ([0.19, 0.58], p=0.0001), while for room air cleaners, the

contrast was β=0.75 ([0.65, 0.86], p<0.0001), (Table 3.6.51). By comparison, for homes with outdoor $PM_{0.2}$ concentrations of 8 μg/m^3, these sham vs. true contrasts were β=0.89 ([0.47, 1.32], p<0.0001) for central air and β=0.39 ([0.07, 0.72], p=0.002) for room air cleaners, respectively. For central air systems, the sham vs. true contrast for $PM_{0.2}$ = 3 μg/m^3 is statistically significantly different than the sham vs. true contrast for $PM_{0.2}$ = 8 μg/m^3.

When considering $PM_{2.5}$, the expected trend was observed. Among air cleaner homes, the sham vs. true contrast were greater (1.08 [0.82, 1.35], p<0.0001) when the outdoor $PM_{2.5}$ levels was 27 μg/m^3 than was the sham vs. true contrast (0.72 [0.61, 0.83], p<0.0001) when outdoor $PM_{2.5}$ levels was 9 μg/m^3 (p=0.01 for interaction term of outdoor $PM_{2.5}$ levels with Sham vs. True contrast for air cleaner homes). The comparisons can be seen in Table 3.6.51, with more details in Appendix F3.

Table 3.6.51 Contrasts in log geometric mean $PM_{0.2}$ and $PM_{2.5}$ concentrations for *selected values* of corresponding outdoor PM levels (a continuous variable) in the log-normal mixed-effects model with interaction term filtration type × filtration system × outdoor PM

	$PM_{0.2}$			**$PM_{2.5}$**		
Contrast	**β**	**95% CI**	**p-value**	**β**	**95% CI**	**p-value**
Outdoor $PM_{0.2}$=3, $PM_{2.5}$=9; Air Cleaner: Sham vs True	0.75	0.65, 0.86	<.0001	0.72	0.61, 0.83	<.0001
Outdoor $PM_{0.2}$=8, $PM_{2.5}$=27; Air Cleaner: Sham vs True	0.39	0.07, 0.72	0.02	1.08	0.82, 1.35	<.0001
Outdoor $PM_{0.2}$=3, $PM_{2.5}$=9; Central: Sham vs True	0.39	0.19, 0.58	0.0001	0.40	0.17, 0.62	0.001
Outdoor $PM_{0.2}$=8, $PM_{2.5}$=27; Central: Sham vs True	0.89	0.47, 1.32	<.0001	0.59	-0.33, 1.50	0.21
Air Cleaner: Outdoor $PM_{0.2}$=8 vs 3, $PM_{2.5}$=27 vs 9 difference in Sham vs True differences	-0.36	-0.68, -0.04	0.03	0.36	0.09, 0.64	0.01
Central: Outdoor $PM_{0.2}$=8 vs 3, $PM_{2.5}$=27 vs 9 difference in Sham vs True differences	0.51	0.06, 0.95	0.03	0.19	-0.72, 1.10	0.69
Outdoor $PM_{0.2}$, $PM_{2.5}$=9: Air Cleaner vs Central difference in Sham vs True differences	0.37	0.14, 0.59	0.001	0.32	0.17, 0.62	0.01
Outdoor $PM_{0.2}$=8, $PM_{2.5}$=27: Air Cleaner vs Central difference in Sham vs True differences	-0.50	-1.02, 0.03	0.06	0.49	-0.43, 1.40	0.30
Outdoor $PM_{0.2}$=8 vs. 3, $PM_{2.5}$=27 vs 9 difference in Air Cleaner vs. Central difference in Sham vs True differences	-0.87	-1.40, -0.33	0.002	0.18	-0.76, 1.11	0.71

Indoor PM levels ($PM_{0.2}$, $PM_{2.5}$, $PM_{0.2\text{-}2.5}$) were generally higher in homes with burning sources (e.g., smoking indoors, frying/sautéing, burning candles or incense) than in homes that rarely reported any burning sources. However, the mean differences in indoor concentrations between sham and true filtration did not vary based on the frequency of indoor smoking, frying/sautéing, or burning candles or incense, thus, indicating no modifying effects of relationship between filtration status and indoor PM levels by these burning sources.

Likewise, having a gas stove did not change the magnitude of the differences in indoor PM concentrations between sham and true filtration in either homes with air cleaners or central filtration. Indoor levels did not appear to differ significantly when homes with gas stoves were compared to homes with electric stoves, while holding filtration status and intervention constant. Similarly, proximity to a major roadway did not modify the filtration status and indoor PM levels relationship even though the levels of all size fractions where generally higher in homes closer to major roads. More information on all of these analyses is available in Appendix F3. Analysis of the effect of a swamp cooler was not conducted because only 5% of homes had a swamp cooler. Window air-conditioning units can also be a source of outdoor air to the home, depending on how the unit is configured, but only 10% of homes had window units so an analysis was not conducted.

Ozone analysis

All indoor ozone concentrations were low. The geometric mean (GM) Ozone I/O ratios in sham and true filtration were 0.05 [0.02, 0.12] and 0.03 [0.02, 0.06], respectively (Appendix F).The sham vs. true filtration differences in log geometric mean Ozone I/O ratios were not statistically significant (β=0.44 [95% CI: -0.42, 1.29], p=0.27) (Appendix F). There were fewer ozone measurements than particulate measurements, making it difficult to draw conclusions.

Reflectance Analysis

The reflectance I/O ratios were 4.39 times higher in sham than in true filtration (β=1.48 [95% CI: 1.14, 1.81], p<0.0001), indicating a 77% reduction (Appendix F). The geometric mean (GM) reflectance I/O ratios in sham and true filtration were 0.45 [0.38, 0.54] and 0.10 [0.07, 0.14], respectively (Table 3.6.52).

Table 3.6.52 Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios by filtration type

Filtration type	Log GM	95% CI	GM	95% CI
Sham	-0.7962	-0.9707 ~ -0.6217	0.4510	0.3788 ~ 0.5370
True	-2.2751	-2.5979 ~ -1.9523	0.1028	0.0744 ~ 0.1419

In contrast to the PM results, there was not a statistically significant difference in the reduction in the I/O reflectance between sham filtration and true filtration between homes that had air cleaners versus central system filtration. Specifically, the 2-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) was not statistically significant, indicating that the type of home filtration system did not modify the effect of sham versus true filtration on the reflectance I/O ratios (p=0.49) (Table 3.6.53). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes with air cleaners (β=1.55 [95% CI: 1.18, 1.91], p<0.0001) and homes with central systems (1.25 [0.49, 2.01], p=0.002). However, the differences between air cleaner and central system homes in sham vs. true log

geometric mean differences in reflectance I/O ratios were not significantly different although slightly higher in air cleaner homes (0.30 [-0.55, 1.14], p=0.49), indicating that improvements in air quality with true filtration did not vary much by the type of home filtration system.

Table 3.6.53 Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x filtration system in the log-normal mixed-effects model

Contrast	Estimate	Std Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	1.5455	0.1872	228	8.25	<.0001	1.1766	1.9144
Central: Sham vs True	1.2500	0.3880	228	3.22	0.0015	0.4854	2.0145
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2955	0.4294	228	0.69	0.4920	-0.5506	1.1417

The geometric means (GM) of reflectance I/O ratios are presented in Table 3.6.54. In homes with air cleaners, the GM reflectance I/O ratios in sham and true filtration were 0.44 [95% CI: 0.36, 0.53] and 0.09 [0.06, 0.13]. In homes with central systems, the GM reflectance I/O ratios in sham and true filtration were 0.50 [0.34, 0.75] and 0.14 [0.07, 0.30], respectively.

Table 3.6.54 Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Log GM	95% CI	GM	95% CI
Sham	Air Cleaner	-0.8271	-1.0137 ~ -0.6404	0.4373	0.3629 ~ 0.5271
Sham	Central	-0.6877	-1.0909 ~ -0.2845	0.5027	0.3359 ~ 0.7524
True	Air Cleaner	-2.3726	-2.7419 ~ -2.0033	0.0932	0.0644 ~ 0.1349
True	Central	-1.9376	-2.6641 ~ -1.2112	0.1440	0.0697 ~ 0.2978

The frequency (days per week) of opening windows for >2 hours modified the effect of sham versus true filtration on the reflectance I/O ratios, indicated with a 2-way interaction term filtration type (sham vs. true) x window usage (always, sometimes vs. rarely open) was statistically significant ($p<0.0001$). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes that always ($\beta=0.53$ [95% CI: 0.09, 0.98], p=0.02), sometimes (2.25 [1.37, 3.14], $p<0.0001$), and rarely opened windows (1.71 [1.24, 2.18], $p<0.0001$) (Table 3.6.55). In addition, the sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes that always opened windows compared with homes that rarely did so (-1.18 [-1.81, -0.54], p=0.0003), indicating that improvements in air quality with true filtration were greater in homes that opened windows less frequently. The sham vs. true log geometric mean differences in reflectance I/O ratios were not significantly different between homes that sometimes vs. rarely opened windows (0.54 [-0.48, 1.56], p=0.30). As the differences between homes with air cleaners and central system filtration were not significant, that term was not included in the model.

Table 3.6.55 Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x window usage in the log-normal mixed-effects model

Contrast	Estimate	Std Error	DF	t Value	Pr > |t|	Lower	Upper
Always open: Sham vs True	0.5327	0.2253	218	2.36	0.0189	0.0887	0.9767
Sometimes open: Sham vs True	2.2535	0.4496	218	5.01	<.0001	1.3674	3.1395
Rarely open: Sham vs True	1.7112	0.2402	218	7.12	<.0001	1.2377	2.1847
Always vs. Rarely open diff in Sham vs True diffs	-1.1785	0.322	218	-3.66	0.0003	-1.8132	-0.5438
Sometimes vs. Rarely open diff in Sham vs True diffs	0.5422	0.5167	218	1.05	0.2952	-0.4762	1.5607

The geometric means (GM) of reflectance I/O ratios are presented in Table 3.6.56. In homes that almost always opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.39 [95% CI: 0.26, 0.59] and 0.23 [0.17, 0.30], respectively. In homes that sometimes opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.65 [0.47, 0.89] and 0.07 [0.03, 0.15]. Lastly, in homes that rarely opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.43 [0.35, 0.53] and 0.08 [0.05, 0.12].

Table 3.6.56 Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x window usage in the log-normal mixed-effects model

Filtration type	Window usage	Log GM	95% CI		GM	Lower	Upper
Sham	Almost always open	-0.9418	-1.3535	-0.5301	0.3899	0.2583	0.5885
Sham	Sometimes open	-0.4334	-0.7473	-0.1196	0.6483	0.4736	0.8873
Sham	Rarely open	-0.8432	-1.0560	-0.6304	0.4303	0.3478	0.5324
True	Almost always open	-1.4745	-1.7550	-1.1940	0.2289	0.1729	0.3030
True	Sometimes open	-2.6869	-3.5079	-1.8659	0.0681	0.0300	0.1548
True	Rarely open	-2.5545	-3.0184	-2.0905	0.0777	0.0489	0.1236

The distance to the roadway did significantly modify the effect of sham versus true filtration on the reflectance I/O ratios, indicated by a 2-way interaction term filtration type (sham vs. true) x proximity to roadway (<2, 2-4 vs. 5+ blocks) that was statistically significant (p=0.01). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes located in each of the categorical distances from a major roadway. However, the difference between measurements taken during true filtration as opposed to sham filtration were smaller for homes in the middle distance, 2-4 blocks from the road (0.73 [0.22, 1.24], p=0.01), as compared to those <2 blocks (β=1.49 [95% CI: 0.96, 2.01], p<0.0001) and ≥5 blocks from a major roadway

(1.98 [1.40, 2.56], p<0.0001) (Table 3.6.57). In addition, the sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes located 2-4 blocks from a roadway compared with homes located 5 or more blocks away (-1.25 [-2.02, -0.48], p=0.002). The sham vs. true log geometric mean differences in reflectance I/O ratios were also lower in homes located less than 2 blocks from a major roadway than in homes 5 or more blocks away, but this comparison did not reach statistical significance (-0.49 [-1.28, 0.30], p=0.29).

The distance to roadway was also dichotomized at <5 blocks and 5 or more blocks. The 2-way interaction term filtration type (sham vs. true) x proximity to roadway (<5 vs. 5+ blocks) was statistically significant, indicating that proximity to a major roadway modified the effect of sham versus true filtration on the reflectance I/O ratios (p=0.01) (Table 3.6.57). The sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes located <5 blocks from a roadway compared with homes located 5 or more blocks away (-0.87 [-1.57, -0.18], p=0.01), indicating that improvements in air quality with true filtration were greater in homes that were farther from a major roadway.

Table 3.6.57 Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x proximity to roadway in the log-normal mixed-effects model, results shown for models including both 3 categories and 2 categories

Contrast	Estimate	Std Error	DF	t Value	Pr > |t|	Lower	Upper
<2 blocks: Sham vs True	1.4890	0.2660	225	5.6	<.0001	0.9648	2.0133
2-4 blocks: Sham vs True	0.7277	0.2599	225	2.8	0.0056	0.2156	1.2397
5+ blocks: Sham vs True	1.9793	0.2960	225	6.69	<.0001	1.3959	2.5626
<2 vs 5+ blocks diff in Sham vs True diffs	-0.4903	0.3986	225	-1.23	0.2200	-1.2757	0.2952
2-4 vs 5+ blocks diff in Sham vs True diffs	-1.2516	0.3908	225	-3.2	0.0016	-2.0217	-0.4816
<5 blocks: Sham vs True	1.1069	0.1930	227	5.74	<.0001	0.7266	1.4871
5+ blocks: Sham vs True	1.9793	0.2960	227	6.69	<.0001	1.3961	2.5626
<5 vs 5+ blocks diff in Sham vs True diffs	-0.8725	0.3523	227	-2.48	0.0140	-1.5667	-0.1783

The use ratio was also tested as an interaction term, but did not significantly modify the results, in contrast to the PM results (Appendix F).

3.6.8 Objective 3: Distribution of Concentrations and Exposures for Pre-Intervention and Unfiltered Air

The third objective of this study was to measure indoor and outdoor concentrations of $PM_{0.2}$, $PM_{2.5}$, PM_{10}, and ozone in homes of children with asthma. To meet this objective, pre-intervention concentration distributions were to be presented. Due to the problem with the O-rings contaminating the $PM_{0.2}$ stage of the impactor, as well as $PM_{2.5}$ as measured by the PEM

sampler, only the distributions for $PM_{0.2-2.5}$ and $PM_{2.5-10}$ can be calculated for a significant portion of the population. These summary statistics are presented in Table 3.6.18.

As an alternative to considering the pre-intervention values, one could observe the summary statistics for the sham filtration period. There is ample data to compare the pre-intervention and sham values for the $PM_{0.2-2.5}$ and $PM_{2.5-10}$ size fractions. It was found that the values from the sham period were 21% and 28% lower than pre-intervention values. One could assume that the $PM_{0.2}$, $PM_{2.5}$, PM_{10} sham values are also likely around 20-25% higher than the pre-intervention values. It is likely the $PM_{0.2}$ size fraction would experience a similar or slightly lower decrease than the $PM_{0.2-2.5}$ size fraction.

Because these participants were recruited from areas of California that have higher levels of outdoor pollution, it is also useful to observe the indoor/outdoor ratios in homes with children with asthma as these values can be applied to some extent to other areas of California. Reviewing Table 3.6.19, one can see that 50% of the homes had an I/O ratio of 0.7% or less for $PM_{0.2-2.5}$, with a 75^{th} percentile value of 1.07. For $PM_{2.5-10}$, the I/O ratios tended to be lower, with a 75^{th} percentile value of 0.80.

3.6.9 Personal Exposure Model Results

A personal exposure model including home, school, outdoors, and other indoor locations was created and run for both a filtered and an unfiltered home environment. The details of creating the personal exposure model are outlined in the methods section of this report on page 88. Indoor concentrations were calculated for both filtered and unfiltered conditions using the log-normal distributions of outdoor concentrations and I/O ratio from the study. Specifically, the distribution of I/O ratio for $PM_{2.5}$ with true filtration (mean=0.46, CV=0.93) was used. There were very few homes included in the pre-intervention I/O $PM_{2.5}$ distribution. The value for $PM_{2.5}$ (mean= 0.88, CV=0.65) and $PM_{0.2-2.5}$ (mean=0.91, CV=0.60) were similar, and the one for $PM_{0.2-2.5}$ was used. Two-thirds of the homes were assumed to be in Fresno and used an outdoor concentration from distribution of Fresno locations (mean=12.8 $\mu g/m^3$, CV=0.82) and one-third from the Riverside distribution (mean=8.8 $\mu g/m^3$, CV=0.28). Two average classroom values were presented in [168], 16.3 $\mu g/m^3$ and 13.2 $\mu g/m^3$. These two values were averaged and the distribution was assigned a CV value of 0.8, similar to the values for other concentration distributions measured in this study. The concentration in other locations was assumed to be an unfiltered indoor environment.

The distribution resulting from 2000 monte-carlo simulations are presented in Table 3.6.58. The arithmetic mean value of the distribution with filtered home air was 33% lower than the mean value of the distribution with unfiltered home air.

Table 3.6.58 Percentiles of the Distribution of the Estimated Personal Exposure

	$PM_{2.5}$ concentrations ($\mu g/m^3$)						
	10%	**25%**	**50%**	**75%**	**90%**	**Mean**	**St Dev**
Filtered home air	2.63	3.65	5.55	8.61	13.30	7.15	5.97
Unfiltered home air	3.48	5.04	7.99	12.83	20.24	10.66	9.49

3.7 Health Measures

We report on the data completeness of the health measures in Section 3.7.1. Summary statistics are included in Section 3.7.2, and results of data analysis are in Section 3.7.3.

3.7.1 Data Completeness

The primary QA/QC evaluation for the health data was the data completeness and if we were able to meet our goals of collecting data each season. An evaluation was conducted partway through the first year to determine if there were any systematic problems, the report is included in Appendix F. Overall the data met the completeness goals for the study. In this section, we report the completeness for each measure type by visit number as a percentage. The completeness is presented as the number and percent of visits completed and then the number and percent of collection of each instrument. Then, for the recall and MiniPAQL, we determine the percent of surveys for which each question was answered. The data for each individual question is reported with the results from the questionnaires. The fraction of individual missing questions is reported as a range for each instrument in this section. For eNO and spirometry, we evaluate the fraction of the time we obtained quantifiable data for the participant. For eNO, we further elevate the percent difference between two consecutive measures.

Table 3.7.1 has the information on data completeness for the study by study visit. The first column is the number of planned visits expected based on the number of active participants. In parentheses following the number of planned visits, is the percent of the enrolled population that was active for the visit. The second column, number of visits conducted, includes all visits for which any data was collected, most commonly this includes a recall questionnaire but in a few instances, only a Mini PAQLQ was collected. The percent of visits conducted is in parenthesis and the number of visits conducted divided by the number of planned visits and equals or exceeds 98% for all visits. The next two columns have the number and % of recall and Mini PAQLQs collected. The percent is calculated from the number of times instrument was collected versus the number of visits conducted. We were able to complete a recall with the participant in at least 98% of all visits. The response rate for each individual question was over 99%. Recall that all collected data were utilized in the analysis, regardless of whether or not the participant completed the study.

Table 3.7.1 Table of Data Completeness

	Number of planned visits	Number of visits conducted	Number of recall surveys	Number of Mini PAQL	Number of ENO	Number of Spirometry
Baseline	191 (100%)	191 (100%)	191 (100%)	185 (97%)	177 (93%)	186 (97%)
3 month	186 (97%)	183 (98%)	182 (99%)	148 (81%)		
6 month	176 (92%)	174 (99%)	174 (100%)	172 (99%)	162 (93%)	170 (98%)
9 month	171 (90%)	168 (98%)	168 (100%)	137 (82%)		
12 month	164 (86%)	160 (98%)	160 (100%)	160 (100%)	149 (93%)	143 (89%)
15 month	157 (82%)	155 (99%)	155 (100%)	123 (79%)		
18 month	152 (80%)	151 (99%)	151 (100%)	148 (98%)	141 (93%)	146 (97%)
21 month	150 (79%)	147 (98%)	144 (98%)	124 (84%)		
24 month	149 (78%)	149 (100%)	149 (100%)	143 (96%)	136 (91%)	129 (87%)

For the eNO, the table presents the number of visits where eNO was attempted versus the number of visits conducted. We were able to attempt eNO measurements at 93% of the visits, except at the 24 month visit where the number fell to 91%. The reasons eNO was not conducted when a visit was completed include the child not feeling well or other problems with child (5), eNO would not calibrate, come to temperature or otherwise wasn't working (8), child wasn't home (19), eNO not available for use – expired sensor or no eNO available (7), problem with take down visit, incomplete, dropped out or visit a phone call (10), or reason unknown (10). The majority of the time eNO was conducted, we obtained quantifiable data, defined as at least one successful attempt was recorded (708 attempts, 92.5%). Where data were not obtained, it was because the child did not understand the directions (21), in all their attempts the child blew too slowly, or too fast (35), or the child did not try (1).

For spirometry, the table presents the number of visits where spirometry was attempted versus the number of visits conducted. Depending on the visit type, the percent of time we attempted spirometry ranged from 87%-98%. Spirometry was not completed for many reasons, including no physical home visit was conducted (4), the spirometer was broken (15), the child was not home (9), the child's blood pressure was too high to perform the test (10), the child's BMI was so low staff felt uneasy performing the test (1), the parent refused the test (3), the child refused the test (1), the child had a chest injury in the last 3 months that prevented the test from being conducted (2), the child was too sick to perform the test (1), and no reason was recorded for an incomplete test (3). Note that the number of times for factors such as the child not being home differ between spirometry and eNO because we generally attempted spirometry at the first visit, and attempted eNO at the second visit.

Of the spirometry attempts, on average, 85% resulted in useable results. A small number of tests were attempted but did not result in quantitative results, specifically 2 children, on one occasion each, who could not blow out long enough or hard enough for the instrument to record a result.

Additionally, 4 records were unavailable due to a technical issue with the spirometer in which the data was not recorded. The children's ability to complete acceptable and reproducible results improved over time, with 76% of tests completed being acceptable and reproducible at baseline and increasing to 84% at 6-months, 89% at 12 months, and 90% at 18-months and 24 months.

Seasonality

Ideally, we wanted sampling to occur in the same 6 week block every season. Ninety-two participants exceeded this goal and had sampling within a 4 week block while another 59 participants met the 6 week goal. Another 12 had all of their visits within an 8 week window in the correct season, while 1 was within the 12 week season. We note that 10 participants started in December 2013, but that these visits were counted as "Fall". Eight of these participants had subsequent visits in a 6 week season window while the remaining 2 were in an 8 week season window. A total of 12 participants had a visit in the wrong season. In some cases, they had True filtration for more or less than 12 months, depending on which visits were late or early. In many cases, the visits were conducted in a shoulder month. Weather in Southern California often changes from season to season slowly and the weather is often not that different than the intended season. Five participants dropped out prior to their 3 month visit and are not counted. In total, 85% of the participants met the goal of having all visits within a 6 week time window. Only 6% had a visit outside the desired season.

3.7.2 Health Measure Results

Summary statistics are presented both at Baseline, and for the study period. Summary statistics for the actual study period are presented separately for data collected when the participant was experiencing True and Sham filtration separately. Results are generally presented separately for the primary child and for the sibling separately.

Recall

Table 3.7.2 has the primary outcome variable from the baseline recall period, as well as during the study. The recall diary asks about number of days of several types of symptoms in the last 14 days, specifically:

- Number of days with wheezing, tightness in the chest, or cough because of asthma.
- Number of days that the child had to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough.
- Number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough, during the two-week recall period.

From the two-week Recall Questionnaire, we determine the maximum number of days with symptoms, defined as the largest value from the above three variables a histogram of the number of days with asthma symptoms can be seen in Figure 3.7.1. All summaries statistics values report

arithmetic mean values. The majority of the participants did not experience symptoms or take medicine during the two weeks prior to enrollment. This was true also for each 2-week recall period during the study period. Frequency of symptoms and taking medicine were slightly higher in the true than sham periods. The statistical analysis is presented in Section 3.7.3.

Table 3.7.2 Summary Statistics from Recall Questionnaire

	N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max-imum
Created Variable: Number of days of asthma symptoms in the last 14 days									
Entire data set – Baseline	191	5.1	4.6	0	2	3	8	14	14
Entire data set – SHAM	622	2.8	3.9	0	0	1	4	8	14
Entire data set – TRUE	661	3.4	4.1	0	0	2	5	10	14
Primary Child - Baseline	172	5.1	4.6	0	2	3	8	14	14
Primary Child – SHAM	566	2.9	3.9	0	0	1	4	10	14
Primary Child – TRUE	604	3.5	4.1	0	0	2	5	10	14
Secondary Child – Baseline	19	5.2	5	0	1	4	10	14	14
Secondary Child – SHAM	56	2.2	3.1	0	0	1	3	7	14
Secondary Child – TRUE	57	3	3.5	0	0	2	5	7	14
Created Variable: Number of days inhaler in the last 14 days									
Entire data set – Baseline	191	2.9	3.9	0	0	2	4	10	14
Entire data set – SHAM	622	1.8	3.4	0	0	0	2	7	14
Entire data set – TRUE	661	2.2	3.6	0	0	0	3	7	14
Primary Child - Baseline	172	3	4	0	0	2	4	10	14
Primary Child – SHAM	566	1.8	3.4	0	0	0	2	6	14
Primary Child – TRUE	604	2.2	3.5	0	0	0	3	7	14
Secondary Child – Baseline	19	1.8	3	0	0	0	3	7	10
Secondary Child – SHAM	56	2.1	3.8	0	0	0	2	8	14
Secondary Child – TRUE	57	2.5	4.4	0	0	0	2	14	14
Created Variable: Number of hospital, ED, and clinic visits last year (Baseline) / 3 months (during study)									
Entire data set – Baseline	191	6.6	8	1	2	4	8	13	58
Entire data set – SHAM	622	0.7	1.6	0	0	0	1	2	16
Entire data set – TRUE	661	0.8	1.6	0	0	0	1	3	16
Primary Child - Baseline	172	6.7	8.3	1	2	4	8	13	58
Primary Child – SHAM	566	0.7	1.6	0	0	0	1	2	16
Primary Child – TRUE	604	0.8	1.7	0	0	0	1	3	16
Secondary Child – Baseline	19	5.7	5.3	1	1	4	8	13	21
Secondary Child – SHAM	56	0.7	1.6	0	0	0	1	2	9
Secondary Child – TRUE	57	0.8	1.1	0	0	0	1	2	6
Created Variable: Controller medication total score [1]									
Entire data set – Baseline	189	0.7	0.8	0	0	0.5	1	2	4
Entire data set – SHAM	618	0.6	0.8	0	0	0	1	2	5
Entire data set – TRUE	660	0.7	0.9	0	0	0.5	1	2	5
Primary Child - Baseline	171	0.7	0.8	0	0	0.5	1	2	4
Primary Child – SHAM	563	0.6	0.8	0	0	0	1	2	5
Primary Child – TRUE	604	0.7	0.9	0	0	0.5	1	2	5
Secondary Child – Baseline	18	0.7	0.7	0	0	0.8	1	2	2
Secondary Child – SHAM	55	0.4	0.6	0	0	0	1	1	3
Secondary Child – TRUE	56	0.6	0.6	0	0	0.5	1	1	2

[1] Controller total between 1 and 0.5 because the median was between 1 and 0.5

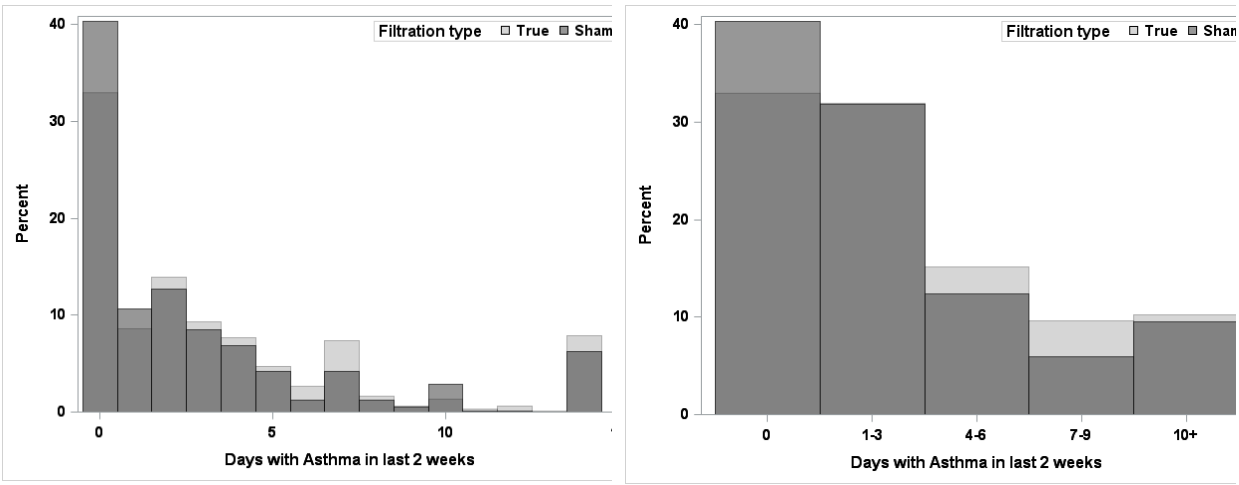


Figure 3.7.1 Days with asthma symptoms in the last 2 weeks by filtration status.

The baseline recall also asked about emergency room visits, overnight hospitalizations, and clinic visits for asthma over the prior year. The total numbers are reported in Table 3.7.2. Figure 3.7.2 shows the distribution of these visits by season, with visits occurring in all four seasons. Total number of medical visits during the study period is reported as events in the prior 3 months in Table 3.7.2.

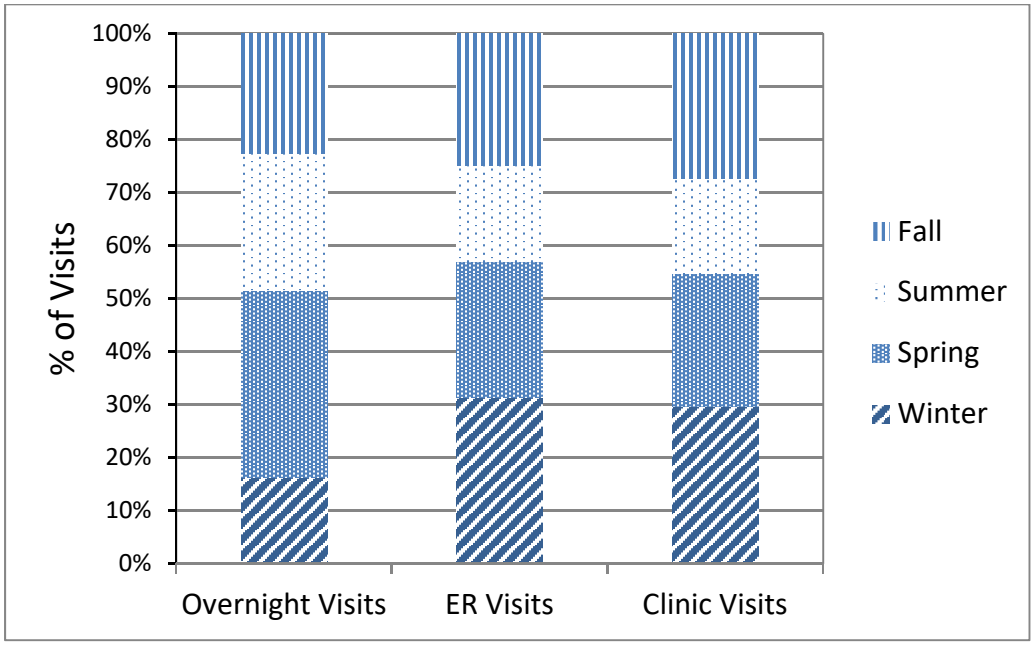


Figure 3.7.2 The relative frequency of each visit type occurring in each season during recall.

A summary variable for number of controller medicines taken is also reported (see Appendix C for details), with most participants not taking any controller medicines, and some participants reporting taking more than 2 controller medicines at a time.

Participants also reported if they had a cold, allergy symptoms, or were taking allergy medicine in the last two weeks (Table 3.7.3). The majority of the participants reported having allergy symptoms and taking allergy medicine.

Table 3.7.3 Whether Participants Had a Cold or Flu, Allergy Symptoms, or Took Allergy Medication during Recall Period

	Entire Data Set		Primary Children		Secondary Children	
	(n)	(%)	(n)	(%)	(n)	(%)
Created Variable: Had cold or the flu						
No - SHAM	462	74%	424	75%	38	68%
No - TRUE	472	71%	430	71%	42	74%
Yes - SHAM	159	26%	141	25%	18	32%
Yes - TRUE	189	29%	174	29%	15	26%
Missing - SHAM	1	0%	1	0%	0	0%
Created Variable: Allergy Symptoms						
No - SHAM	174	28%	154	27%	20	36%
No - TRUE	140	21%	130	22%	10	18%
Yes - SHAM	448	72%	412	73%	36	64%
Yes - TRUE	521	79%	474	78%	47	82%
Created Variable: Took allergy medicine						
No - SHAM	252	41%	235	42%	17	30%
No - TRUE	266	40%	246	41%	20	35%
Yes - SHAM	370	59%	331	58%	39	70%
Yes - TRUE	395	60%	358	59%	37	65%

The full list of responses from the baseline recall and from the recalls conducted during the study is included in Appendix C.

MiniPAQL

The MiniPAQL is completed by the child and results in summary scores for three domains: symptoms, emotional function, and activity limitations. Each individual item is scored from 1 to 7, with 1 being very bothered and 7 being not bothered, with the domains being sums of scores. The summary statistics in Table 3.7.4 indicate that participants were generally not bothered by their asthma. The scores were generally similar between the Baseline, True, and Sham periods.

3.7.4 Summary Statistics from MiniPAQL

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl
Sum of symptom responses: sum Q1-Q6									
Entire data set - Baseline	182	31.6	8.2	6	20	26	34	38	41
Entire data set - SHAM	557	35.8	6.9	9	26	33	38	41	42
Entire data set - TRUE	582	35.3	7.3	9	26	32	38	41	42
Primary Child - Baseline	164	31.6	8.0	6	20	26	34	38	41
Primary Child - SHAM	507	36.0	6.8	9	26	33	38	41	42
Primary Child - TRUE	536	35.3	7.2	9	26	32	38	41	42
Secondary Child - Baseline	18	31.5	9.6	9	14	26	36	38	41
Secondary Child - SHAM	50	34.6	7.8	10	24	31	37	41	42
Secondary Child - TRUE	46	34.8	8.3	12	18	29	39	41	42
Sum of emotional function responses: sum Q7-Q10									
Entire data set - Baseline	183	22.8	5.8	4	15	19	25	28	28
Entire data set - SHAM	559	25.6	4.2	4	20	25	28	28	28
Entire data set - TRUE	586	25.2	4.4	8	19	24	27	28	28
Primary Child - Baseline	165	22.8	5.9	4	15	19	25	28	28
Primary Child - SHAM	509	25.6	4.1	4	20	25	28	28	28
Primary Child - TRUE	540	25.2	4.4	8	19	24	27	28	28
Secondary Child - Baseline	18	23.3	5.5	12	15	19	26	28	28
Secondary Child - SHAM	50	25.5	4.5	8	21	25	27.5	28	28
Secondary Child - TRUE	46	24.8	4.6	11	17	22	27.5	28	28
Sum of activity limitation responses: Sum Q10-Q13									
Entire data set - Baseline	181	16.2	4.0	3	11	14	17	19	21
Entire data set - SHAM	555	18.2	3.3	4	14	17	19	21	21
Entire data set - TRUE	583	17.8	3.6	3	13	16	19	21	21
Primary Child - Baseline	164	16.2	4.0	3	11	14	17	19	21
Primary Child - SHAM	507	18.3	3.2	6	14	17	19	21	21
Primary Child - TRUE	536	17.8	3.6	3	13	16	19	21	21
Secondary Child - Baseline	17	16.0	3.6	9	9	14	17	18	20
Secondary Child - SHAM	48	18.0	3.9	4	12	17	19	21	21
Secondary Child - TRUE	47	17.7	3.4	8	12	15	19	21	21

eNO

Out of 765 eNO tests conducted, 57 had 0 successful attempts (7%), 31 had one successful attempt (4%) and 677 had two successful attempts (88%). There were 8 visits where both values were less than 5ppb, for these cases we used 4ppb as the value, just below the minimum value of 5ppb recorded by the NIOX because it is unlikely eNO concentrations are much lower than 5ppb as all humans do have some level of eNO. There were 13 visits where one value was less than

5 ppb, and the other value was small, between 5 and 8 ppb, in those cases where we substituted the less than 5 ppb with 4 and averaged the two values.

We reviewed the values where the average was above 110 ppb, which occurred 24 times. Of these, all but two were from 11 children who had repeated high measures, either above 110 ppb, or one child with another value another value very near 110 ppb. Two occurrences were from children who had typical values for the remaining visits. No outlier values were excluded from the analysis. There were only 4 values where the absolute difference was >20ppb. Table 3.7.5 has summary statistics for eNO, with all values presented in the units of ppb. Distributions are presented for the whole dataset for baseline measurements, the measurements taken during TRUE filtration, and the measurements taken during SHAM filtration. The same statistics are also presented for the primary child in the study, as well as the siblings. Normal values of eNO are below 30 ppb, with higher values indicating some degree of inflammation. The 75th percentile values exceed 30 ppb.

3.7.5 Summary Statistics from eNO (Units in ppb)

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Mean of successful trial measurement values										
Entire data set - BASELINE	150	25.6	25.7	5	7	9	14	33	58	135
Entire data set - SHAM	279	29.9	32.2	4	7	9	15	40	79	168
Entire data set - TRUE	279	30.2	29.3	4	7	10	17	45	68	163
Primary Child - BASELINE	137	25.9	26.4	5	7	9	14	33	59	135
Primary Child - SHAM	254	30.9	32.7	4	7	9	16	43	79	168
Primary Child - TRUE	255	31.4	30.1	4	7	10	18	48	72	163
Enrolled Sibling - BASELINE	13	21.9	16.7	8	8	11	17	22	56	57
Enrolled Sibling - SHAM	25	19.9	26.1	5	8	8	11	15	46	112
Enrolled Sibling - TRUE	24	17.1	12.9	6	7	8	13	25	36	57
Percent difference between 2 successful values										
Entire data set	677	10%	11%	0	0	1%	7%	13%	22%	67%
Absolute value of the difference between 2 successful values										
Entire data set	677	2.3	4.0	0	0	1	1	3	5	67

Spirometry

Table 3.7.6 has summary statistics for three measurements of spirometry, FEV1, FVC, and FEV1/FVC, with all values presented as the percent predicted for children of their race, gender, and height. Distributions are presented for the whole dataset for baseline measurements, the measurements taken during TRUE filtration, and the measurements taken during SHAM filtration, presented for the primary child in the study, as well as the secondary children, the

siblings. One of the factors for defining severity of asthma as moderate is having FEV1 or FEV1/FVC as less than 80% of the predicted value. The majority of the children had lung functions values exceeding these values.

Table 3.7.6 Summary Statistics for Spirometry (reported as percent predicted)

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
FVC % Predicted										
Entire data set - Baseline	141	102.4	15.1	73	83	92	101	109	123	149
Entire data set - SHAM	258	99.4	11.6	60	84	91	100	107	114	130
Entire data set - TRUE	260	99.5	12.4	66	83	92	99	108	116	129
FEV1% Predicted										
Entire data set - Baseline	141	101.4	16.3	71	78	90	100	113	124	140
Entire data set - SHAM	258	94.9	13.9	48	76	85	96	105	112	138
Entire data set - TRUE	260	95.3	14.1	52	77.5	86	96	104	112	137
FEV1/FVC % Predicted										
Entire data set - Baseline	141	97.8	7.7	71	89	93	99	103	107	113
Entire data set - SHAM	258	95.2	8.6	60	84	91	97	101	105	116
Entire data set - TRUE	260	95.5	8.9	62	86	91	97	101	105	112

BMI

BMI was measured prior to performing spirometry. BMI is calculated as a person's weight in kilograms divided by their height in meters squared and is reported without units. In cases where no spirometry data was obtained BMI was sometimes measured and sometimes was not. All BMI measurements are included in the summary statistics, despite whether spirometry data was obtained. BMI summary statistics for boys and girls are presented below in Table 3.7.7. It is noted these are actual BMI values, rather than age- and sex-adjusted BMI values. BMI values are not used in any statistical analysis.

Table 3.7.7 Summary Statistics for BMI

	N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Entire data set	785	19.9	4.9	12.8	15.3	16.6	18.6	22.1	26.2	45.0
Entire data set - Male	499	20.0	5.1	13.5	15.1	16.3	18.5	22.4	26.0	45.0
Entire data set - Female	286	19.8	4.5	12.8	15.5	16.9	18.7	21.6	26.5	35.6

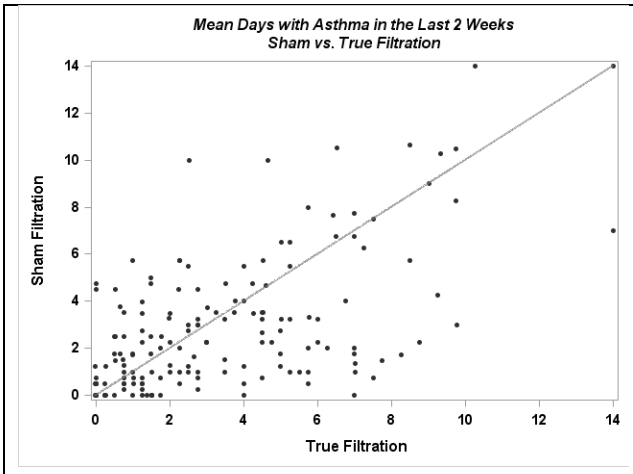
Severity Results

Eleven percent of our population was classified as severe persistent asthma, 41% as moderate persistent asthma, and 48% as mild persistent asthma. As compared to asthmatics as a whole, we had more classified as moderate. This is to be expected because our screening criteria specified that participants were only eligible if they had symptoms at least twice a week for several weeks in a row, and that these symptoms occurred within the last six months. This assessment was more conservative than that estimated by physicians in the TENOR study and that was our intention [169] . Other studies, including Dusser et al.[170], gauged mild persistent asthma as 50-75% of all asthmatics.

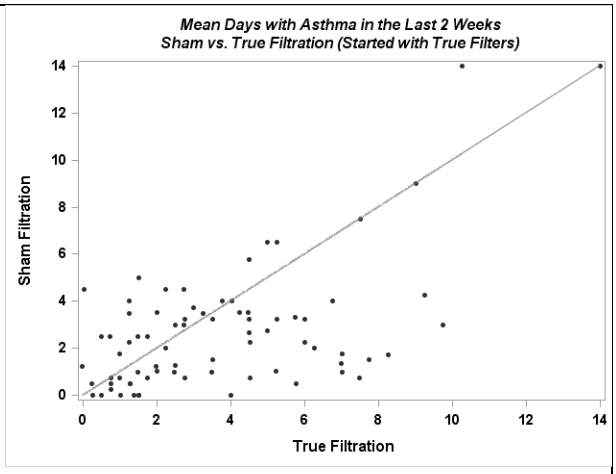
3.7.3 Objective 2: Evaluation of Intervention: Reduction of Asthma Symptoms and Indicators

Objective 2 investigated the relationships between filtration status and various health endpoints relevant to asthma. The primary health endpoint, obtained via the Recall Questionnaire, was the number of days the child experienced asthma symptoms in the previous 2 weeks. The main analysis consisted of fitting two types of mixed-effects models deemed most appropriate for the outcome data: (a) Poisson and (b) Ordered Multinomial (with the outcome categorized as 0, 1-3, 4-6, 7-9, and 10+ days with asthma); other models specifying Beta and Negative Binomial distributions were also attempted but did not converge. All models specified subject ID as a random effect and included covariates city and season. Recall that data was collected to provide seasonally matched comparisons, with the majority of participants having all visits of a season within a 6-week time window. An indicator variable for study year (year 1, year 2) was also added to control for calendar time effects that were not fully accounted for in this cross-over design. An analysis was also completed to compare pre-intervention measurements with measurements collected in both true and sham periods.

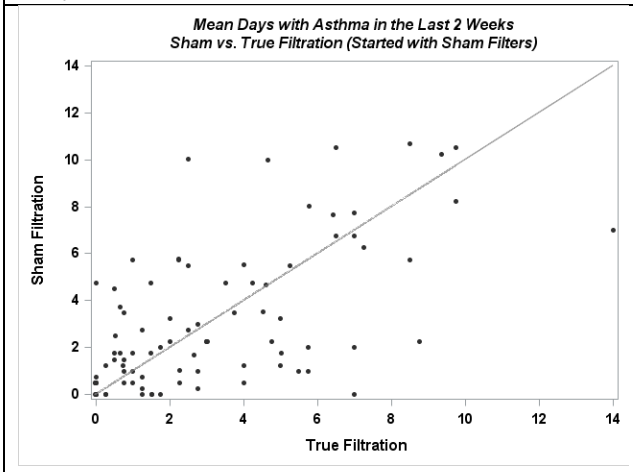
Initial examination of data included generating plots and descriptive statistics. The scatter plots in Figure 3.7.3 illustrate that children experienced fewer days with asthma symptoms, on average, with sham filtration compared with the true filtration period. This is indicated by more points falling below the diagonal line in these plots, particularly in plots A, B and D. Further examination of the data revealed that there were fewer symptoms in the second year of the study (analyses presented in Appendix F4, sections 3-5). Given that there was more true filtration in the first year (75% of study visits were in true filtration) than the second year (25% of the study visits were in true filtration), the results presented in the scatter plots cannot disentangle year effects. Therefore, year in study was added as a covariate. When stratified by covariates study year, city, and season, mean days with asthma symptoms did not strikingly differ by filtration status. These descriptive statistics are presented in Table 3.7.8.



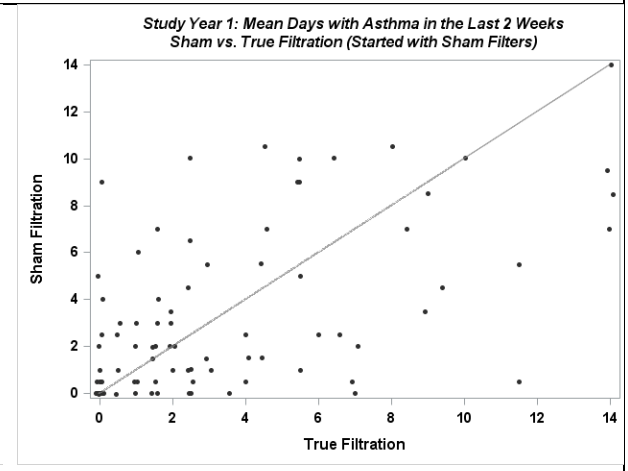
A. All households irrespective of filter type at start of the study



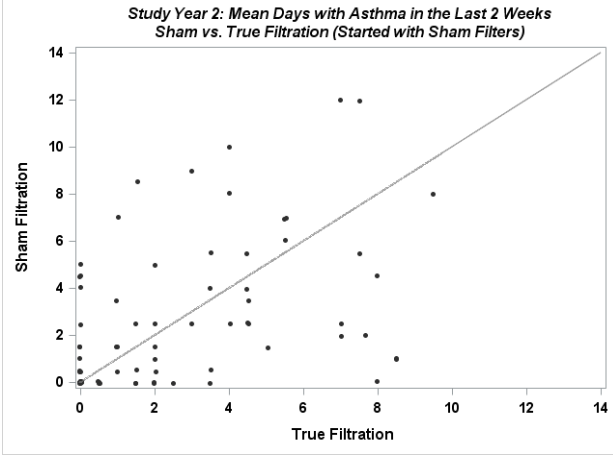
B. Households with true filters installed at the start of study



C. Households with sham filters installed at the start of study



D. Households with sham filters at the start of study in Year 1



E. Households with sham filters at the start of study in Year 2

Figure 3.7.3 Scatter plots comparing asthma symptoms in Sham vs. True. Each data point represents days with asthma symptoms in the last 2 weeks averaged over the entire Sham or True period for each child. Data points falling on the diagonal line indicate no differences in mean days with asthma by filtration status. Points above the line indicate more days with asthma during Sham while points below the diagonal line indicate fewer days with asthma in Sham.

Table 3.7.8 Days with asthma symptoms in the last 2 weeks by filtration status, stratified by covariates Study Year, City, and Season

			Days with asthma symptoms in last 14 days											
			Filtration Status											
			SHAM						TRUE					
Study	**City**	**Season**	**N**	**Mean**	**StdDev**	**Median**	**P25**	**P75**	**N**	**Mean**	**StdDev**	**Median**	**P25**	**P75**
Year 1	**Fresno**	**Winter**	23	4.4	5.4	3	0	10	83	4	4.54	2	0	7
		Spring	28	4	4.75	2	0.5	5.5	85	3.9	4.25	3	1	5
		Summer	32	3	4.19	1	0	4	76	3.1	4.28	2	0	4
		Fall	40	3.5	4.1	2	0	7	72	4.4	4.21	3	1	7
	Riverside	**Winter**	30	3.4	4.17	2	0	5	34	3.8	4.04	2	1	7
		Spring	10	1.7	3.06	0.5	0	2	50	3.5	4.34	2	0	4
		Summer	5	1.8	2.49	0	0	4	56	2.8	3.7	1	0	4
		Fall	24	2.8	4.02	1	0	5	36	3.4	4.04	2	0	4
Year 2	**Fresno**	**Winter**	74	2.6	3.34	1.5	0	4	22	3.1	4.39	2	0	3
		Spring	70	3	3.85	2	0	4	25	3.4	3.81	2	0	6
		Summer	60	2.2	3.58	1	0	3	37	2.2	3.36	1	0	2
		Fall	69	3	3.57	2	0	4	31	3.2	3.3	2	0	6
	Riverside	**Winter**	27	1.7	3.04	0	0	3	24	2.8	3.84	2	0	4
		Spring	44	3.7	4.83	1	0	7	8	2.4	2.26	2.5	0	4
		Summer	51	1.7	2.98	0	0	3	2	1	1.41	1	0	2
		Fall	35	2.1	3.34	1	0	3	20	2.2	3.47	0.5	0	3

Symptoms were evaluated using generalized linear mixed-effects models. Both the Poisson and Ordered Multinomial models produced comparable results. The findings presented below are from Poisson models with the endpoint expressed as a continuous count of days with asthma symptoms in the last 14 days (log counts). True filtration status was not associated with improvements in asthma symptoms (β= -0.05 [-0.19, 0.08], p=0.41) (Table 3.7.9). On average, children experienced two days with asthma symptoms in periods with sham (Mean =2.16 [1.84, 2.54]) and true filtration (Mean=2.28 [1.95, 2.68]) (Table 3.7.10).

Table 3.7.9 Parameter Estimates from Poisson Mixed-Effects Model Examining Whether the Number of Days the Child Had Asthma in the Last 2 Weeks Differs by Filtration Type

Effect	City	Season	Filtration Status	Study year	Estimate	SE	t Value	Pr > |t|	Lower	Upper
Intercept					0.65	0.15	4.26	<.0001	0.35	0.95
TRUE			SHAM		-0.055	0.067	-0.82	0.41	-0.19	0.077
TRUE			TRUE		0	.	.	.	.	.
season		Fall			-0.05	0.081	-0.67	0.50	-0.21	0.10
season		Summer			-0.32	0.086	-3.66	<.001	-0.49	-0.15
season		Winter			-0.050	0.083	-0.6	0.55	-0.21	0.11
season		Spring			0	.	.	.	.	.
area	Fresno				0.30	0.15	2.02	0.04	0.009	0.59
area	Riverside				0	.	.	.	.	.
VisitYr1				Year 1	0.26	0.07	3.38	<.001	0.11	0.41
VisitYr1				Year 2	0	.	.	.	.	.

Table 3.7.10 Log Mean Counts of Days the Child Had Asthma Symptoms in the Last 2 Weeks by Filtration Type

Filtration type	Log Mean	95% CI		Mean	95% CI	
SHAM	0.77	0.61	0.93	2.16	1.84	2.54
TRUE	0.83	0.67	0.99	2.28	1.95	2.68

As an alternative analysis a balanced study design was constructed by considering only months 1-6 and 13-18. Approximately half the population was in true for months 1-6 and in sham for months 13-18, with the other half of the population having the opposite filtration schedule. After controlling for season and city, the sham and true filtration treatments did not differ significantly with respect to the log-mean number of days the child experienced asthma symptoms (β= -0.08 [-0.25, 0.09], p=0.35) (Appendix F4, Section 6).

Several mediating factors were examined in the relationship between filtration status and asthma symptom episodes; these included (1) using controller medication, (2) having a cold or flu in the past 2 weeks, and (3) averaged measurements of indoor $PM_{0.2}$, $PM_{2.5}$, and PM_{10} levels during the sham and true filtration periods. Controller medication was the only factor that met the definition of a mediator (M) (i.e., was associated with filtration status, the predictor [X →M], and with days with asthma symptoms, the outcome [M→Y]). Nonetheless, adding controller medication to the main model that assessed the relationship between filtration status and asthma symptoms did not change the lack of association observed between filtration status and asthma symptoms in the main analysis. Cold or flu in the past 2 weeks did not meet the definition of a mediator. Both filtration groups had the same frequency of cold/flu episodes. Likewise, indoor PM levels did not meet the definition of a mediator. While PM levels ($PM_{0.2}$, $PM_{2.5}$, PM_{10}) were significantly lower

in the true filtration group compared with sham (all p<0.0001), PM levels were not associated with the number of days the child experienced asthma symptoms in the last 2 weeks. For details, see section "Medication analyses" in Appendix F.4.

Moderating factors (effect modification) that were examined included (1) having air cleaners versus central filtration in the home, (2) asthma severity (rated mild, moderate, or severe), (3) presence of allergies to furry pets in homes with furry pets, (4) gas stove in the home, (5) presence of mold or water damage, (6) filtration use ratio (proportion of volume normalized to what asked to use during air sampling week), and (7) the sham-true difference in indoor $PM_{0.2\text{-}2.5}$ (in a subset including study months 1-6 and 13-18 only, for a balanced crossover design, and omitting covariate study year). Moderation with presence of any allergy was not conducted because only 4% of the population did not have allergies. Two-way interaction terms (filtration type × *moderator*) were added one-by-one to the main model to determine whether any of these factors modified the association between filtration status and days with asthma symptoms.

Air cleaners versus central filtration in the home and asthma severity modified the association between filtration status and asthma symptoms (p<0.15). These moderators are described below.

The proportions of homes with air cleaners vs. central filtration were similar by filtration status, as expected, with approximately 22-24% of homes using central filtration. The 2-way interaction term filtration type × filtration system was significant, indicating that having a central filtration system in the home modified the association between days with asthma symptoms and filtration status (p=0.07).

During the sham period, days with asthma symptoms were significantly higher in homes with air cleaners compared with homes with central system filtration (0.37 [0.18] *p*=0.05). In homes with central filtration systems, the log mean number of days with asthma symptoms was significantly lower during the period with sham filtration compared with the period with true filtration period (β= -0.30 [-0.60, 0.00], p=0.05) (Table 3.7.11); however, in homes with air cleaners, no differences were detected in days with asthma symptoms between true and sham (β=0.00 [-0.16, 0.16], p=0.98). The difference in sham-true differences in log mean days with asthma between air cleaner and central system homes was marginally statistically significant (β= -0.30 [-0.03, 0.63], p=0.07).

During the period with sham filtration, the mean number of days with asthma in homes with air cleaners and central system filtration were 2.32 [1.94, 2.78] and 1.61 [1.16, 2.25], respectively. During the true filtration period, the mean number of days with asthma in homes with air cleaners and central system filtration were 2.32 [1.93, 2.78] and 2.18 [1.64, 2.90], respectively.

Table 3.7.11 Contrasts in log geometric mean days the child had asthma symptoms in the last 2 weeks for each level of filtration type x filtration system (TRUE x HVAC) interaction term in the negative binomial mixed-effects model

Contrast	β	95% CI	p-value
Air Cleaner: Sham vs True	0.00	-0.16, 0.16	0.98
Central: Sham vs True	-0.30	-0.60, 0.00	0.05
Air Cleaner vs Central diff in Sham vs True diffs	**0.30**	**-0.03, 0.63**	**0.07**

The majority of children had mild asthma (48-51%), followed by moderate (40-42%), and then severe asthma (9-10%). The 2-way interaction term filtration status x asthma severity was statistically significant, indicating that asthma severity modified the association between days with asthma symptoms and filtration status (p=0.05). The sham vs. true filtration differences in log mean days with asthma for each level of severity are presented in Table 3.7.12, along with comparisons of asthma severity categories with respect to these sham-true mean differences.

During the sham period, log mean number of days with asthma symptoms were significantly higher in children with severe asthma compared to children with mild asthma (difference in log means=0.78 [0.21] *p*=0.0003); similarly, during the true filtration period, log mean number of days with asthma symptoms were higher in children with severe asthma compared to mild asthma (difference in log means=0.65 [0.23], *p*=0.01).

The log mean number of days with asthma symptoms did not differ between true and sham filtration in children with mild asthma (β=0.02 [-0.19, 0.24], p=0.82). Children with severe asthma had slightly fewer symptoms with true filtration, although the result was not significant (0.15 [-0.09, 0.39], p=0.22). Interestingly, among children with moderate asthma, the number of days with asthma symptoms was significantly lower during sham compared with the true filtration period (-0.20 [-0.38, -0.03], p=0.03). The difference between severe and mild asthma in sham vs. true filtration differences in log mean days with asthma was not significant (0.13 [-0.18, 0.44], p=0.42). The difference between moderate and mild asthma in sham-true differences was marginally significant (-0.23 [-0.50, 0.04], p=0.10).

The log mean and mean number of days with asthma symptoms are presented in Table 3.7.13. During the sham period, the mean number of days with asthma symptoms in children with mild, moderate, and severe asthma were 1.98 [1.59, 2.46], 2.01 [1.56, 2.58], and 4.31 [2.98, 6.23], respectively. During the true filtration period, the mean number of days with asthma in children with mild, moderate, and severe asthma were 1.93 [1.56, 2.38], 2.46 [1.94, 3.12], and 3.70 [2.44, 5.62], respectively.

Table 3.7.12 Contrasts in log mean number of days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	β	95% CI	p-value
Mild: Sham vs True	0.02	-0.19, 0.24	0.82
Moderate: Sham vs True	-0.20	-0.38, -0.03	0.03
Severe: Sham vs True	0.15	-0.09, 0.39	0.22
Severe vs Mild difference in Sham vs True differences	0.13	-0.18, 0.44	0.42
Moderate vs Mild difference in Sham vs True differences	-0.23	-0.50, 0.04	0.10

Table 3.7.13 Log Mean and Mean number of days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Filtration type	Asthma severity	Log Mean	95% CI	Mean	95% CI
Sham	Mild	0.68	0.46, 0.90	1.9786	1.59, 2.46
Sham	Moderate	0.70	0.44, 0.95	2.0053	1.56, 2.58
Sham	Severe	1.46	1.09, 1.83	4.3098	2.98, 6.23
True	Mild	0.66	0.45, 0.87	1.9300	1.56, 2.38
True	Moderate	0.90	0.66, 1.14	2.4576	1.94, 3.12
True	Severe	1.31	0.89, 1.73	3.7006	2.44, 5.62

Having allergies to furry animals and having a furry animal in the home did not modify the frequency of symptoms between true and sham filtration (p=0.68). However, participants with an allergy to a furry pet who had a furry pet in their home, compared with those with no allergies, reported more symptoms during sham filtration (β= 0.30 [-0.04, 0.63], p=0.08) and there were moderately more symptoms during true filtration (0.24 [-0.05, 0.54], p=0.11) than those participants not living with an animal to which they were allergic.

Homes with gas stoves or with evidence of mold or water damage were not associated with children experiencing more or fewer days with asthma symptoms regardless of filtration status. Filtration status was also not associated with asthma symptom frequency regardless of whether the home had a gas stove or not or whether there was mold or water damage in the home. Approximately 72% of homes had gas stoves. Mold or water damage was present in 20% of homes during sham treatment and 26% of homes during true filtration treatment. The filtration use ratio also did not significantly modify results, meaning that the sham versus true filtration differences in asthma symptom frequency did not vary at different filtration use ratios. (For details, see section 8-16 Appendix F.4).

Symptoms in the pre-installation period were compared to those in the first year of the study to evaluate the potential impact of being in the study. The same statistical methods were used as

were used for the comparison between the sham and true periods. Only the first year was included in this analysis due to the decrease in asthma symptoms over time. In a main effect model, the number of days with asthma symptoms (expressed as log counts) was significantly higher before installation of high-efficiency filtration than during sham (β= 0.47 [0.26, 0.68], $p<0.0001$) and true filtration periods (0.35 [0.20, 0.51]; $p<0.0001$) in the first year of the study (Table 3.7.14). The mean number of days with asthma symptoms at pre-installation and during the sham and true filtration periods were 3.97 [3.41, 4.63], 2.49 [2.04, 3.04], and 2.79 [2.40, 3.25], respectively.

Because severity was found in the main analysis to be a significant modifying factor, it was added to the analysis comparing with pre-intervention measures, finding that asthma severity significantly modified the association between filtration status and days with asthma symptoms ($p<0.0001$) at pre-installation and in the first year of the study. Among children with mild asthma, the difference in log mean days with asthma symptoms in the prior 2 weeks was not statistically significant between the pre-installation period and either the sham period that occurred in the first year (β= -0.18 [-0.53, 0.16], p=0.29); or the true filtration period that occurred in the first year (-0.21 [0.11], p=0.06) (Table 3.7.14). Among children with moderately severe asthma, log mean days with asthma symptoms were significantly higher at pre-installation than during the sham (0.86 [0.57, 1.15], p<0.0001) and during true filtration (0.63 [0.40, 0.86], p<0.0001) periods occurring during the first year of the study. Among children with severe asthma, days with symptoms were also higher at pre-installation compared with sham (0.42 [-0.02, 0.86], p=0.06) and true (0.44 [-0.01, 0.89], p=0.05) filtration periods occurring in the first year. Contrasting the pre-installation vs. sham differences in log mean days with asthma across asthma severity categories revealed significant differences, with greater pre-installation vs. sham differences observed among children with severe asthma (0.60 [0.06, 1.15], p=0.03) and moderately severe asthma (1.04 [0.61, 1.48], p<0.0001) compared to those with mild asthma. Contrasts with pre-installation vs. true filtration periods revealed the same patterns, with higher number of days with asthma at pre-installation compared with true filtration periods seen among children more severe asthma (severe vs. mild asthma, pre- vs. true: 0.65 [0.16, 1.15], p=0.01; moderate vs mild asthma, pre- vs. true: 0.84 [0.53, 1.16], p<0.0001). Although comparisons of pre-installation means with post-installation means is only of secondary importance, the higher levels of symptoms seen in the pre-installation period compared to the post-installation periods suggests that “regression-to-the-mean” effects are present in this trial.

Symptoms reported at the baseline visit were one of the factors used in classifying participants between mild, moderate, severe asthma, and thus it is expected that these participants have more symptoms at pre-installation.

Overall, children with more severe asthma experienced more days with asthma symptoms, compared to children with milder asthma, irrespective of the study period (pre-installation, sham, or true filtration). At pre-installation, days with symptoms were significantly higher in children

with moderate and severe asthma compared with mild asthma (moderate: 1.20 [0.13], $p<0.0001$; severe: 1.31 [0.24], $p<0.0001$). The same trends were observed during sham and true filtration periods but to a lesser extent.

At pre-installation, the mean number of days with asthma symptoms in children with mild, moderate, and severe asthma were 1.87 [1.52, 2.30], 6.23 [5.27, 7.37], and 6.93 [4.49, 10.68], respectively. In sham, the mean number of days with asthma symptoms in children with mild, moderate, and severe asthma were 2.25 [1.62, 3.12], 2.65 [2.00, 3.51], and 4.56 [2.77, 7.51], respectively. In true filtration, the mean number of days with asthma symptoms in children with mild, moderate, and severe asthma were 2.31 [1.88, 2.85], 3.32 [2.69, 4.10], and 4.45 [2.65, 7.49], respectively.

Table 3.7.14 Contrasts in log mean days with asthma symptoms for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	β	95% CI	p-value
Main Effects Analysis:			
All: Pre vs Sham	0.47	0.26, 0.68	<.0001
All: Pre vs True	0.35	0.20, 0.51	<.0001
All: Sham vs True	-0.12	-0.30, 0.07	0.22
Interaction Analysis			
Mild: Pre vs Sham	-0.18	-0.53, 0.16	0.29
Moderate: Pre vs Sham	0.86	0.57, 1.15	<.0001
Severe: Pre vs Sham	0.42	-0.02, 0.86	0.06
Severe vs Mild difference in Pre vs Sham differences	0.60	0.06, 1.15	0.03
Moderate vs Mild difference in Pre vs Sham differences	1.04	0.61, 1.48	<.0001
Mild: Pre vs True	-0.21	-0.43, 0.01	0.06
Moderate: Pre vs True	0.63	0.40, 0.86	<.0001
Severe: Pre vs True	0.44	-0.01, 0.89	0.05
Severe vs Mild difference in Pre vs True differences	0.65	0.16, 1.15	0.01
Moderate vs Mild difference in Pre vs True differences	0.84	0.53, 1.16	<.0001

Next, analyses with secondary health outcomes were conducted. Severity was included as a moderator in all analysis as it was a significant modifier in the main analysis. Secondary health outcomes included the following: (1) the number of days the child used a rescue inhaler in the previous 2 weeks, (2) the number of missed school days due to asthma in the previous 2 weeks (if in school), (3) the number of hospital, emergency department (ED), or clinic visits in the previous 3 months (examined collectively and individually), (4) the number of times the child received steroid treatments in the past 3 months, (5) Mini PAQL scores on the symptom, emotional function, and physical limitation scales, (6) mean exhaled Nitric Oxide (eNO), (7) spirometry measurements (forced vital capacity [FVC], forced expiratory volume at 1.0 second [FEV1], and FEV1/FVC %), and (8) the number of nights the child woke in the air-cleaner homes, modified with whether the bedroom door was open.

There were statistically significant findings in the anticipated direction for both the number of clinic visits and the sum of hospital, ED, and clinic visits in the previous 3 months, nights the child awoke, and MiniPAQL symptom scores. Additionally, the number of clinic visits was also evaluated for months 1-6 and 13-18, which provided a balanced study design. All of these results are presented below.

None of the other health outcomes differed significantly by filtration status: (1) the number of days the child used a rescue inhaler in the previous 2 weeks, (2) the number of missed school days due to asthma in the previous 2 weeks (if in school), (3) the number of times the child received steroid treatments in the past 3 months, (4) Mini PAQL scores on the emotional function and physical limitation scales, (6) mean exhaled Nitric Oxide (NO), and (7) spirometry measurements (forced vital capacity [FVC], forced expiratory volume at 1.0 second [FEV1], and FEV1/FVC %). These results are not presented here, but are included in Appendix F5. Appendix F5 also includes additional tables on the results presented below.

Children had more total healthcare resource use, the combined log mean hospital, ED, and clinic visits during the sham period compared with the true filtration period (β= 0.21 [0.002, 0.42], p=0.048) (Table 3.7.15). This reflects a 19% reduction in visits during the true filtration period. The mean number of visits in sham and true filtration periods were 0.52 [0.42, 0.64] and 0.42 [0.34, 0.52], respectively. Overall, the associations between filtration status and the number of hospital, ED, and clinic visits only slightly varied depending on asthma severity (p=0.16). The number of visits was only significantly higher in sham than in true filtration among children with severe asthma (0.55 [0.05, 1.04], p=0.03) but not among those with moderate or mild asthma (Table 3.7.16. However, we do not have statistically significant evidence that the sham versus true filtration contrasts in mean number of visits varied by asthma severity, so the results seen in the subgroup of patients with severe asthma should be interpreted cautiously.

When examined individually, hospital visits were too sparse for further analyses, with fewer than 3% of children with any hospital visits. Emergency Department visits were also sparse, with less than 9% of children having any ED visits. There were no significant differences in the frequencies of ED visits by filtration status, although data were sparse.

The log mean number of clinic visits was significantly higher during the sham period compared with the true filtration period (β= 0.22 [0.01, 0.42], p=0.04) (Table 3.7.16). This reflects a 20% reduction in visits during the true filtration period. There were slight variations in sham vs. true differences in log mean clinic visits across levels of asthma severity (p=0.11). The largest differences in log mean clinic visits were observed among children with severe asthma (0.57 [0.01, 1.13], p=0.05) followed by sham vs. true differences among children with mild asthma (0.24 [-0.03, 0.50], p=0.08). No significant differences in log mean clinic visits between

sham and true filtration were detected among children with moderately severe asthma (-0.04 [-0.32, 0.24], p=0.80). The sham vs. true differences in log mean visits were not significantly different between those with severe asthma compared with those with mild asthma (0.33 [-0.29, 0.95], p=0.29); while the sham vs. true differences were slightly smaller in magnitude among children with moderately severe asthma than those with mild asthma (-0.27 [-0.62, 0.07], p=0.12).

Asthma severity was also examined as a moderator in the relationship between filtration status and the number of unplanned clinic visits for asthma symptoms in a balanced crossover design (study months 1-6 and 13-18 only and omitting covariate study year). The number of clinic visits did not differ by filtration status (p=0.96) in this subset, and the severity of asthma did not modify this association.

Table 3.7.15 Contrasts in log mean visits to the hospital, ED, and clinic in the last 3 months for each level in the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	β	95% CI	p-value	% of population	% reduction
Main Effects Analysis:					
Sham vs True	0.21	0.002, 0.42	0.048	100%	19%
Interaction Analysis:					
Mild: Sham vs True	0.20	-0.08, 0.48	0.17	48-51%	
Moderate: Sham vs True	-0.01	-0.32, 0.29	0.94	40-42%	
Severe: Sham vs True	0.55	0.05, 1.04	0.03	9-10%	42%
Severe vs Mild difference in Sham vs True differences	0.35	-0.23, 0.93	0.23		
Moderate vs Mild difference in Sham vs True differences	-0.21	-0.58, 0.17	0.28		

Table 3.7.16 Contrasts in log mean visits to the clinic in the last 3 months for each level in the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	β	95% CI	p-value	% reduction
Main Effects Analysis:				
Sham vs True	0.22	0.01, 0.42	0.04	20%
Interaction Analysis:				
Mild: Sham vs True	0.24	-0.03, 0.50	0.08	21%
Moderate: Sham vs True	-0.04	-0.32, 0.24	0.80	
Severe: Sham vs True	0.57	0.01, 1.13	0.05	43%
Severe vs Mild difference in Sham vs True differences	0.33	-0.29, 0.95	0.29	
Moderate vs Mild difference in Sham vs True differences	-0.27	-0.62, 0.07	0.12	

The number of days a child awoke was considered a secondary outcome. As the children with filtration using air cleaner had an air cleaner in their room, and it was thus anticipated that they would have the lowest nighttime particle concentrations, particularly if they kept their door shut, the analysis was limited to that group. A moderator for door open was included. The days per week the child's bedroom door was kept open was the same during true and sham filtration, as expected (Mean=4.0, Median=6). The 2-way interaction term filtration type x bedroom door was statistically significant, indicating that the frequency of keeping the child's bedroom door open changed the magnitude of the association between days the child woke up due to asthma and filtration type (p=0.03) (Table 3.7.17). For children that always kept their door shut, there were less frequent incidences of waking in the night with true filtration than with sham filtration. Specifically, the difference in log mean days the child woke up due to asthma between sham and true filtration periods decreased by a factor of 0.0976 for each additional day per week that the bedroom door was kept open.

For example, in homes that never kept the child's bedroom door open (0 days per week), the number of days the child woke up with asthma symptoms was, on average, 1.75 times higher during sham compared with true filtration (β= 0.56 [0.08, 1.04], p=0.02); and in homes where the bedroom door was left open 3 times per week, the number of days the child woke up at night was 1.31 times higher during sham (0.27 [-0.07, 0.60], p=0.12). Meanwhile in homes that always kept the child's bedroom door open (7 days per week), the number of days the child woke up due to asthma was slightly lower during sham though not statistically significant (-0.12 [-0.54, 0.29], p=0.56). Furthermore, the difference in the mean differences for homes where the bedroom door was always open versus never was statistically significant (-0.68 [-1.30, -0.07], p=0.03), thus, demonstrating that the effect of filtration on the number of days the child woke up due to asthma depended on how often the child's bedroom door was kept open.

Table 3.7.17 Contrasts in log mean days the child woke up due to asthma for each level of the filtration type x bedroom door interaction term in the Poisson mixed-effects model (Households with Air Cleaners Only)

Contrast	β	95% CI	p-value
Door open 0 days per week: Sham vs True	0.56	0.08, 1.04	0.02
Door open 3 days per week: Sham vs True	0.27	-0.07, 0.60	0.12
Door open 5 days per week: Sham vs True	0.07	-0.26, 0.41	0.67
Door open 7 days per week: Sham vs True	-0.12	-0.54, 0.29	0.56
Door open 7 vs 0 days difference in Sham vs True differences	-0.68	-1.30, -0.07	0.03

The Mini PAQL symptom scores were reversed for modeling purposes, so that higher scores indicated more asthma symptoms. The Mini PAQL symptom scores (expressed as log counts)

were marginally higher during sham compared with true filtration (β= 0.04 [0.00, 0.09], *p*=0.07) (Table 3.7.18). The associations between filtration status and symptom scores slightly varied based on levels of asthma severity (*p*=0.14). The Mini PAQL symptom scores were significantly higher during the sham period than the true filtration period (0.08 [0.01, 0.15], *p*=0.04) but only among children with moderately severe asthma. The sham vs. true differences in log mean symptom scores were smaller in magnitude among children with severe asthma than among those with mild asthma although this difference did not reach statistical significance (-0.09 [-0.22, 0.04], p=0.16). The sham vs. true differences were similar between moderate and mild asthma (0.04 [-0.07, 0.14], p=0.48). As expected, symptom scores were significantly higher, indicating more asthma symptoms, for children with severe compared with mild symptoms irrespective of filtration status (SHAM: 0.24 [0.11], *p*=0.02; TRUE: 0.34 [0.11], *p*=0.003).

Table 3.7.18 Contrasts in log mean MiniPAQL symptom scores (reversed) for each level in the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	β	95% CI	p-value
Main Effects Analysis:			
Sham vs True	0.04	0.00, 0.09	0.07
Interaction Analysis:			
Mild: Sham vs True	0.04	-0.04, 0.11	0.31
Moderate: Sham vs True	0.08	0.01, 0.15	0.04
Severe: Sham vs True	-0.06	-0.17, 0.06	0.33
Severe vs Mild difference in Sham vs True differences	-0.09	-0.22, 0.04	0.16
Moderate vs Mild difference in Sham vs True differences	0.04	-0.07, 0.14	0.48

Chapter 4 Discussion

Study Population

The enrollment of a study population of 191 nearly reached the goal of 200 participants. Nineteen of the participating households, just over 10%, had two children in the study. This met our goal of only a small portion of the population being comprised of siblings.

The population had a lower fraction with moderate to severe asthma than desired. Forty-eight percent of the participants were classified as mildly asthmatic, while moderate and severely asthmatic children made up only 41% and 11% of the population, respectively. The primary means of recruitment was through schools, where all enrolled children were informed of the study. A greater portion of children with asthma have mild asthma, and by recruiting from the general population of children, many families with a child with mild asthma were informed

about the study and subsequently called to participate. Although the screening criteria excluded many potential participants who had very mild asthma, many more who were still mildly asthmatic where included. Stricter screening criteria could have resulted in a greater portion with moderate to severe asthma, although the geographic region would have had to have been much greater to find enough participants or the recruitment strategy would have need to have been changed to recruit participants primarily through medical networks, a more labor intensive approach.

The study population met the goal of being diverse, mirroring the population of California. Twenty-three percent of the population was from families that earned less than $23,000 annually, and another 20% came from families that earned between $23,000 and $46,000. While there was a good representation in these lower income brackets, there was still a significant portion that came from families that had higher incomes (37% from households with earning above $70,000). Seventeen percent of the population had an advanced degree, while another 20% had a college degree. Self-selection into studies among educated individuals is common. There was significant diversity based on race and ethnicity, with 47% of the population identifying themselves as Hispanic, 23% as white, 11% as black or African American, and 5% as mixed race.

Seventy-eight percent of the participants completed the study. Ideally, study completion rates should be around 85%, and while this goal was not met, the completion rate was only slightly lower. The study was long, with many interactions, and thus it was difficult to maintain a high completion rate over such an intensive study. There were some difficulties with both of the interventions, specifically problems with the thermostats and concern over the costs associated with running the fan with central filtration, and problems with an offensive odor emanating from the stand alone air cleaners, which likely decreased the study completion rate. However, given the number of interactions with study staff, we had excellent completion rates of study components for those in the study, with over 90% of most elements completed. This number excludes collection of outdoor air samples as the collection rates of outdoor air samples was dependent on the configuration of the participants home, rather than their willingness to complete the study protocol.

Central System Filtration

Installing filtration through the central system added significant complexity to the study, and as discussed in the section on air pollution below, did not reduce indoor particle concentrations as much as stand-alone air cleaners.

The most affordable way to provide high-efficiency filtration through a central forced air heating and cooling system is by installing a different filter into the existing ducted system. In some cases, the cross sectional area of a filter would need to be increased in order to filter at the desired levels of particle removal efficiency while maintaining a pressure drop that can be accommodated by the fan. The solution we used did indeed use a larger filter, installing a larger

filter holder over the existing air intake. A significant portion of the homes we evaluated (20%) could not physically accommodate the larger filter holder. In order to provide comparable filtration to the stand alone air cleaners, a new thermostat needed to be installed that could run just the fan for 15 minutes of every hour. Many homes did not have a central forced air system, or indicated that it worked poorly. A small number of homes (7%) could not have the new thermostat installed, for varying reasons. Older homes with old central systems were problematic because they were not wired to run the fan-only mode, while some new two-story homes had an upstairs and downstairs thermostat as a convenience to residents. Two homes had thermostats installed by the electric utility to facilitate energy conservation, a trend likely to increase. For these reasons, among others, only 29% of the homes inspected had central system filtration installed, and thus the study could not reach the goal of 50% with central system filtration. Additionally, homes could not be randomized between stand-alone and central filtration and thus there may be differences in the physical housing characteristics and resulting air exchange rates between the two groups.

While thermostat technology and features continue to advance, there were limitations at the time the study was conducted. Many thermostat models are available for use in homes with a five-wire connection between the thermostat and the central unit, typically only found in newer homes. However, at the time we began recruitment for this study, there were very few thermostat models available that provided a clean-air cycle that could be installed if there was a three-wire connection between the thermostat and the heating/cooling unit common in older housing stock. Unfortunately, the only thermostat available that provided the desired run-time of 15 minutes per hour seemed to have a technical problem, given the large number of cases where the cooling cycle could not be turned off at the home. Additionally, while some household members are adept at learning to use new technology, some individuals found it difficult to use a programmable thermostat and preferred their old, simple ones that involve just setting the temperature for the current time. An additional problem with the thermostat is that participants could turn the clean-air cycle off, either intentionally or accidentally. The impact of this was seen in the lower compliance with the protocol for central forced air system filtration than for stand-alone air cleaners. Adoption of programmable thermostats may be a problem for wider adoption of central system filtration, although this concern should diminish over time as a greater fraction of the population is more adept with technology in general and programmable thermostats specifically.

A third concern with running filtration through the central system was the expense. A number of households requested greater reimbursements than had been calculated based on average fan-power. While requesting households generally submitted electricity bills that did show greater electricity use, it could not be determined if increased electricity use was due to the increased run-time of the fan, the increased run time in combination with potentially running the air conditioning more due to the programmable thermostat failures, or an increase in electricity use

unrelated to the central system. There is considerable variability in fan power requirements. Another increased cost of running the fan more was added wear and tear on the central system, requiring repairs more often. Put simply, utilizing portable air cleaners with efficient fan systems designed for use with high efficiency filters will often be more energy efficient than upgrading filtration in central forced air systems, particularly older forced-air systems with fans that are often costly to run, repair, or replace.

While it was very clear that running the fan for additional time, especially in homes with older systems, was not an efficient way to provide filtration to a home, providing filtration through the central system may be very effective in new construction with central systems designed for this purpose, or potentially even in newer homes more generally. This study was not designed to answer those questions. Also, in areas of significant cooling and heating requirements, providing filtration through the central system may very well be the most cost-effective way to reduce indoor concentrations, as in those homes the additional clean-air cycle may not be required.

Stand Alone Air Cleaners

The stand-alone air cleaners were easy to utilize in the study. Participants generally did not object to where they were placed in the home, and they generally ran them utilizing the recommended airflow. A small subset of participants did not to leave them on, but this was uncommon. Since they used a known amount of electricity, participants generally were satisfied with the reimbursement they received. One participant was able to identify when their air cleaners had been switched to sham filtration, but fortunately this was an isolated incident.

The only significant problems this study experienced with the stand-alone air cleaners was the filters to remove VOCs. The first problem was that the filters did not have an adequate holding capacity to last the full duration while in the study homes. The homes were in areas with high outdoor pollution, and many were low income homes which tend to have higher indoor sources of VOCs than higher income homes. The second problem was that the pattern of calls complaining about the odor emanating from the air cleaner would indicate that there might have been a manufacturing flaw with some of the filters we received. Recall that of the first 60 homes, most likely all in the first batch, only one home complained in the first six months while in the next 30 homes installed, 14 homes complained in the first six months. Likewise, of the 24 homes who started in sham that received a true filter from the first batch, only three complained, whereas of the 60 homes receiving a true filter from the second batch, ten had complaints.

While ideally an analysis should be conducted to determine if the odors were associated with higher frequency of symptoms, there is no feasible way to do so, as we have no way to know if the homes that did not complain may have experienced the same odors coming from the filter and did not comment on them.

Indoor Air Quality

High efficiency filtration had a clear positive impact on indoor concentrations of particulate matter. Concentration for all size fractions, $PM_{0.2}$, $PM_{2.5}$, PM_{10}, $PM_{0.2-2.5}$ and $PM_{2.5-10}$ as well as I/O ratios of $PM_{0.2}$, $PM_{2.5}$, PM_{10} and reflectance measured on $PM_{2.5}$ filters were significantly lower with true filtration than sham filtration for homes with air cleaners. The percent decrease in the geometric mean of the indoor concentration from sham to true was the same for $PM_{0.2}$ and $PM_{2.5}$ (48%), and slightly lower for PM_{10} (31%), driven by a small reduction in $PM_{2.5-10}$ (10%). The observed differences are likely due to several factors. Smaller particles ($PM_{2.5}$) have a lower deposition velocity than larger particles ($PM_{2.5-10}$), and thus a longer residence time in indoor air. The high-efficiency filtration removes particles in both size fractions, but the relative change in the total removal rate from filtration, deposition and air exchange is greater for smaller particles since the removal rate in sham is relatively lower for the small particles than larger particles, which still have significant removal from deposition with sham filtration.

For homes with filtration through the central system, PM concentrations were statistically significantly lower with true versus sham for all size fractions except $PM_{2.5-10}$. The sham central filters were MERV 4 and primarily removed this size fraction, and thus it is not surprising that there is not a difference between sham and true filtration for this size fraction. The mean difference between indoor concentrations measured with sham filtration and indoor concentrations measured with true filtration was statistically significantly greater for all size fractions for homes with air cleaners as compared to those with central system filtration. It is noted that the homes in the study all had central systems that recirculated air, rather than drawing air directly from outside.

Comparing the percent decrease in indoor concentrations from sham to true conditions between central filtration and air cleaners, the percent decrease is approximately 20% greater for air cleaners across all size fractions (e.g. 52% vs. 34% for $PM_{0.2}$, 36% vs. 16% for PM_{10}).

Reductions in I/O ratios were also greater with air cleaners than central filtration for all size fractions, with differences being statistically significant for I/O $PM_{0.2}$ and I/O PM_{10}. Both the indoor concentrations and I/O ratios were lower with air cleaners than with central system filtration, although only for $PM_{0.2}$ were the indoor concentrations and I/O ratio statistically significantly lower.

These results clearly indicate that improved indoor air quality can be achieved with high efficiency filtration. Additionally, in this study the improvements were greater with air cleaners than with central filtration. Based on mean airflows and time of operation, a greater volume of air was filtered relative to the volume of the home with central system filtration as opposed to air cleaners, so this was not the cause of the difference. One of the two stand-alone air cleaners was located in the room where air samples were obtained, and so this room may have had the lowest concentration in the house. This would result in stand-alone air cleaners appearing to be more

effective than central system filtration. Additionally, the effectiveness of central filters could be the same or betterin newer homes with central systems designed for high efficiency filtration.

The interaction analysis results primarily had findings that corresponded to what was anticipated. There was a greater reduction in the indoor concentration with true filtration when windows were rarely open as opposed to frequently open, with the differences in concentrations between the two window opening conditions being most pronounced for $PM_{0.2}$. Closing windows decreases the air exchange rate of the home and thus the effective filtration rate is increased relative to the rate of particle entry, increasing the particle concentration reductions from cleaning. Newer homes typically have lower air exchange rates than older homes, and thus a greater degree of cleaning was anticipated with newer homes. There was greater reduction in indoor concentrations among newer homes with air cleaners than older homes with air cleaners. In homes with central system filtration, the trend was in the unexpected direction, with older homes having a greater reduction with true filtration than sham filtration. With the available data, it could not be determined why this was the case.

The more air filtered, the lower the indoor concentrations expected. For homes with air cleaners, a desired average flow rate through the units was determined, and the flow rate for each home for the sampling week was measured and compared to this value. For homes with central filtration, the desired value was the proportion of time air was flowing through the central system, and the time was measured for each sampling week and compared to this value. This utilization value was a statistically significant interaction term for all three particle size fractions considered, $PM_{0.2}$, $PM_{2.5}$, and $PM_{0.2\text{-}2.5}$. Given the fact that there was little variability in the utilization of the filtration systems between homes, this factor clearly had a strong influence on the indoor particle concentrations. A second, similar measure was derived that took into effect the home size and for central system filtration, the measured flow rate through the return air intakes of the forced air systems. However, this was not a significant interaction term. Since one of the air cleaners was located in the main living area, and the air sampler was typically also located in this room, the impact of imperfect mixing in the home may not have been captured.

Analysis for distance from the road yielded inconsistent trends. The reflectance I/O ratio with true filtration was extremely low, with a geometric mean of 0.06 for homes 5 or more blocks from a busy road. The homes closer to the road had slightly higher values, 0.15 and 0.17 for homes <2 and 2-4 blocks from the road, respectively. With sham filtration, the homes closest to the road had the highest reflectance I/O ratio, with a geometric mean of 0.68. Homes 2 or more blocks from the road had roughly the same value during the sham filtration period, 0.36 and 0.40 for homes 2-4 blocks and 5 or more blocks from the road, respectively. This resulted in less of a reduction for homes 2-4 blocks from the road than either other distance from the road. To simplify the analysis, the data were recategorized at less than 5 blocks and 5 or more blocks from the road. The extremely low reflectance I/O ratio with true filtration resulted in the finding that filtration was more effective for homes 5 or more blocks from the road as measured by

reflectance I/O ratio. In part, this result may not be entirely related to distance from road, but may be related also to differences in socio-economic status, which tends to be higher for homes further from the road. Also, the reflectance values themselves were more uncertain for homes further from busy roads as the values were lower, and low values typically have more uncertainty associated with them.

Although there were slight correlations between indoor particle levels and potential particle sources, indoor sources were not significant interaction terms. Although there was some statistically significant interaction between outdoor levels and the level of reduction with the true filtration, there was no consistent trend between size fraction or intervention type. It is clear that the factors related to the proportion of the air being cleaned relative to the air exchange rate are more influential than factors contributing to the particle load in the home on the effectiveness of reducing concentrations.

Indoor particle concentrations were lower with sham filtration than during the pre-intervention period. There are five potential reasons, each discussed below: 1) outdoor levels were higher during the pre-intervention measurement weeks; 2) indoor sources were greater during pre-intervention weeks; 3) some particles were removed with sham filtration; 4) deposition velocities within the home were greater in the sham period; 5) behavioral changes. Recalling that we have the most complete pre-intervention datasets for $PM_{0.2-2.5}$ and $PM_{2.5-10}$, we focus on those size fractions. For homes with air cleaners, the differences were statistically significant for both size fractions, while neither size fraction was significant for homes with central filtration. For $PM_{0.2-2.5}$, the estimate of the difference was actually greater for homes with central system filtration than air cleaners, but since the sample size is smaller, the difference is not significant.

For $PM_{2.5-10}$, there could have been a greater contribution from outdoors, as outdoor levels were statistically significantly higher during the pre-intervention period for this size fraction. There was no difference for $PM_{0.2-2.5}$. There is no reason to believe indoor sources were higher in the pre-intervention period as there were similar frequencies of indoor sources reported on the symptom diary. There was slightly more window opening reported during the pre-intervention period so more particles may have entered the home from the outdoors.

We next consider additional removal of particles from sham filtration as opposed to pre-intervention conditions. It is certainly plausible that the increased utilization of the central system from the clean-cycle implemented by the study thermostat could have removed particles from the air during the sham period. While the sham filter installed, a MERV 4 filter, was much less efficient than the true filter, it did remove some particles. For the air cleaner, there was no air drawn through the sham filter. It was noted that there were some particles attaching to the filter, likely due to electrostatic forces. Pictures of used sham filters can be seen in Figures 4.1 and 4.2, taken from a report on the accumulation of particles on the sham filters found in Appendix A “IQ Air Report on Filter Analysis”.

While it does appear that a large number of particles are on these filters, Figure 4.2 indicates that the particles are mainly on the surface of the filter. There are no coarse particles deposited on these filters due to electrostatic forces. In contrast, one can see significant coarse particles on a typical used true filter in Figure 4.3, and that the particles were drawn into the filter pleats (Figure 4.4).

Additionally, controlled studies have found increased particle deposition rates with increased movement of indoor air, which would have occurred in the sham period with either the air cleaners or the central filtration. Recall that during the sham period, vents are opened on the back of the air cleaner and the same volume of air is pulled through the fan and circulated into the room. For homes with central filtration, the clean-cycle on the thermostat ran the system and thus increased the air flow within the home. Experiments have measured particle deposition velocities in a small chamber to surfaces of 3 roughness values, finding deposition velocities to increase with air speed [171]. Experiments conducted in a single room with air speed controlled by the setting on a fan found a roughly 50% increase in deposition rate, with larger particles exhibiting greater effects than smaller particles [172]. Both the removal of particles to the filter, by electrostatic forces in the case of the air cleaners and by additional run time in the case of central system filtration, and increases in the deposition rate as the air velocity increased within the home, likely contributed to the decrease in indoor concentrations as measured during the sham period as compared to the pre-intervention period.

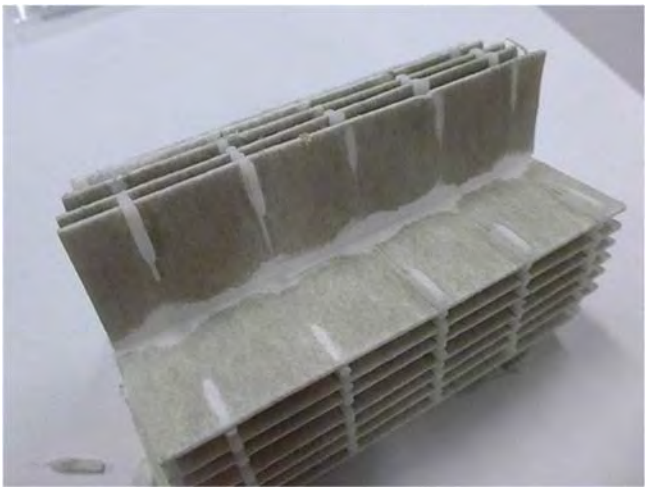


Figure 4.1 Uniform soiling of very fine dust on the sham filter.

Figure 4.2 Dust on the surface of the sham filter.

Figure 4.3 Dust piles are predominantly coarse dust on a used true filter.

Figure 4.4 Coarse dust drawn down into the pleats due to airflow *through* the real filter.

The final potential reason for higher PM levels during the pre-intervention period than the sham period is behavioral changes. Windows and door opening rates were slightly decreased in the sham period relative to the pre-intervention period. Additionally, it is possible that participants may have cleaned their homes more during the study.

Overall, indoor ozone concentrations were low. Homes with central filtration had the lowest concentrations, with no difference found for homes with true or sham filtration. This was expected since both conditions ran air through a filter which may have had chemicals on it which would have reacted with the ozone. Concentrations in homes with true filtration provided by stand-alone air cleaners were slightly lower than with sham filtration. Due to the small sample size and lack of matching homes, it is difficult to make robust conclusions from this data.

Asthma Symptoms

The primary study outcome was asthma symptoms reported in a recall questionnaire asking about the previous two weeks. The recall questionnaire was conducted every 3 months. This was evaluated with two different analyses: (i) using all collected data, including a study year variable to account for the unbalanced study design; and (ii) using only months 1-6 and 13-18, which provided a balanced study design. Neither analyses resulted in statistically significant differences in asthma symptoms when true versus sham filtration was used. There are several potential reasons for the lack of statistical significance, each of which is expanded upon later in this discussion. Potential reasons include 1) regression to the mean, 2) better control of the child's asthma over time, 3) the fact that children were still exposed to air pollution and other asthma triggers outside of their home, 4) potential external factors, 5) the particle concentration reductions were not sufficient to significantly diminish asthma health effects, and 6) the allergenic and inflammatory particles most clearly linked to asthma tend to be large particles and the filtration systems only modestly reduced exposure to large particles relative to sham conditions as these larger particles already have the largest deposition rates.

There were, however, a number of true versus sham contrasts that reached statistical significance, including 1) number of unplanned use of medical services, the sum of ED, hospitalizations, and clinic visits, as well as clinic visits on their own, 2) nights the child woke during the night in homes with air cleaners where the bedroom door was kept shut, and 3) symptoms scores on the Mini PAQL, although there is a lack of confidence on those results. All three of these findings are discussed below.

One statistically significant positive finding was fewer clinic visits during the true period than during sham air cleaning. The total healthcare resources used, calculated as the sum of clinic visits, ED visits, and hospitalizations, was also greater in the sham period. There was a 20% reduction in visits with true filtration. It is noted that there were so few hospitalizations they could not be modeled as an outcome. Also, there were very few ED visits and these on their own were not statistically different, so the significant finding related to the summed total of all three

visit types was likely driven by the clinic visits. As expected, there were more clinic visits among the severe asthmatics and it was only this group that had significantly more visits with sham than true filtration, although for mild asthmatics, the difference was moderately significant. The clinic visits were evaluated over a three month period, rather than a two week period, and thus clinic visits over three months may have been a more robust measure. The finding for fewer clinic visits with true filtration for severe asthmatics could potentially be important in terms of total medical spending as the severe group has the most interactions with the medical system.

A second evaluation of clinic visits was conducted for only months 1-6 and 13-18, which provided a balanced study design. For these time periods, visits to clinics were not statistically significantly reduced during true filtration, further supporting the idea that it was important to include data from the full study period.

Children in homes with filtration by air cleaners had an air cleaner in their bedroom. Hence, if they kept their bedroom door shut at night, they would be expected to have cleaner air as they slept. A sub-analysis of only children with air cleaners found that among children who kept the bedroom door shut, they woke during the night less frequently with true filtration. Similar findings have been found in other studies that focused just on providing clean air during the night [32]. Filtration in the bedroom may be the most effective for reduction of asthma health effects. It is important to note that changing a behavior like shutting a bedroom door may be difficult to achieve in real-life situations.

There was a statistically significant finding for improved symptoms on the Mini PAQL, with the most pronounced results for moderately asthmatic children. This finding is odd, given that the moderately asthmatic group actually have statistically significantly worse symptoms as reported by the recall diary. Recall that the Mini PAQL is a quality of life questionnaire administered to the child and in the recall diary, the parent reported on the child's symptoms over the previous two-week period. One would anticipate that parent report of symptoms and child report of symptoms would be correlated. A scatter plot of these two symptom scores (Figure 4.5), revealed that while they were moderately correlated ($r=0.55$), there was still considerable scatter. These opposite findings for these two methods for reporting symptoms highlight some of the difficulties in utilizing self-reported health outcomes in asthma studies.

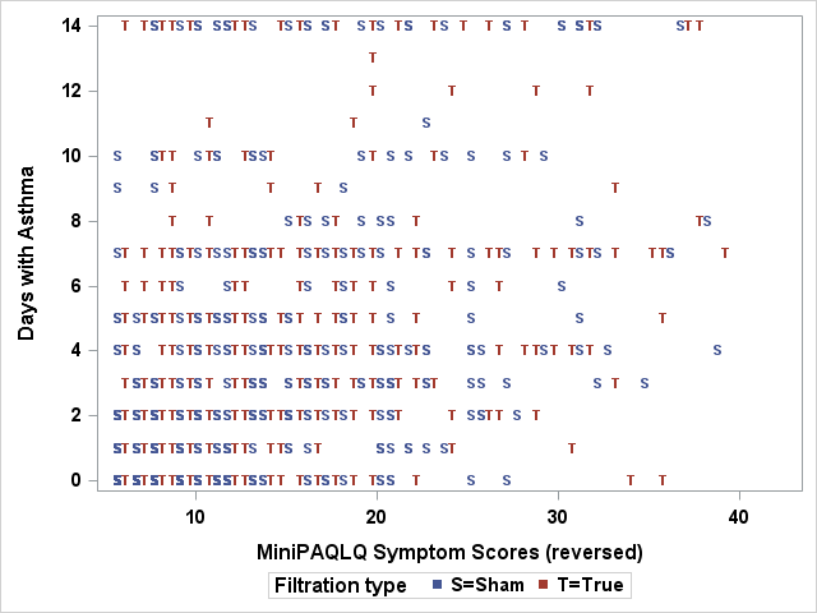


Figure 4.5 Scatter plot between reported symptoms on the symptom recall and the MINI PAQL score for symptoms.

There were no other statistically significant findings for secondary health outcomes, including use of rescue inhaler, missing school, eNO, emotional and physical limitations scales on the MINI PAQL, or spirometry. We consistently saw more symptoms, more rescue inhaler use, more steroid use, poorer MINI PAQL scores, higher eNO values, and lower FEV1 and FEV1/FVC results among severe asthmatics as compared to mild asthmatics. One reason there were not more findings in this study is that there were so few severe asthmatics and this group has the most symptoms and quantitative measures deviating from normal values.

An evaluation of symptoms in the pre-intervention period as compared to the first year of the study found significantly more symptoms during the pre-intervention period. This fact supports the idea that we may have seen regression to the mean. Basically, participants were recruited based on the fact that they had multiple weeks with regular asthma symptoms in the 6 months prior to being enrolled in the study. This period may have been typical for the child, or may have been their most significant experience with asthma. If the later were true, their asthma would naturally improve to its typical state for that child.

Another potential contributing reason for the improvement in asthma control in children between the pre-intervention period and first year, as well as continued improvement in the second year of the study, could be improved control of the child's asthma that occurs during the course of the disease, as patients, parents, and their clinicians developed more effective asthma medication strategies. Such effects would be expected to become more apparent the longer the study progresses. The revised AIRE study design called for SHAM filtration to be utilized predominantly in the second year of the study. By that time, children and parents had likely

developed a better understanding of their asthma, therefore, the improved optimization of asthma controller medications correlated with better symptom management and fewer asthma exacerbations. This correlation can take participants several months to understand and establish. While we did not see a general increase in controller medicine, we did find that many participants had shifting patterns of controller medicine use over the course of the study. They may have been working with their doctor to determine the correct medicine, the correct dosage, or possibly if they only needed medicine during certain months. This 'study effect' is well known in asthma clinical trials. For example, it is known that the rates of adherence to asthma controller medication are quite high, often exceeding 90% over 1 year [173-175]. However, this rate of adherence appears to hold only for studies where medication usage is monitored, such as ours. In one study where participants were not informed that medication adherence was being monitored, use of inhaled steroids dropped to less than 50%, which would affect asthma symptoms and study endpoints [176]. Beyond this, we must attribute our findings of fewer asthma symptoms in the placebo period as a random effect. Improvements in asthma symptoms with placebo interventions have been a frequent topic of study [177]. Reports on the placebo effect in asthma, usually in the range of 30-50% improvement in planned endpoints, have not only contributed to an understanding behind the placebo response but also shed an interesting light on the current treatment and diagnosis of asthma. There is a general belief that placebo must be introduced surreptitiously in asthma studies. It is unclear given the nature of our intervention whether we achieved this.

There are other reasons we may have observed a reduction in symptoms between the pre-intervention values and those recorded in the first year of study. All participants received mattress and pillow covers upon enrollment into the study. This intervention has been shown to improve symptoms, particularly in the eastern part of the country where dust mites are more prevalent. They were provided in this study to allow participants who might suffer from dust mites to receive the full benefit of the filtration used in the study. This may have reduced symptoms. Also, parents may have learned other factors that triggered their child's asthma, and taken care to reduce exposure to those triggers. Finally, there were improvements in indoor air quality between the pre-intervention period and the sham period. These reductions may have improved symptoms. Although, for this to be the case, there would need to be some sort of non-linear response curve as the further improvements in air quality with true filtration did not result in further reductions in symptoms.

A reason participants may have had no improvement in lung health between true and sham filtration was exposure to pollutants and other asthma triggers outside the home, or exposure to pollutants and triggers not reduced with the air filtration systems used. Children spend a considerable amount of time at school during the school year, as well as time outside, and in other indoor locations throughout the year. Specifically, children only spend, on average, 16.25 hours per day at home. For the remaining time, they are exposed to the same level of pollutants

or triggers regardless of experiencing true or sham filtration in their own home. This was exemplified in the personal exposure modeling, which found only a 33% anticipated reduction in the true versus sham $PM_{2.5}$ concentration, compared to a 48% reduction in their homes. It is noted that there were fairly consistent outdoor concentrations measured throughout the study and thus it is assumed concentrations in other locations essentially remained steady throughout the study period as well.

VOCs are also thought to contribute to asthma exacerbation [178-180]. While the homes that had air cleaners had filters to reduce VOCs, the homes with filtration through the central system did not, and thus levels of VOCs in the homes were likely consistent throughout the study. Also, early on in the study, there were problems with the VOC-removing filters. Many homes complained of an offensive odor, which likely indicated that the filters were off-gassing either a mixture of VOCs or VOC reaction products. While there was no way to conduct a statistical analysis to determine if there was any impact from the offensive smell, the chemicals associated with the smell may have impacted asthma symptoms.

The severity of influenza can the estimated by looking at influenza hospitalizations, plotted in Figure 4.6. Influenza hospitalizations are generally highest in January-March of any given year. We did not have very many participants in the study during this time in 2014, and so just considered the 2015 (2014-15 season) and 2016 (2015-16 season). The rate of hospitalizations was highest in January and February of 2015, when we had more people in true than sham, and was lower in 2016, when more people were in sham (Figure 4.6). This may have influenced asthma symptoms, but would be difficult to quantify.

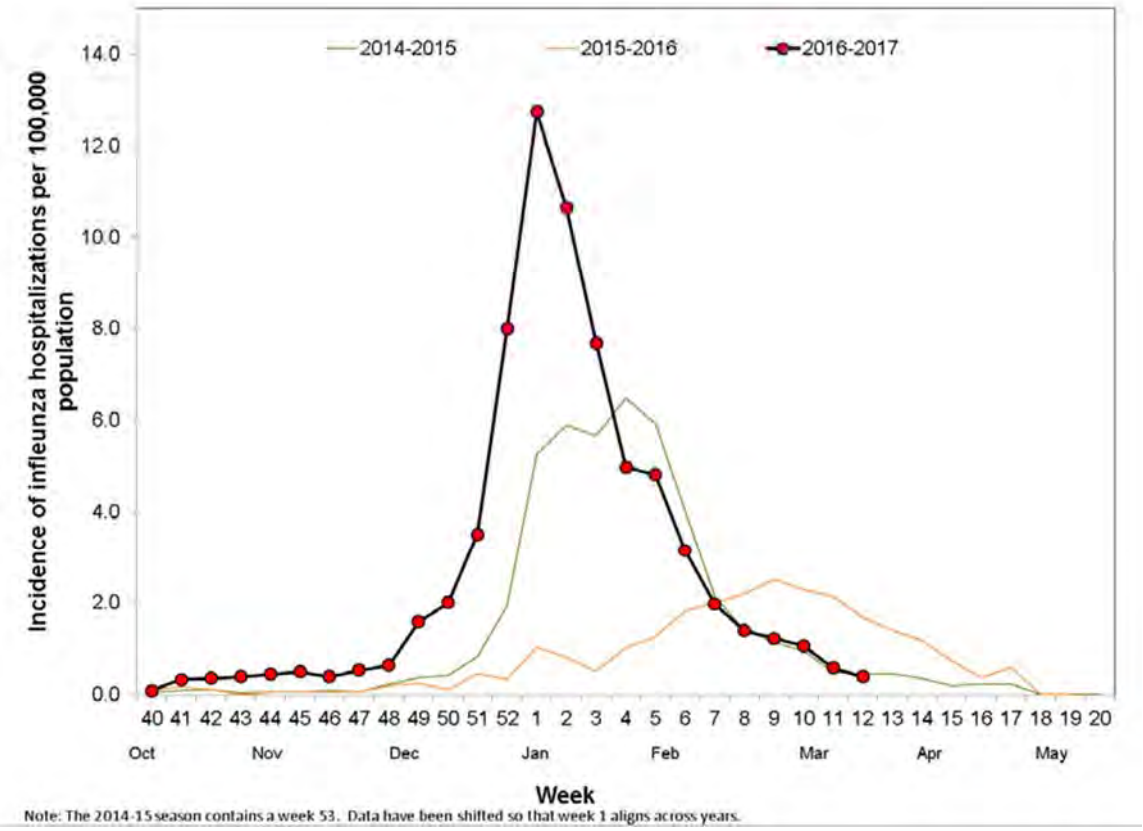


Figure 4.6 Incidence of Influenza Hospitalizations in CEIP Counties, 2014–2017 [181].

Rhinovirus infection reportedly accounts for up to 70% of severe asthma attacks among children [182, 183]. Rhinovirus also contributed to less severe asthma symptoms. The State of California does not track rhinovirus closely, but does track asthma hospitalizations. The rate of hospitalizations can be used as a proxy for the severity of rhinovirus in a given winter. If rates of rhinovirus were more severe in one winter than another, this could influence the prevalence of symptoms in true compared to sham since the portion of participants experiencing true filtration varied from winter to winter. Unfortunately, data on hospitalization rates are currently only available through 2015 and thus this factor will need to be evaluated at a later date.

Chapter 5 Summary and Conclusions

One-hundred ninety-one asthmatic children 6-12 years old, from 172 households, located in regions with high outdoor pollution (in and around Fresno and Riverside, CA), were enrolled in a randomized placebo cross-over trial to evaluate the effectiveness of high efficiency filtration in reducing indoor pollutant exposures and asthma symptoms. Overall, 78% of the participants completed the study, specifically 149 from 136 households. Study completeness for that group was excellent, with over 98% of all scheduled encounters obtaining some data, and with most

data elements having a 90% or greater completion rates. One notable exception was a lack of valid PM data for $PM_{0.2}$ and $PM_{2.5}$ size fractions early in the study.

There was a 48% reduction between sham and true filtration for both the geometric mean concentrations of $PM_{0.2}$ and $PM_{2.5}$. For PM_{10}, the reduction was 31%, lower due to the small 10% reduction for $PM_{2.5-10}$. The sham filtration did lower geometric mean concentrations relative to the pre-intervention period, 21% for $PM_{0.2-2.5}$ and 28% for $PM_{2.5-10}$, so total reductions were actually greater than indicated by the true/sham comparisons.

Participants primarily had mild and moderate asthma, with a smaller portion having severe asthma. Forty-three households with 52 participants had high efficiency filters installed in their central forced air heating and cooling systems. The portion with filtration in central systems was smaller than desired due to many homes not being able to accommodate the filter upgrade. The remaining 129 households with 139 participants each had two high efficiency stand-alone air cleaners. Improvements in asthma symptoms were evaluated in a cross-over design, with each participant receiving true air filtration for a year and sham filtration for a year, allowing the improvements related to the air filtration to be estimated. Compliance with running both the central systems and air cleaners was high, with approximately 70% of the population using the central system at least 75% of the time they were asked and approximately 80% running at least 75% of the requested volumetric flow rate. There were slight variations on the percent of the population meeting these goals over time.

There were greater reductions in indoor PM resulting from the air cleaners than from the central filtration system. For example, $PM_{0.2}$ reductions were 52% compared to 34%, and PM_{10} reductions were 35% compared to 16%, respectively. The two air cleaners together ran, on average, slightly less air through the system than the central systems in the homes. Therefore, the air cleaners reduced levels more effectively.

Reductions in indoor particle levels were greater for participating homes that ran their systems more often. Also there was a trend towards greater improvements if windows were kept closed more often, with the differences reaching statistical significance for some size fractions.

The primary health outcome was asthma symptoms in the prior two weeks, evaluated quarterly throughout the study . When evaluated with a generalized linear mixed effect model including study year, city, and season as covariates in the model, there were no differences in asthma symptoms between true and sham filtration. A wide range of secondary health outcomes was also evaluated. There were fewer unplanned utilizations of the health care system (the sum of ED visits, clinic visits, and hospitalizations) as well as just clinic visits with true filtration compared to sham filtration, with the most significant difference being among severe asthmatics. This measure included the entire 2 year period as opposed to eight 2-week periods. For the children in homes with air cleaners, which included an air cleaner in the bedroom, there were also fewer

nights awaking during true air cleaning if the child shut the bedroom door, which would have resulted in a very clean environment.

While there were significant reductions in indoor air particle levels, only limited reductions in some health outcomes were observed. There is likely a multitude of explanations, among them exposure to pollutants, allergens, and viruses outside of the home, a low number of severe asthmatics in the study that likely would have had more benefit, and families learning to better control their asthma over time.

Chapter 6 Recommendations

The recommendations from the study are broken into two categories, recommendations for future studies addressing similar issues and recommendations for use of air cleaning in the home.

Recommendations for Future Studies

Future studies should focus only on individuals with severe asthma. Recruitment should be conducted through doctors, hospitals, and other providers to ensure greater proportion of moderate and severe asthmatics. This approach is very labor intensive and requires researchers plan for significant man power and time for recruitment. Limiting the study to severe asthmatics would therefore be more difficult and expensive.

If studying health impacts in older housing stock and a study objective is to control air flow, filtration should always be provided by stand-alone air cleaners as these provide more consistent results, are logically simpler for the study team, and are easier for the participants to utilize.

The most promising applications of central system filtration are in new construction in regions with high heating and cooling demands. In new construction, the application would be in homes with systems specifically designed to accommodate high MERV filters, and fans designed to run cost-efficiently. Studies should be conducted to evaluate this application in terms of improving indoor air quality. A potential uncertainty with this application is whether participants would continue to buy high efficiency filters after the study ended. The second air quality application that should be further evaluated is the effectiveness of installing filters that do not need an extended size filter holder in homes that frequently call for both heating and cooling, and run the systems only during these times. While clean air would not always be provided, the cost would be minimal and the filters could be installed in a greater number of homes.

Filtration systems that focus on the breathing zone while the participant sleeps should also be further evaluated in health studies. Previous studies have found promising results, but were small in size and funded by industry.

If one was doing a study with a filter that removes VOCs, they would need to be mindful that filter life testing is often conducted in homes typical of the anticipated customers, which may be

higher income homes in those in the study population. Because VOC levels are often higher in lower income homes, filters may need to be changed more regularly than recommended by the manufacturer. The filter life for all filters may be shorter in lower income homes. Filter life would need to be evaluated in any study prior to implementation. Studies should also include direct measurements of VOC concentrations. Likewise, direct measurement of allergens in the air should be measured.

It may also be beneficial to do studies on other health endpoints, such as on an elderly population with compromised health, such as COPD.

Recommendations for Use of High-efficiency Filtration

When considering if high efficiency filtration should be recommended for use in the general population, the cost of running the filter also needs to be considered, including the initial cost of the unit, filter costs, and energy costs [184]. The greatest benefits were observed for severe asthmatics, so they would be the group most likely to benefit. We note that theoretically, everyone benefits from particle concentration reductions in high pollution areas as exposure to PM has been found to be related to a variety of adverse health impacts. Air cleaners use considerable electricity, which can be expensive, particularly in California. If one were to use only one air cleaner, we recommend it be placed in the bedroom of the person with asthma, and that the windows and doors should be shut, particularly at night. This study did observe a decrease in how often the participants woke, particularly with the door closed.

We noted that the effectiveness of using high efficiency, readily available, “drop in” filters be further evaluated. However, due to the minimal costs associated with their use, with normal heating and cooling cycles, and the fact that there would likely be at least moderate improvements, we feel that it is appropriate to recommend them.

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Glossary

AC	Stand-Alone Air Cleaner
AER	Air Exchange Rate
AIRE	Asthma and Indoor air: Reducing Exposures
ANOVA	Analysis of Variance
ARB	Air Resources Board
ATS	American Thoracic Society
BMI	Body Mass Index
C	Concentration
CA	California
CARB	California Air Resources Board
Cfm	Cubic Feet per Minute
CI	Cascade Impactor
CI	Confidence Intervals
COPD	Chronic Obstructive Pulmonary Disease
CSF	Central System Filtration
CV	Coefficient of Variation
DCM	Dichloromethane
DK	Don't Know
EC	Elemental Carbon
ED	Emergency Department
EIB	Exercise Induced Bronchoconstriction
ERS	European Respiratory Society
eNO	Exhaled Nitric Oxide
FDA	Federal Drug Administration
FEF25-75	Forced Expiratory Flow 25-75%
FEV1	Forced Expiratory Volume in 1 Second

FVC Forced Vital Capacity

GLMM Generalized Linear Mixed-Effects Model

GM Geometric Mean

HEPA High Efficiency Particulate Air

HVAC Heating, Ventilating, and Air Conditioning

I/O Ratio Indoor / Outdoor Ratio

IAQ Indoor Air Quality

ICAS Inner City Asthma Study

ICS Inhaled Corticosteroids

IRB Institutional Review Board

ISO International Organization for Standardization

LOD Limit of Detection

LPM Liters per Minute

MERV Minimum Efficiency Reporting Value

NAEPP National Heart, Lung, Blood Institute- National Asthma Education and Prevention Program

NHANES National Health and Nutrition Examination Survey

NIOSH National Institute of Occupational Safety and Health

NO_2 Nitrogen Dioxide

O_3 Ozone

PAQLQ Pediatric Asthma Quality of Life Questionnaire

PEF Peak Expiratory Flow

PEFR Peak Expiratory Flow Rate

PEM Personal Exposure Monitor

PM Particulate Matter

PTEAM Particle Total Exposure Assessment Methodology Study

PUF Polyurethane Foam

QA/QC Quality Assurance / Quality Control

QAPP Quality Assurance Project Plan

QxQ	Question by Question Guidance Document
RF	Refused
RH	Relative Humidity
RTI	Research Triangle Institute
SABA	Short Acting Beta Agonists
SD	Standard Deviation
SOP	Standard Operating Procedure
SQL	Structured Query Language
T	Temperature
UFP	Ultrafine Particulate
US	United States
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Chemicals
WSLH	The University of Wisconsin State Laboratory of Hygiene

APPENDIX A: MATERIALS RELATED TO SCREENING, INTERVENTIONS, AND FOLLOW-UP

Contents ***Page***

A.1 Participants Who Did Not Complete the Study

Overall, 42 participants did not complete the study. We grouped the participants by reason for leaving the study and attempted to capture any anomalies in these descriptions.

Twenty participants from 19 households dropped out of the study. Of these, six participants dropped out due to unavoidable family problems, illnesses, or injuries. One participant with central system filtration dropped out as a result of their thermostats not working properly. Two participants dropped out because they were unhappy with the stand-alone air cleaners, specifically an odor that was emitted from the material to reduce ozone levels. Five participants dropped out for reasons related to concerns about the cost of running the intervention or because they were unhappy with the reimbursement rates. Six participants from five households did not provide a reason for dropping out.

Eight participants from six households were withdrawn, each household for a different reasons. One of the 6 households remained in the study because only one sibling was withdrawn, as they were originally planned for HVAC and ended up in air cleaner and did not share a bedroom. Other reasons households were withdrawn were air cleaners were stolen from home, participant realized they were in switched to SHAM, participant moved and wanted HVAC which could not be installed, participant had problem with broken air conditioner due to thermostat problem and their demands could not be met, and participant installed air cleaning system in the home.

Three participating children from two households moved out of the area. One household did not use their air cleaners. Ten participants from nine households were categorized as loss to follow-up, seven defined as being unable to contact their household or schedule visits over at least a six-month period.

A.2 Eligibility for Central System Upgrades

There were several criteria that had to be met for a home to be eligible for a central forced-air system filtration upgrade and therefore required a home inspection. We conducted inspections of the central forced-air system for the first 146 homes that completed the enrollment visit. In some cases, the inspection was completed at the consent visit. All but 13 of these homes had an intervention installed in their home. We ceased inspecting homes for possible central forced-air system filtration upgrades on July 5, 2014, due to problems that occurred with the thermostatic control of system operation. There are many reasons for the difficulties of installing upgrades, but they fall into six primary categories:

1. Participant did not have a central system;
2. Problems with the central system made it infeasible to filter the air;
3. Problems with being able to install the filter system we were using;
4. Problems with being able to install the thermostat;
5. Participant worried about obtaining permission to make changes to their system since they are a renter;
6. Participant did not want to run the central system 15 minutes of every hour.

The portion of homes and reasons that did and did not have a central forced-air system installed is summarized in Table A1. Besides the above six issues, there were other miscellaneous reasons that an upgrade could not be conducted (5 homes). A total of 43 homes (29% of total homes) had the central system installed.

Table A1 Summary of problems observed during the central forced-air system inspection and installation.

Problems with installing central system upgrade	# of HH	%
No central system	20	14%
Problems with central system		
– Not working or operating poorly	11	8%
– Central system share with neighbor or does not service child's room	3	2%
– No fan only mode	5	3%
– Has swamp cooler	4	3%
Problems with installing the filter		
– Inlet grill inaccessible, on floor, behind door, etc. [1]	6	4%
– Insufficient clearance around grille [2]	17	12%
– Existing inlet could not be removed or was not mounted to flat, intact wallboard [3]	6	4%
Problem with installing thermostat		
– No common wire [4]	3	2%
– Multiple thermostats controlling one central system	4	3%
– No modification allowed on thermostat by utility company [5]	3	2%
No landlord permission	5	3%
Participant does not want upgrade	6	4%
Other [6]	5	3%
Status of qualified homes		
Central System Filtration installed	43	29%
Qualified, ended up not in study	1	1%
Qualified, switched to stand-alone air cleaners prior to CSF installation	4	3%
Total	**146**	**100%**

[1] The filter is located somewhere in the home that, as the filter is elevated by 2 inches, it is not practical to have it installed, such as behind the door, on the floor, or behind a built-in cabinet or piece of furniture.

[2] The filter opening needs to have approximately 2 inches of clearance before a junction with a wall.

[3] The existing filter was mounted in a way that cannot be removed or was not mounted to the flat, intact wallboard. For example, in two homes, the wallboard was damaged near the intake and screws could not be securely installed. In one home, the return grill was an integral component of the ducting and in another it was glued to the wall. One home had a bowed ceiling, and thus the filter could not be installed properly without air leakage.

[4] We were initially only installing systems in homes with a common wire to the thermostat (see Section A.3 on thermostats below). We installed stand-alone air cleaners in these homes prior to locating a thermostat that did not require a common wire (3 homes).

[5] Two homes in Fresno and one in the Riverside area were enrolled in a program through their utility provider that utilized special thermostats to control energy use. The utility company had placed signage on the thermostat forbidding the occupant to remove the thermostat (3 homes).

[6] Examples include plans to replace central system, only spoke Lao, had 3 return grills.

A.3 Study Thermostats

The study required that the central system run in "fan-only" mode for 15 minutes of every hour. This is called a "clean-air" mode. There were several thermostats used over the course of the study. The first one was a Robert Shaw product. This one required the home have a five-wire connection between the thermostat and the heating and cooling unit. Many modern central systems have a five-wire system. In the five-wire system, a steady 24V power supply leads from the furnace/cooling unit to the thermostat. This wire is typically called the common wire. The other wires lead to heat, fan, and cooling. This is what is required in order to install an electric "smart" thermostat. In these systems, switching is not done manually by triggering a switch. In these cases, the switching is done electronically, powered by the 24V power supply. This thermostat was installed in 3 homes, however 2 of these homes had the Central System Filtration removed within the first month, and the third was replaced with a different model thermostat after 6 months because it was not turning the fan on properly. It was apparent that very few homes in the study population have a five-wire connection; therefore, a different thermostat was found that could be installed in more homes.

Most of the study homes had a three-wire system. In a three-wire system, the thermostat generally has a "heat – off – fan only" switch and a temperature setting. When the switch is turned to the off position, the circuit is broken such that neither the furnace nor the fan will turn on. When this switch is in the heat position, the circuit is triggered open and closed by a switch within the thermostat, and thus the heater is turned on and off at the appropriate times based on the temperature at the thermostat. When the switch is in the fan only position, this switch manually connects the circuit that signals the furnace to turn only the fan on.

There were two three-wire compatible thermostats available at the time: The Lux Pro PSP722E and the RobertShaw RS 6220. The LuxPro was selected because it ran for 15 minutes of every hour while the RobertShaw ran for five minutes out of every 15 minutes, for a total of 20 minutes per hour. Given that our target was 15 minutes per hour, and that we thought participants might object to the fan going on every 15 minutes, we selected the LuxPro.

The LuxPro was installed in 33 homes from February 2014 to July 2014 (including the one home that changed from original RobertShaw). Prior to the last day in June, we received two calls with homes reporting that their air-conditioner would not turn off, and one home that was generally unhappy with their thermostat. A technician was able to work with the homes and get the air conditioner to turn off or otherwise solve the problem. These homes were considered by our team as isolated incidents.

The temperature increases significantly across California in late June/early July 2014, and we received six calls reporting that the air conditioning could not be turned off in participants homes between June 30th and July 5th, 2014. Some participants reported the system running for several days before they called. It became clear that the LuxPro thermostat was problematic. The decision was made to replace all homes with the RobertShaw thermostats and increase electrical reimbursements corresponding to the increased hourly run time. Problems with the thermostat continued to be reported. In all, eleven households reported problems with their air-conditioning not turning off. In addition, there were another two homes with poorly defined thermostat

problems. A total of 20 homes that had the LuxPro never experienced any problems in relationship to their thermostat.

Homes scheduled for filtration through the central system were given the choice to wait for a solution or have stand-alone air cleaners installed. No new homes were evaluated.

We note that some participants were not happy with their RobertShaw replacement thermostat. One household specifically requested to go back to the LuxPro. By that time, a new LexPro model was available that was thought to be more reliable than the original PSP722E model installed and this new model was installed in their home. Two homes requested to shift to the portable air cleaner group while they were still receiving true filtration. An additional 3 homes requested a thermostat that did not have the "clean-air" mode while they were in the final sham period and one was installed. One of these homes was particularly concerned that it would not run the system the recommended amount, and thus, a portable air cleaner with sham filtration was also installed in this home. One household moved during the final sham period and received air cleaners in their new home. One household experienced family difficulties and the mom moved out of the home and received air cleaners while still experiencing true filtration. The child may have additionally spent time in the home with the Central System Filtration, but it was unclear how much time the children spent at the house with Central System Filtration after that point.

A.4 Other Problems with use of Central Systems Encountered

Another difficulty when using the central system is that the components in the central system may fail while the participating household is in the study due to normal wear-in-tear, which may have been accelerated due to increased usage or the units cooling for extended periods. Repairs were needed in three homes due to extended periods of cooling. Repairs due to typical wear and tear were needed in 6 homes, and the study paid for minor repairs in additional 3 homes and declined repairs in 3 homes. Finally, a handful of participants were concerned that their system was not running properly, but the service contractor indicated that there were no actual problems with the central system.

Additionally, one home had the filtration unit fall from the ceiling. Fortunately, no one was home at the time. An IQAir technician determined that two of the screws that were have thought to have gone into a wood stud had failed to do so, and the other two screws, intended to go in to the wallboard, had devices inadequate for securing the unit. IQ Air or study staff checked the mounting of all of the central system filtration units and replaced the mounting devices used when the device was mounted into wallboard as necessary.

Electricity reimbursements were based on estimated power consumption by the blower motor in the central system. It is noted that actual power consumption is variable and depends on the efficiency of the blower in the central unit. Several households reported concerns regarding compensation for electricity. If their year-to-year bills showed a greater increase in use than expected based on the estimated fan power usage we did our best to properly reimburse them for their increased electricity use, and this was generally resolved by increasing reimbursement. One household did drop out because they were unsatisfied with our proposed reimbursement. This

household also had their air conditioner on for several days due to a problem with the thermostat, which may have also contributed to them dropping out of the study. As study personnel had no way to determine actual fan use, determining correct electricity reimbursements for central system filtration households was difficult.

A.5 Follow-Up of Central System Homes

We present the information on the follow-up of the participating Central System Filtration households in Figure A1 and A2 below. Please note that the unit is households, rather than participants.

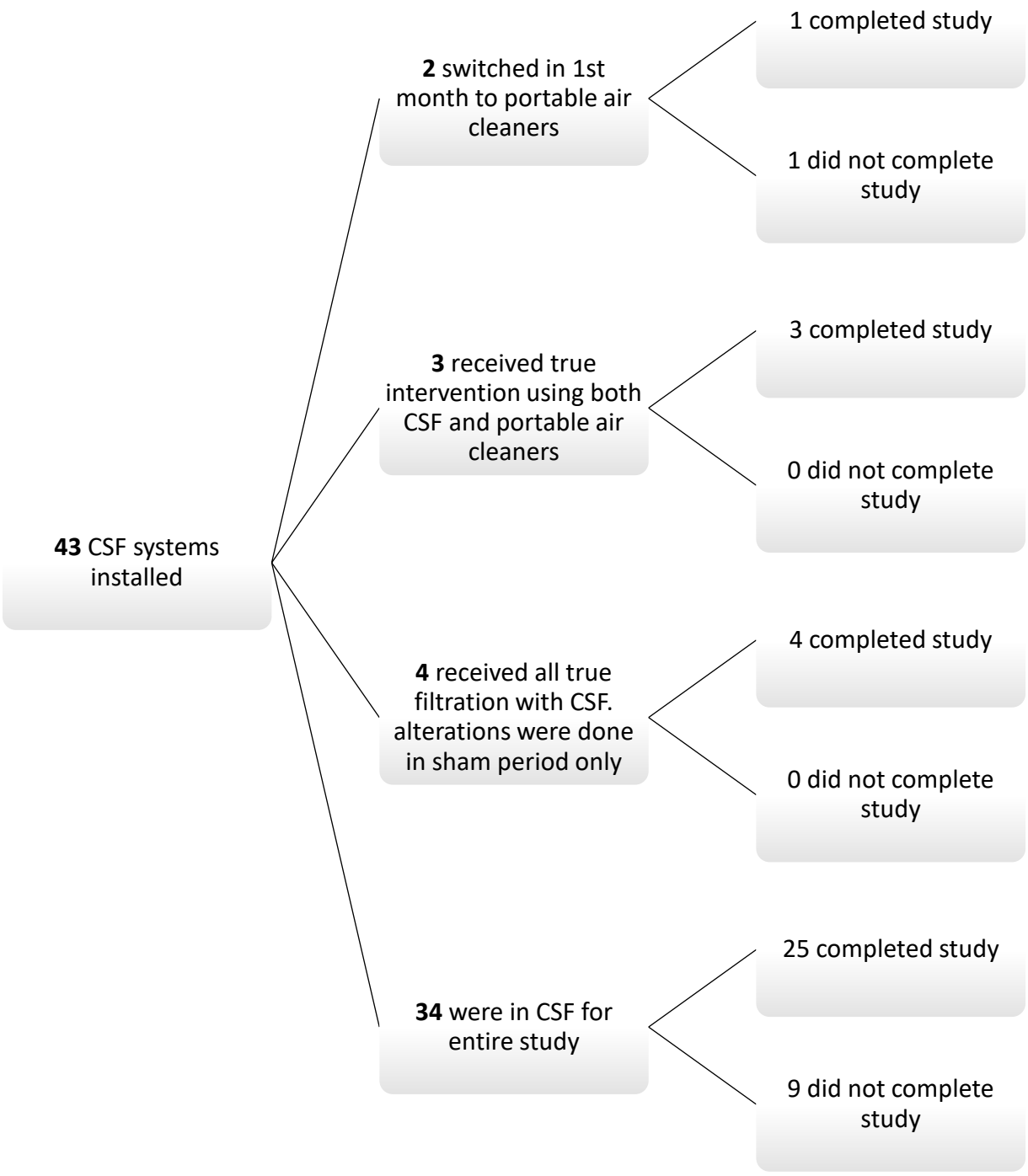

Figure A1. Follow-up of participating households with Central System Filtration installed. The figure first lists if they had any changes in how they received their intervention, and then lists whether or not they completed the study.

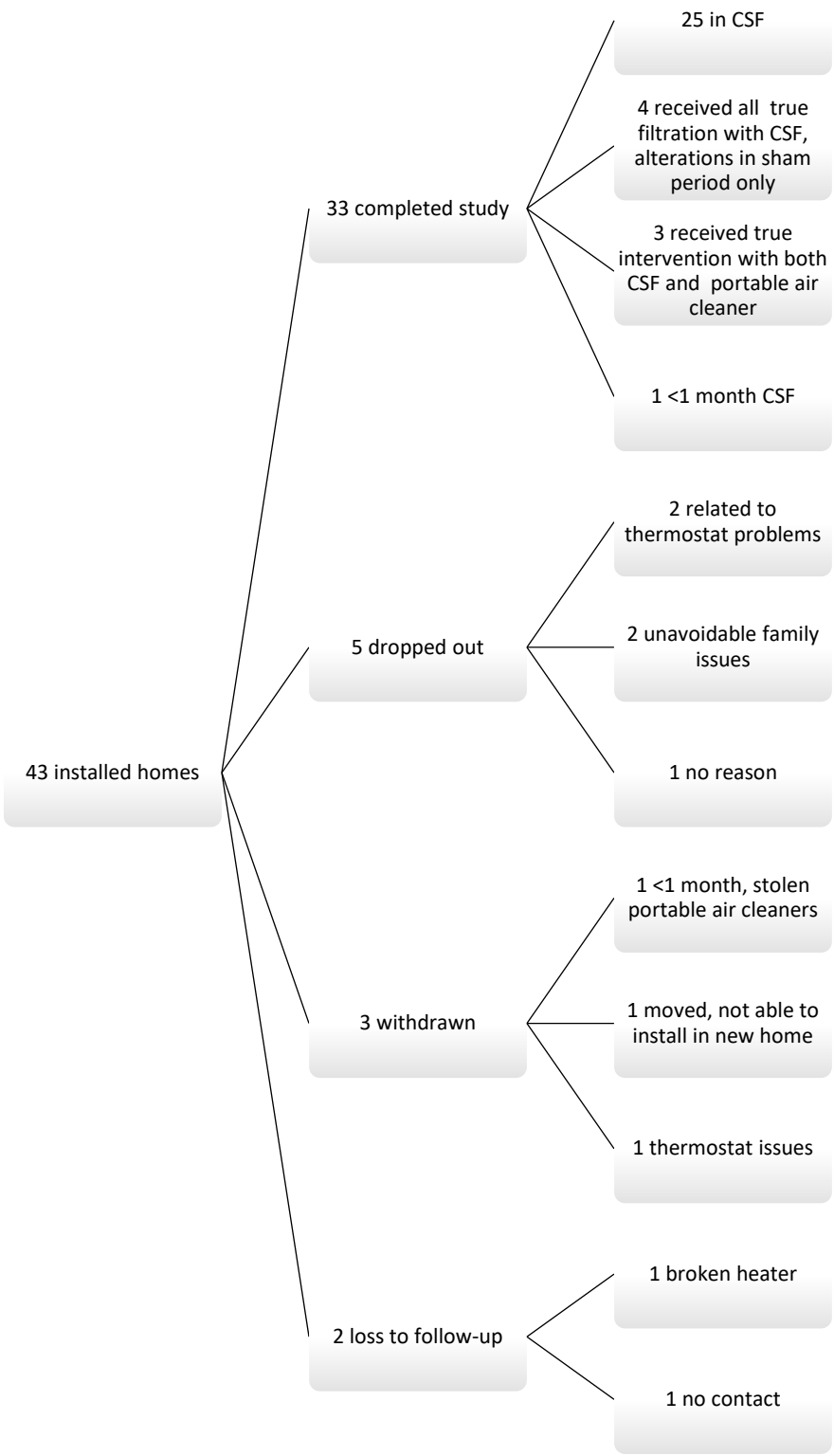

Figure A2. Follow-up of participating households with Central System Filtration installed. The figure first lists if they completed the study, then changes in how they received their intervention or reasons for participants not completing the study.

Filter Analysis
23 March 2015

Product Information:

Description:	**Filter "EE" for Large Air Cleaner**
HHID:	**90044 – Living Room**
Description:	**Filter "EE" for Small Air Cleaner**
HHID:	**80066 - Bedroom**
Description:	**Filter "E" for Large Air Cleaner**
HHID:	**80016 – Living Room**

Status:

Date Received:	23 March 2015 June 2014	(HHID 90044 & HHID 80066) (HHID 80016)
Inspection:	23 March 2015	
Summary Findings:	"EE" filters functioning properly as placebo filters. Soiling characteristics differ from "E" real filters.	
Recommendation:	no change required	

Sample Evaluation:

Reason for Analysis:

UC Davis Asthma Study researchers noticed unusual soiling on the "EE" placebo filters used in the stand-alone air cleaners. This ran the gamut from particularly clean filters that looked like new, to grey filters that appeared to have dust deep within the pleats. They expressed concern that some of the placebo filters may be malfunctioning, drawing air through the filter and therefore acting as an air cleaner during the placebo portion of the test.

UC Davis performed their own inspection of the filters, cutting open some "EE" filters and confirming the presence of the blocking panel. Still, the soiling deep within the pleats concerned the researchers, so they sent examples of the filter media to IQAir for analysis.

Incoming Inspection

The two samples of "EE" placebo/sham filters exhibited light grey dust on the surface of the filter media. This was uniformly deposited across the media except where the pleats were folded over upon itself. The dust appeared to be fine dust.

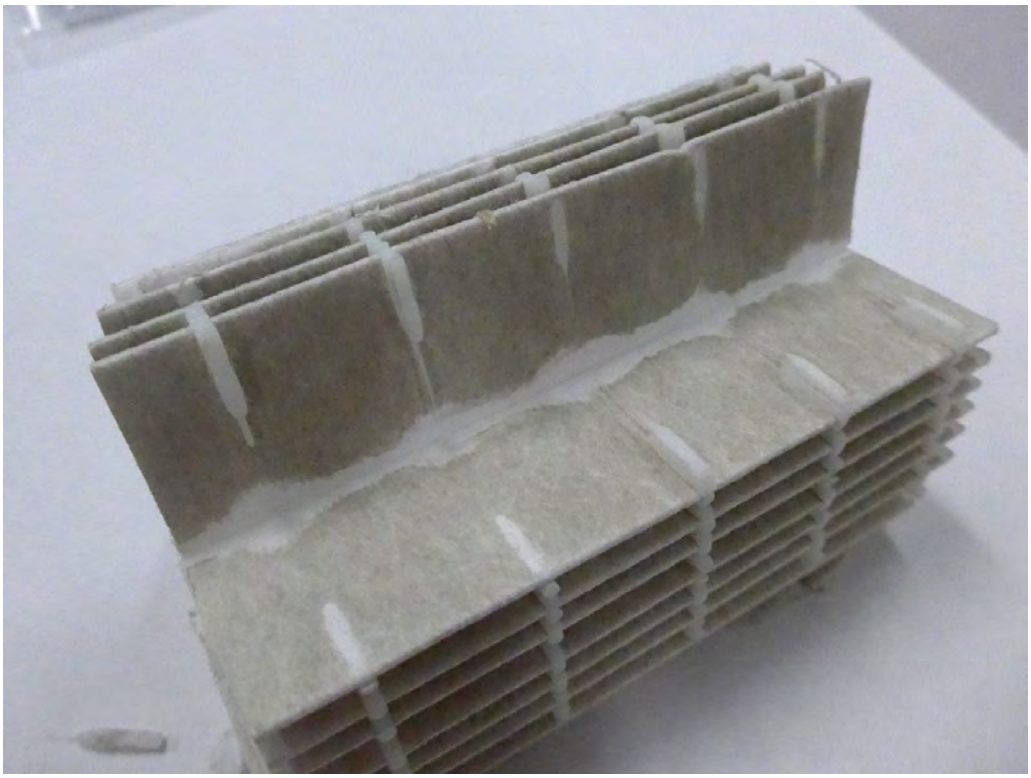

Figure 1: uniform soiling of very fine dust on the “EE” placebo filter

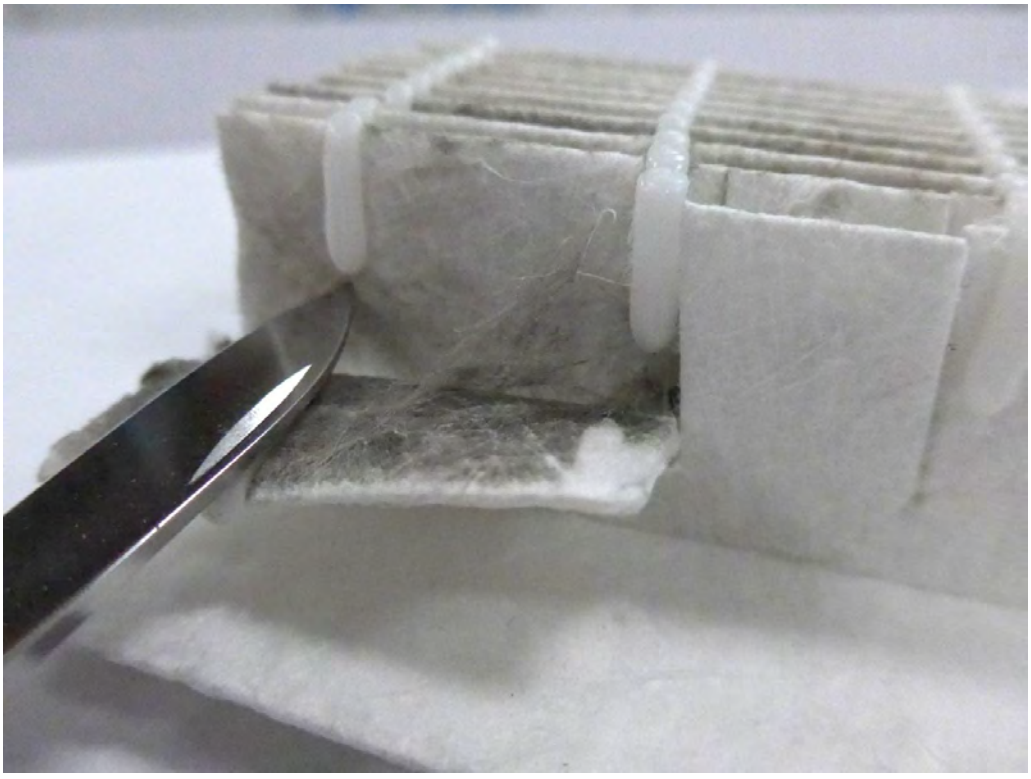

Figure 2: dust on the surface of the “EE” filter

Comparison with “E” Filter

For comparison, a used “E” real filter from the UCD Asthma Study archives was similarly cut open and compared.

- Presence of Dust Piles. The “E” real filters exhibited piles of coarse dust forming on the face of the filter that coincided with the inlet opening patterns. The “EE” placebo filters did not exhibit the dust piles

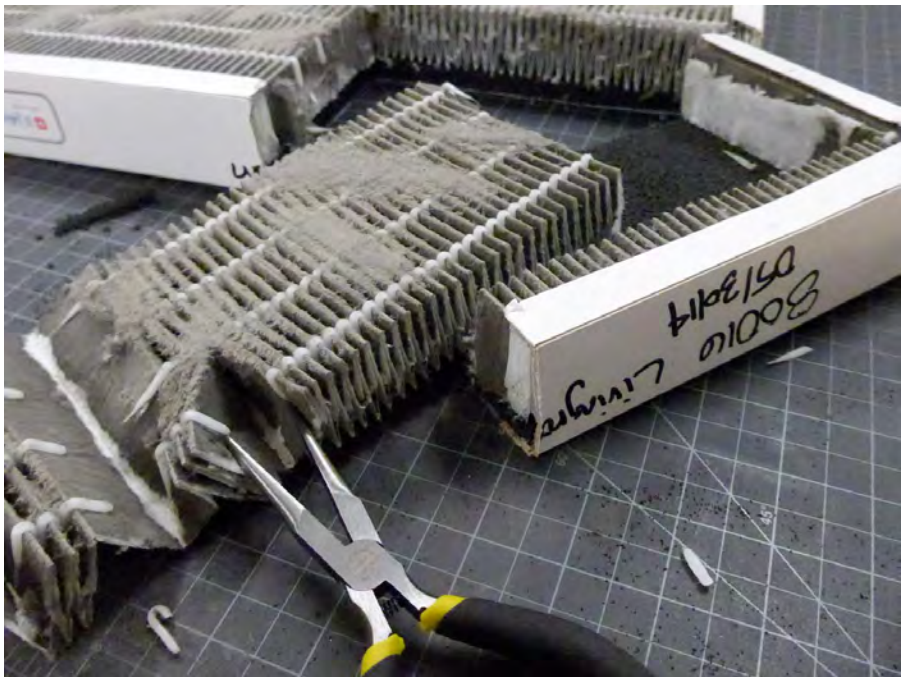

Figure 3: dust piles on the face of the “E” real filter

Figure 4: dust piles are predominantly coarse dust

- Coarse Dust in the Pleats. The “E” real filters had both coarse dust and very fine dust embedded deep in the pleats, whereas the “EE” placebo filters only showed very fine dust. This demonstrates that air was not passing *through* the “EE” filters, and confirms that the device was not actively cleaning the air. The soiling corresponds to the ultra-fine particles (UFPs) and the fine particles (FPs) that would be attracted to the electrostatic filter media despite the lack of airflow through the filter.

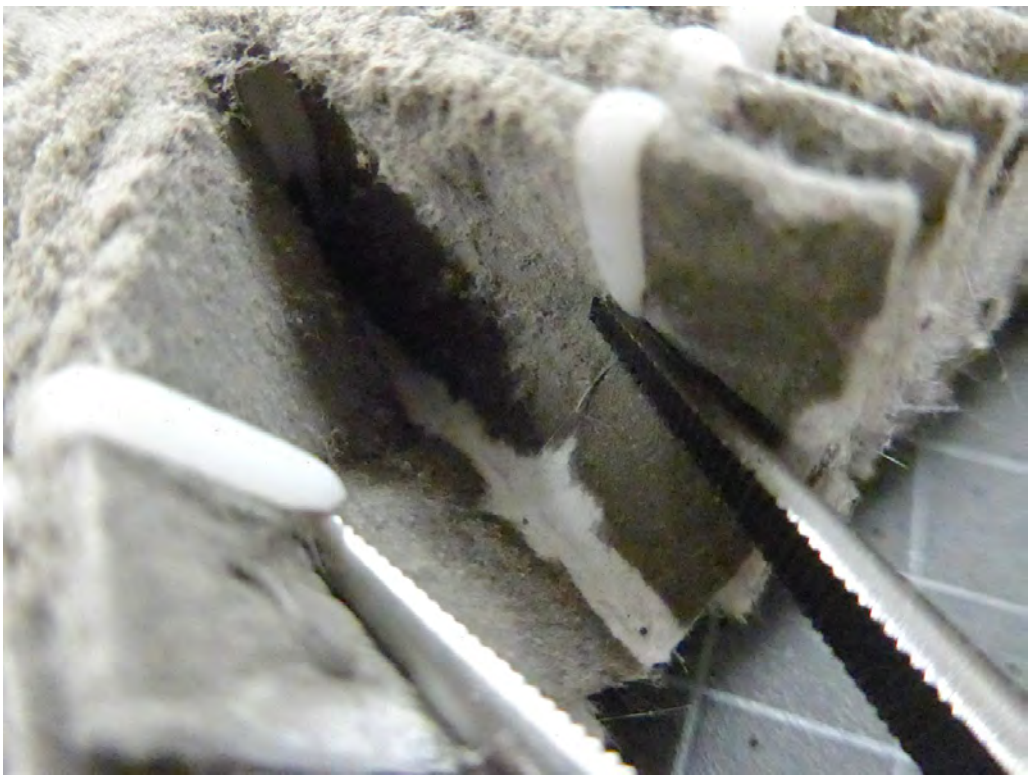

Figure 5: coarse dust drawn down into the pleats due to airflow *through* the real filter

Figure 6: coarse dust found at the bottom of the pleats

Figure 7: torn cross section of “E” filter media shows coarse as well as very fine dust

Preliminary Findings:

The “EE” filter media samples were indeed curious, as they exhibited a level of soiling that was higher than expected; however, closer inspection of the dust characteristics (size) in comparison to the dust loading on a real filter showed marked differences. The “EE” filters were soiled only with very fine dust, whereas the “E” filters showed a broad mix of coarse and fine particles consistent with airborne pollution. The “EE” filters were not actively cleaning the air, and were performing properly as placebo filters.

Because filters were not weighed prior to installation, it is not possible to quantify the amount of dust removed passively by the placebo filter. It is expected that the even if the filters had been weighed, the increase due to the soiling would likely be below the accuracy tolerances for the measurement equipment.

Recommendations:

No change required.

Changing to a non-electrostatic filter media for the “EE” filters would eliminate the soiling; however, it would have a slightly different appearance than the “E” filters that may make it less effective as a placebo.

Asthma Study Participant Recruitment/ Eligibility Screening Script

[Note: Information in parentheses indicates the need to fill-in the stated info or to choose the applicable option. For simplicity, parts of this script refer to the parent of the participating child as the participant.]

If returning a call from message on voicemail: "Hello, this is (your name) from the Asthma study at the University of California. May I speak with (participant's name)?"

[**WHEN SUBJECT IS ON THE PHONE**]: "Hi Mr./Ms. (last name of participant). This is (your name) from the Asthma Study at the University of California, Davis.

If answering an incoming call, answer the phone with this introduction: "Hello, this is (your name) from the Asthma study at the University of California."

We are conducting an Asthma study examining how in home air filtration affects both indoor air quality and children with asthma and would like to invite you and your child to participate. For this study, we're assessing how high efficiency air filtration in homes affects children with asthma. If you decide to participate, we would visit your home several times over a two year period to gather information about home air filtration, to install a high efficiency air filter, measure your child's lung function and ask you and your child about your child's medical history related to their asthma and their current asthma symptoms. At the end of the study, you would be able to keep the high-efficiency air filters that we placed in your home. If this sounds like something you might be interested in, I'd be glad to give you more information now—do you have a few more minutes so that I can explain further?

<IF YES, CONTINUE> Your decision whether or not to participate in this study will in no way effect your relationship with UC Davis. The rest of this information should take about 5 minutes of your time. First I have a few questions to determine if you are eligible for this study.

- Is there a child living in your home, who has asthma, between the ages of 6-12 years old (or 6-17, if we expand the study)?
  - **If NO ->** At this time we are only enrolling children between the ages of 6-12 years old (or 6-17 years old).
- **If YES** -> Has your child been diagnosed with moderate or severe asthma by a doctor?
  - **If NO ->** At this time we are only enrolling children who have been diagnosed with moderate to severe asthma by a doctor.
- **If YES ->** Does anyone in your home currently smoke cigarettes?
  - **If YES ->** At this time we are only enrolling non-smoking homes in this study.
- **If NO->** Would you be willing to run the fan on your home HVAC system for a portion of each day (15min/hour) or run an air cleaner for most of the day during this study?
  - **If NO ->**At this time we are only enrolling homes that are able to run either their HVAC system or a portable air cleaner for the majority of the day.
- **If YES ->** Do you currently use an air cleaner or high efficiency air filter in your home HVAC system?
  - **If YES ->** Please tell me more about the system that you are currently using:
    - Determine if the filter in an HVAC system is thicker than 1 inch and/or what the filtration cut point is for their air cleaner they are using.
      - If it can be determined that they have a high-efficiency filter with MERV rating equal to 15 then inform them: -> It appears that you already have a high-efficiency air filter like the one being examined in this study. At this time we are only able to enroll homes that are not using a high efficiency air filter.
- **If you have reached this point and it appears that they are not using a high efficiency air filter: ->** It appears that you are eligible for this study and we would like you to volunteer to join our study. However, if you decide to participate, your final determination of eligibility would occur at your first home visit, so that we can verify that your filtration system is not a high-efficiency filter like the one being used in this study.

If you decide to participate:

- Study staff will come to your home, at a prearranged times, for 1-2 hours up to 10 times in a two year period. During these visits you will be asked to:

- Allow study staff to inspect your HVAC system and then install a high-efficiency filter in your HVAC system OR place an air cleaner in your main living area and in your child's bedroom. You will be randomly assigned to receive an HVAC filter or a portable air cleaner.
- For a portion of the study your air will be filtered and for a potion of the time your air will not be filtered. You will not be told when your air is being filtered.
- Some participants that have been assigned to the portable air cleaner filtration group will have an extra filter installed that reduces the ozone levels in the air.
- Use a provided mattress cover on your child's bed.
- Answer questions about your child's health history and your home environment (ventilation systems, pets, carpeting, cooking sources).
- Have air quality monitoring equipment set-up both inside (in your child's bedroom) and outside your home. This equipment will measure the air quality for two weeks at a time and will be done up to 5 times during the study. The equipment consists of a pump in a sound reducing box about the size of a toaster oven, with 2-4 small monitors attached to a rod on the top of the box. The device makes minimal noise, similar to a fish tank motor, has no external moving parts, and is both child and pet safe.
- If you live near a busy roadway, we may also collect an additional air quality measurement for black carbon, both inside and outside your home. This will be done using the same equipment that is already being used to monitor the air quality inside and outside of your home.
- Fill out a questionnaire once every 3 months asking about your child's medication use and visits to the emergency room or other unplanned doctor visits due to your child's asthma.
- Have your child perform Spirometery lung function testing, during a scheduled home visit, up to 3 times during the study.
- Have your child perform exhaled nitric oxide (eNO) measurements, during a schuedled home visit, up to 5 times during the two year study period.

- The following activities will be completed by you or your child during the study and may be either delivered to you at a scheduled home visit or mailed to you with packaging to mail back to the study staff when completed:
  - Have your child use a peak flow meter (Piko) two times a day, in the morning and evening, for one-week at a time. This may be done up to 9 times during the two year study.
  - Have your child answer questions about their asthma symptoms each day for 2-weeks. This will be a short questionnaire that they fill in each day and may require help from you to complete. This may occur up to 9 times over the two-year study period.
- Some study participants may be asked to collect a personal air sample. For this we would ask your child to wear a small backpack containing a small pump with a sampling device attached for 48-hours. This may be done up to 4 times during the two year study period.
- Do you have any questions about the study? <IF YES, ANSWER QUESTIONS>
- We would like to invite your child to participate—does this sound like something that would interest you?"
- You will receive $15 for each questionnaire set you complete. This equates to $120 if both you complete all 8 of the questionnaire sets. Your child will receive a $10 toy at the initial visit to your home and a $5 each time they complete the peak flow meter testing. If you drop out of the study at any point, you may keep the money and toys you have received.

<IF NO TIME FOR DETAILS ON PHONE> Is there a better time to contact you? (note day and time)

<IF DON'T APPEAR INTERESTED IN STUDY>: Are there any questions I can answer that would help you in making your decision? [NOTE RESPONSE]

Volunteers needed for Asthma Research Study

UC DAVIS UNIVERSITY OF CALIFORNIA | CENTRAL CALIFORNIA ASTHMA COLLABORATIVE CCAC | UCSF fresno

What is this study about?

The AIRE Study (Asthma and Indoor air - Reducing Exposures) is looking to see if improved air filtration in homes of children with asthma will help reduce a child s exposure to indoor air pollution and improve their asthma symptoms.

Who is doing this study?

This study is being conducted by Dr. Deborah Bennett from UC Davis, with researchers at UCSF Fresno and the Central California Asthma Collaborative.

What does this study involve?

High-efficiency air filters or cleaners will be installed in your home. Study st f will visit your home up to 10 times over a 2-year period to measure the air quality and assess your child's asthma symptoms and lung function.

Who is eligible to participate in this study?

Any child (6 -12 years old) who has been diagnosed with asthma, lives in the Fresno/Clovis area, and is not already using a high-efficiency air cleaner in your home

What are the benefits of participating in this study?

It is anticipated that this study will improve the air quality in your home, which may improve your child's health. You will also get to keep the high-efficiency air filters or cleaners at th end of the study.

Will I get paid for being in this study?

Each household that completes the study will be financially compensated for their time, effort and any additional electricity that may be associated with operating the high-efficiency air cleaners.

Please Contact Our Office for More Information

Call (855)398-4740

OR

email: asthmastudy@ucdavis.edu

This flyer has been reviewed and approved by FUSD Health Services and REA Office

Volunteers needed for Asthma Research Study

UC DAVIS
UNIVERSITY OF CALIFORNIA

AIRE STUDY

What is this study about?

The AIRE Study (Asthma and Indoor air - Reducing Exposures) is looking to see if improved air filtration in homes of children with asthma will help reduce a child s exposure to indoor air pollution and improve their asthma symptoms.

Who is doing this study?

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What does this study involve?

High-efficiency air filters or cleaners will be installed in your home. Study st f will visit your home up to 10 times over a 2-year period to measure the air quality and assess your child's asthma symptoms and lung function.

Who is eligible to participate in this study?

Any child (6 -12 years old) who has been diagnosed with asthma, lives in the Riverside or San Bernardino area, and is not already using a high-efficiency air cleaner in thier home

What are the benefits of participating in this study?

It is anticipated that this study will improve the air quality in your home, which may improve your child's health. You will also get to keep the high-efficiency air filters or cleaners at th end of the study.

Will I get paid for being in this study?

Each household that completes the study will be financially compensated for their time, effort and any additional electricity that may be associated with operating the high-efficiency air cleaners.

Please Contact Our Office for More Information

Call (855)398-4740

OR

email: asthmastudy@ucdavis.edu

APPENDIX B: APPENDICES RELATED TO THE BASELINE QUESTIONNAIRES

BASELINE QUESTIONNAIRE/ HOME WALKTHROUGH – PART 1

"THANK YOU FOR PARTICIPATING IN THIS STUDY. THIS INTERVIEW CONSISTS OF QUESTIONS RELATING TO YOUR CHILD'S MEDICAL, FAMILY, AND ASTHMA HISTORY AND YOUR HOME ENVIRONMENT. FOLLOWING THE QUESTIONNAIRE, WE WOULD LIKE TO WALK-THROUGH YOUR HOME WITH YOU TO RECORD SOME GENERAL INFORMATION ABOUT THE PLACE WHERE YOUR CHILD SLEEPS."

GENERAL INFORMATION

Visit code:

Enrollment **Other:**_____

HHID : _____

LANGUAGE OF INTERVIEW: English ……..1

Spanish ……..2

DATE OF INTERVIEW __ __ / __ __ / __ __ __ __
M M D D Y Y Y Y

DATA ENTERED BY: _ _ DATE: __ __ / __ __ / __ __ __ __

DATA EDITED BY: _ _ DATE: __ __ / __ __ / __ __ __ __

HEALTH HISTORY

1. How are you related to [CHILD]? ***(Check one)***
   - ☐ Mother (bio or adoptive)
   - ☐ Father (bio or adoptive)
   - ☐ Step-mother
   - ☐ Step-father
   - ☐ Foster parent
   - ☐ Grandmother
   - ☐ Grandfather
   - ☐ Sibling
   - ☐ Other family Specify: _____
   - ☐ Other non-family Specify: _____

2. At what age was [CHILD] diagnosed with asthma? _____ years old

3. Has [CHILD] ever been hospitalized because of asthma?

☐ No **[SKIP TO 4]**

☐ Yes

☐ DK/RF **[SKIP TO 4]**

4. Has [CHILD] **EVER** had a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu? (For example, when s/he is near a furry animal or around pollen or mold.)

☐ No **[SKIP TO 5]**

☐ Yes

☐ DK/RF **[SKIP TO 5]**

a. During the **past 12 months**, has [CHILD] had a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu?

☐ No

☐ Yes

☐ DK/RF

b. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around or in contact with furry animals?

☐ No

☐ Yes

☐ DK/RF

c. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around mold or a musty smell?

☐ No

☐ Yes

☐ DK/RF

d. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around pollen?

☐ No **[SKIP TO 5]**

☐ Yes

☐ DK/RF **[SKIP TO 5]**

i. What time of the year did [CHILD] have a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around pollen? Would you say: ***(Read categories)***

	Yes	No	DK/RF
Early Spring (March-April)			
Late Spring (May-June)			
Fall (September – October)			

5. Has [CHILD] ever been diagnosed by a doctor as having hayfever or seasonal allergies (allergic rhinitis?)
   - ☐ No **[SKIP TO 6]**
   - ☐ Yes
   - ☐ DK/RF **[SKIP TO 6]**

   a. Has [CHILD] ever received shots to treat his/her allergies?
      - ☐ No
      - ☐ Yes
      - ☐ DK/RF

6. Has [CHILD] ever had an itchy rash that comes and goes for at least 6 months?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF

7. Has a doctor ever diagnosed [CHILD] with <u>eczema or atopic dermatitis</u>?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF

8. Has a doctor ever diagnosed [CHILD] with a <u>sinus infection or sinusitis</u>?
   - ☐ No **[SKIP TO 9]**
   - ☐ Yes
   - ☐ DK/RF **[SKIP TO 9]**

   a. Was [CHILD] referred to a specialist to treat this sinus problem?
      - ☐ No
      - ☐ Yes
      - ☐ DK/RF

ASTHMA MANAGEMENT

"NOW I WANT TO ASK YOU SOME QUESTIONS ABOUT SYMPTOMS THAT ARE RELATED TO [CHILD'S] ASTHMA. YOU CAN ANSWER YES/NO/NEVER HAD OR NEVER BEEN IN CONTACT WITH."

9. Do any of the following make [CHILD]'s asthma symptoms including wheezing, coughing, chest tightness, or shortness of breath worse? ***(Read all categories)***

Do _____ make [CHILD]'s asthma symptoms including wheezing, coughing, chest tightness, or shortness of breath worse?	**Yes**	**No**	**Never Had / No Contact**	**DK/RF**
Colds				
Sinus infections				
Bronchitis				
Pets or other animals				
Dust				
Aspirin				
Smog				
Cigarette or cigar smoke				
Wood smoke, as from a campfire, fireplace or wood burning stove				
Perfumes				
Strong smells (Sources other than perfumes, including cleaning products)				
Cold air				
Exercise				
Pollen				
Other (specify) :				

10. Has a doctor or other health care provider given a written plan for managing [CHILD's] asthma? This is also called an asthma action plan.

☐ No

☐ Yes

☐ DK/RF

OTHER

11. Does anyone who currently spends time with [CHILD] smoke around him/her, either indoors or outdoors?

☐ No **[SKIP TO 12]**

☐ Yes

☐ DK/RF **[SKIP TO 12]**

a. Do they smoke around [CHILD]: ***(Read all categories)***

	No	Yes
In the car		
In [CHILD]'s house		
In another house the [CHILD] spends time in		
In an outdoor location		
Other:		

12. Do you have any pets right now?

☐ No **[SKIP TO 13]**

☐ Yes

☐ DK/RF **[SKIP TO 13]**

a. Do you have?		**b. How many___ do you have?**	**c. Do any of your _____spend time indoors?**	**d. Do any of your _____sleep in [CHILD'S] bedroom regularly?**
Cats	No Yes		No Yes	No Yes
Dogs	No Yes		No Yes	No Yes
Rodents	No Yes		No Yes	No Yes
Birds	No Yes		No Yes	No Yes
Other (indoor pets): _____	No Yes		No Yes	No Yes

PRE-INTERVENTION RECALL QUESTIONS:

THE FOLLOWING QUESTIONS ASK ABOUT THE EFFECT OF [CHILD]'S ASTHMA IN THE LAST TWO WEEKS; THAT IS, THE PAST 14 DAYS, FROM [14 DAYS AGO] TO TODAY." [SHOW CALENDAR.]"

13. During the last 14 days, how many days did [CHILD] have wheezing, tightness in the chest, or cough because of asthma?

_____ Days

14. During the last 14 days, how many days did [CHILD] have to slow down or stop his/her play or activities due to wheezing or tightness in the chest, or cough because of asthma?

_____ Days

15. During the last 14 days, how many days did [CHILD] use his/her rescue inhaler during the day for relief of asthma symptoms? Please do not include use of the rescue inhaler taken prior to physical activities such as playing sports or exercising.

_____ Days **[IF 0, SKIP TO 16]**

a. During the last 14 days on average, on the days [CHILD] used his/her rescue inhaler, how many total puffs or inhalations did he/she use each day?

_____ Puffs

16. During the last 14 nights, how many nights did [CHILD] wake up due to wheezing or tightness in the chest, or cough because of asthma?

_____ Nights

a. During the last 14 nights, how many nights did [CHILD] wake up and use a rescue inhaler or breathing machine/nebulizer after going to sleep?

_____ Nights

17. During the last 14 days, how many days was school in session? [Response cannot be greater than 10 days.]

_____ Days **[IF 0, SKIP TO 18]**

a. How many times in the last 14 days did [CHILD] miss school due to asthma?

_____ Times

18. During the last 14 days, how many days has [CHILD] had a cold or a respiratory flu (NOT including the stomach flu)?

_____ Days

19. During the last 14 days, how many days has [CHILD] had a runny or blocked nose?

_____ Days

20. During the last 14 days, how many days has [CHILD] had sneezing or an itchy nose?

_____ Days

21. During the last 14 days, how many days has [CHILD] had red/ itchy eyes, watery eyes, or irritated eyes?

_____ Days

22. During the last 14 days, how many days has [CHILD] taken oral anti-histamines for his/her allergies?

_____ Days

23. During the last 14 days, how many days has [CHILD] used prescription allergy eye drops?

_____ Days

24. During the last 14 days, how many days has [CHILD] used a prescription allergy nose spray?

_____ Days

"THE NEXT QUESTION IS ABOUT MISSING WORK DUE TO [CHILD]'S ASTHMA"

25. Are you currently employed (working for pay)?

☐ No **[SKIP TO 26]**
☐ Yes
☐ DK/RF **[SKIP TO 26]**

a. During the last 14 days, how many hours of work did you miss because of problems associated with [CHILD]'s asthma? [If necessary, review with caretaker the number of hours per week he/she works.]

_____ hours **[IF 0, SKIP TO 26]**

b. In general, how many hours per week do you usually work? _____ hours/week

26. During the last 14 days, did any other of [CHILD]'s caregivers miss work because of problems associated with [CHILD]'s asthma?

☐ No **[SKIP TO 27]**
☐ Yes
☐ DK/RF **[SKIP TO 27]**

a. During the last 14 days, how many hours of work did they miss because of problems associated with [CHILD]'s asthma?

_____ hours **[IF 0, SKIP TO 27]**

i. In general, how many hours per week do they usually work? _____ hours/week

"THE NEXT FEW QUESTIONS ARE ONES YOU HAVE ALREADY DEALT WITH TO SOME EXTENT. I NEED TO ASK THE QUESTIONS JUST AS THEY ARE WORDED HERE, SO BEAR WITH ME.I AM GOING TO ASK YOU ABOUT THE EFFECT OF [CHILD]'S ASTHMA IN THE LAST YEAR."

27. During the last year, because of problems with asthma, how many times has [CHILD] stayed overnight in the hospital?

_____ Times **[IF 0, SKIP TO 28]**

a. When were these visits? (what month/s) ***(Mark all that apply)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

b. Was there a specific identifiable cause of these asthma attack(s) that you are aware of?

☐ No
☐ Yes
☐ DK/RF

i. If YES, specify: _____

28. During the last year, because of problems with his /her asthma, how many times has [CHILD] been seen in the emergency room?

_____ Times **[IF 0, SKIP TO 29]**

a. When were these visits? (what month/s) ***(Mark all that apply)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

b. Was there a specific identifiable cause of these asthma attack(s) that you are aware of?

☐ No
☐ Yes
☐ DK

i. If YES, specify: _____

29. During the last year, because of problems with asthma, how many times has [CHILD] been seen in the doctor's office or clinic for a sick visit?

_____ Times **[IF 0, SKIP TO 30]**

a. When were these visits? (what month/s) ***(For each visit reported, ask "Was that a visit related to asthma symptoms?" and only record if yes.)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

30. During the last year, how many times has [CHILD] been given steroid pills or liquid, or a steroid shot (such as prednisone)?

_____ Times

31. During the last year, has [CHILD] had: *(read and mark all that apply)*

If "Yes" to any of the following, after each ask:

During the last year, how many times has [CHILD] had [Cold/Flu/Sinus Infection/Ear Infection/Pneumonia/Other]?

	Yes	**No**	**DK/RF**	**Number of Instances**
Cold/ Flu (not stomach flu)				
Bronchitis				
Sinus Infection				
Ear Infection				
Pneumonia →Was it diagnosed by a doctor? ☐ No ☐ Yes ☐ DK/RF				
Any other respiratory infection:				

"I WOULD LIKE TO REMIND YOU THAT YOU DON'T HAVE TO ANSWER ANY QUESTIONS THAT YOU ARE UNCOMFORTABLE ANSWERING. NOW I HAVE SOME MORE GENERAL QUESTIONS ABOUT [CHILD], YOU AND YOUR FAMILY. "

32. What grade is [CHILD] currently enrolled in? ***(If baseline occurs during the summer break, ask, "In what grade will [CHILD] be enrolled in September?")***

_____

33. How would you describe [CHILD]'s race or ethnic background?

- ☐ Hispanic
- ☐ Black or African American
- ☐ White
- ☐ Asian
- ☐ American Indian/Alaskan Native
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Other: _____
- ☐ DK/RF

34. How would you describe your race or ethnic background?

- ☐ Hispanic
- ☐ Black or African American
- ☐ White
- ☐ Asian
- ☐ American Indian/Alaskan Native
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Other: _____
- ☐ DK/RF

35. How many people currently live in your home, including [CHILD] and you? ***(The respondent should be included, if appropriate.)***

_____

a. How many of these household members are adults? (18 years and over) _____

b. How many of these household members are under the age of 18 years old? _____

c. How many of these household members are in preschool/daycare (kids younger than kindergarten)? _____

QUESTIONS ABOUT THE PRIMARY CAREGIVER:

36. Who is the primary caregiver for [CHILD]?

- ☐ Mother (bio or adoptive)
- ☐ Father (bio or adoptive)
- ☐ Step-mother
- ☐ Step-father
- ☐ Foster parent
- ☐ Grandmother
- ☐ Grandfather
- ☐ Sibling
- ☐ Other family Specify: _____
- ☐ Other non-family Specify: _____

a. What is the highest grade or school level that (you/he/she) has completed? ***(See education codes below)***

_____

EDUCATION CODES:

0 = Never attended school	13 = 1 to 3 years of college/technical/voc training/Associate
1-11 = Specific grade completed for grades 1-11	14 = 4 years of college/technical/voc training/bachelors
12 = GED or 12th grade	15 = 5+ years of college/technical/voc training/grad degree

b. ***(Only ask if the primary caregiver is not the interviewee)*** Is he/ she currently employed?

- ☐ No
- ☐ Yes
- ☐ DK/RF

c. What is (your/ his/her) current marital status?

- ☐ Married/ Co-habituating
- ☐ Divorced / Separated
- ☐ Single
- ☐ Widowed
- ☐ Other : _____
- ☐ DK/RF

QUESTIONS ABOUT THE HOUSEHOLD:

37. Which of these comes closest to your household income for the last calendar year (before taxes)? Would you say: ***(Read categories)***

- ☐ Less than $23,000
- ☐ Between $23,000 and 46,000
- ☐ Between $46,000 and 70,000
- ☐ More than $70,000
- ☐ DK/RF

38. Is [CHILD] currently covered by health insurance?

☐ No **[SKIP TO 39]**

☐ Yes

☐ DK/RF **[SKIP TO 39]**

a. Is it a program paid for by: ***(Read categories and select only ONE)***

☐ Your work or your spouse's work

☐ The government (not including government workers)

☐ Self pay

☐ Other _____

☐ DK/RF

MEDICATION

"NOW I WILL ASK SOME QUESTIONS ABOUT MEDICATIONS THAT HAVE BEEN PRESCRIBED FOR [CHILD'S] ASTHMA."

39. Please tell me (show me) all the medications [CHILD] is currently taking for asthma: ***(Record each medication in the table below, under Medication Name, then read each question below and record the answer for each medication in the table)***

a. How often was [CHILD] directed by his/her doctor to take this medication? You can answer in times per day, as needed or prior to exercise.

b. How many times per week does [CHILD] actually use this medication?

c. For his/her rescue inhaler, how many puffs does he/she use at a time?

Medication Name	Prescribed frequency/ instruction (times/day, as needed, prior to exercise)	Typical Frequency (times/ week)	Puffs per time (# or NA)

40. Does [CHILD] ever take Tylenol or other acetaminophen (generic Tylenol)? ***(Please have parent show you what they give their child to verify)***

☐ No **[SKIP TO 41]**

☐ Yes

☐ DK/RF **[SKIP TO 41]**

a. On average, how often does [CHILD] take Tylenol or other acetaminophen per month?

_____ / month

b. During the last 14 days, how many days has [CHILD] taken Tylenol or other forms of acetaminophen?

_____ Days

WALKTHROUGH WITH THE PARTICIPANT

"NOW, I HAVE A COUPLE QUESTIONS ABOUT THE PLACE WHERE [CHILD] SLEEPS. WOULD IT BE OKAY TO GO THE ROOM WHERE HE/SHE SLEEPS THE MOST?"

CHILD'S PRIMARY SLEEPING AREA:

41. Where does [CHILD] usually sleep? Can you show me?

☐ Own/shared bedroom

☐ Parent's bedroom

☐ Family/TV room

☐ Other: _____

42. Has [CHILD]'s bedroom been painted in the **last 6 months**?

☐ No

☐ Yes

☐ DK/RF

43. Is there any new furniture that was purchased in **the past year** in [CHILD]'s bedroom? ***(Primary Bedroom)***

☐ No **[SKIP TO 44]**

☐ Yes

☐ DK/RF **[SKIP TO 44]**

a. Can you show it to me? ***(Identify if furniture is solid wood or particle board/compressed wood, do not read the answers)***

- ☐ There is no compressed wood furniture in the room less than one year old
- ☐ There is compressed wood furniture less than one year old
- ☐ DK/can't tell

"AS PART OF THE STUDY, [CHILD] WILL BE GETTING AN ALLERGY MATTRESS COVER. IS IT OKAY IF I PULL BACK THE COVERS, TAKE A LOOK AT THE MATTRESS AND TAKE SOME MEASUREMENTS TO DETERMINE WHICH SIZE ALLERGY COVER WILL FIT BEST?"

44. ***(Do not ask)*** Is there a plastic, vinyl, or other allergy cover encasing [CHILD]'s primary bed mattress or box springs?

- ☐ No **[SKIP TO 45]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 45]**

a. What parts are encased/covered with the allergy cover? ***(Check all that apply)***

- ☐ Mattress
- ☐ Box Spring
- ☐ Pillows

45. ***(Do not ask)*** How many beds are in the child's bedroom/ primary sleeping area? _____ Beds

46. ***(Do not ask)*** Determine the size of mattress cover which would best fit the child's primary bed.

- ☐ None (no mattress)
- ☐ Twin (28" x 75")
- ☐ Double/full (54" x 75")
- ☐ Queen (60" x 80")
- ☐ King (76" x 80")

47. ***(Do not ask)*** Determine the depth of mattress cover which would best fit the child's primary bed.

- ☐ None (no mattress)
- ☐ 9"
- ☐ 12"
- ☐ 15"

CHILD'S SECONDARY SLEEPING AREA:

48. Is there another place in this home where [CHILD] regularly sleeps? **(By regularly, we mean at least 20 hours per week.)**

- ☐ No **[END]**
- ☐ Yes

a. Where? Can you show me?

- ☐ Parent's bedroom
- ☐ Sibling's bedroom
- ☐ Other: _____

b. Typically, how many nights per week does [CHILD] sleep here? _____Night's per week

c. Typically, how many hours per night? _____ Night _____Hours

IF CHILD SLEEPS IN SECONDARY BED FOR <u>LESS THAN 20 HOURS A WEEK</u>, THE INTERVIEW IS OVER. SKIP TO END.

"IS IT OKAY IF I PULL BACK THE COVERS, TAKE A LOOK AT THE MATTRESS AND TAKE SOME MEASUREMENTS TO DETERMINE WHICH SIZE ALLERGY COVER WILL FIT BEST?"

49. ***(Do not ask)*** Is there a plastic or vinyl cover encasing [CHILD]'s secondary bed?

- ☐ No **[SKIP TO 50]**
- ☐ Yes
- ☐ DK **[SKIP TO 50]**
- ☐ N /A (no secondary bed) **[END]**

a. ***(Do not ask)*** What parts are encased/covered with the allergy cover? ***(Check all that apply)***

- ☐ Mattress
- ☐ Box Spring
- ☐ Pillows

50. ***(Do not ask)*** Determine the size of mattress cover which would best fit the child's <u>secondary</u> bed (if applicable).

- ☐ None (no mattress)
- ☐ Twin (28" x 75")
- ☐ Double/full (54" x 75")
- ☐ Queen (60" x 80")
- ☐ King (76" x 80")
- ☐ N/A (no secondary bed)

51. ***(Do not ask)*** Determine the depth of mattress cover which would best fit the child's <u>secondary</u> bed.

- ☐ None (no mattress)
- ☐ 9"
- ☐ 12"
- ☐ 15"
- ☐ N/A (no secondary bed)

BASELINE QUESTIONNAIRE/ HOME WALKTHROUGH – PART 2

"THANK YOU FOR PARTICIPATING IN THIS STUDY. THIS INTERVIEW CONSISTS OF QUESTIONS RELATING TO [CHILD'S] HOME ENVIRONMENT."

GENERAL INFORMATION

Visit code (Circle ONE):		**Enrollment**	**Installation**
3-month	**6-month**	**9-month**	**12-month**
15-month	**18-month**	**21-month**	**24-month**
Other:_____			

HHID : _____

LANGUAGE OF INTERVIEW: English 1

Spanish 2

DATE OF INTERVIEW __ __ / __ __ / __ __ __ __
M M D D Y Y Y Y

DATA ENTERED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

DATA EDITED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

HOME OBSERVATION BY STAFF

THE FOLLOWING QUESTIONS ARE OBSERVED BY THE STAFF BEFORE THEY ENTER THE HOME.

1. What kind of home does the enrolled child live in?
   - ☐ Single Family Home (Detached House)
   - ☐ Duplex/Triplex
   - ☐ Townhouse/ Row House
   - ☐ Low rise apartment or condo (1-3 floors)
   - ☐ High rise apartment or condo (>3 floors)
   - ☐ Mobile Home/Trailer
   - ☐ Other: _____

2. What is the ground surface covering near the home?
   - ☐ Primarily vegetation, hardscape, other landscaping or paving
   - ☐ A mix of vegetation and bare dirt
   - ☐ Primarily bare dirt
   - ☐ Other _____

3. Is there a door mat in front of the front door?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF

HOME CHARACTERISTICS

"FIRST, I WOULD LIKE TO ASK YOU ABOUT THE HOME WHERE YOU AND [CHILD] LIVE."

GENERAL HOME QUESTIONS:

4. Do you rent or own this home?
   - ☐ Rent
   - ☐ Own
   - ☐ DK/RF

5. How long has [CHILD] lived at this (his/her current) address? _____Years

6. Are shoes generally removed when entering your home?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF

7. Is there a door mat in front of the back door?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF
   - ☐ N/A

8. During the **past 12 months (or since living at current address, if <12 months)**, have you had any problems with any of the following pests? (***Read categories and check all that apply)***

	Yes	No	DK/RF
Mice			
Rats			
Cockroaches			
Ants			
Spiders			
Bed Bugs			
Other pests:			

9. Is your home within ¼ mile of: ***(Read answers)***

	Yes	Maybe	No	DK/RF
Gas station				
Farm/ agriculture				
Industrial facility				
Railroad tracks				
Dry Cleaners				
Bus/Truck Depot				
Construction				
Waste processing or sewage treatment facility				
Restaurant				

10. How close is the nearest freeway, major highway, major intersection, or street with substantial traffic? (Street with a continuous flow of cars throughout the day)

☐ Immediately in front, behind or beside child's residence

☐ One block away, length of football field

☐ 2-4 blocks away

☐ More than 5 blocks away (more than ¼ mile)

☐ DK/RF

WINDOW USAGE:

"NOW I WOULD LIKE TO ASK YOU ABOUT HOW OFTEN WINDOWS ARE USED IN YOUR HOME."

11. During the cold months (Dec-Feb), about how many days per week do you open more than 1 window or door in your home?

    _____days/week **[If 0, SKIP TO 12]**

    a. During the cold months (Dec-Feb), on days your windows or doors are open, on average, how many hours per day are your windows or doors kept open in your home?

       _____hours/day

12. During the cold months (Dec-Feb), how many days per week do you open a window in the [CHILD]'s bedroom?

    _____days/week **[If 0, SKIP TO 13]**

    a. During the cold months (Dec-Feb), on days when you open a window, on average, how many hours per day is the window kept open in [CHILD]'s bedroom?

       _____hours/day

13. During the hot months (June-Sept), how many days per week do you open more than 1 window or door in your home?

    _____days/week **[If 0, SKIP TO 14]**

    a. During the hot months (June-Sept), on days your windows are open, on average, how many hours per day are your windows or doors kept open in your home?

       _____hours/day

14. During the hot months (June-Sept), how many days per week do you open a window in the [CHILD]'s bedroom?

    _____days/week **[If 0, SKIP TO 15]**

    a. During the hot months (June-Sept), on days when you open a window, on average, how many hours per day is the window kept open in [CHILD]'s bedroom?

       _____hours/day

OTHER HOME QUESTIONS

15. Is there a bathroom exhaust fan (in any bathroom)?

    ☐ No **[SKIP TO 16]**

    ☐ Yes

    ☐ DK /RF **[SKIP TO 16]**

    a. How often is it turned on when showers are taken? Would you say: ***(Read Categories)***

       ☐ Continuously operating fan that is on all the time (***do NOT read***)

       ☐ Most of the time

       ☐ Sometimes

       ☐ Rarely/never

       ☐ DK/RF

16. Is there an enclosed garage attached to this home?
    - ☐ No
    - ☐ Yes
    - ☐ DK /RF

17. What year was your home built? ***(If participant is unsure, please have them estimate)*** _____ year

18. What is the square footage of your home? ***(If participant is unsure, please have them estimate)*** _____ ft^2

HOME EVALUATION/ WALKTHROUGH WITH THE PARTICIPANT

HEATING:

19. What is the <u>one main heating system</u> used the most in your home? Can you show me how you turn it on? ***(Have them show you what they use, do not read the answers)***

    ☐ Forced air (central warm air furnace with ducts to individual rooms)

    a. Is it run off propane, gas or electricity?
       - ☐ Gas (from pipes)
       - ☐ Electric
       - ☐ Bottles/tank LP/Propane (Can I see your propane tank?)
       - ☐ Other _____
       - ☐ DK/RF

    b. How often do you replace/change/clean your filter for this heating system? _____

    c. When was the last time the filter was changed? _____

    d. Is your home less than 5 years old or have you replaced the heater/HVAC system in the last 5 years? (This would have involved major construction)
       - ☐ No **[SKIP TO 20]**
       - ☐ Yes
       - ☐ DK/RF **[SKIP TO 20]**

       i. Does your system have an additional outdoor air intake?
          - ☐ No
          - ☐ Yes
          - ☐ DK/RF

    ☐ Gas Floor Heater without fan

    ☐ Baseboard Electric heaters

    ☐ Wall Heaters (with or without fans)
    - ☐ Gas
    - ☐ Electricity

- ☐ Bottles/tank LP/Propane
- ☐ Other _____
- ☐ DK/RF

☐ Hot water in floor pipes

- ☐ Gas
- ☐ Bottles/tank LP/Propane
- ☐ Other _____
- ☐ DK/RF

☐ Wood stove/fireplace

a. Type of stove?
   - ☐ Wood stove/Insert
   - ☐ Fireplace

b. Fuel type?
   - ☐ Gas
   - ☐ Wood
   - ☐ Manufactured wood product or other manufactured product
   - ☐ Bottles/tank LP/Propane
   - ☐ Other _____
   - ☐ DK/RF

☐ Portable space heaters

- ☐ Gas
- ☐ Electric
- ☐ Kerosene
- ☐ Other: _____
- ☐ DK/RF

20. This past winter, how often did you use your main heating system during the cold months? Would you say: ***(Read categories)***

☐ Most days/Daily

☐ About ½ the days

☐ Not very often

☐ DK/RF

"NOW, I AM GOING TO ASK ABOUT THE TIMES OF THE DAY WHEN YOU USE YOUR PRIMARY HEATING SYSTEM."

a. On the days you use this heating system, do you regularly use it in the morning?
   - ☐ No
   - ☐ Yes
   - ☐ DK/RF

b. On the days you use this heating system, do you regularly use it during the daytime?

☐ No
☐ Yes
☐ DK/RF

c. On the days you use this heating system, do you regularly use it in the evening?

☐ No
☐ Yes
☐ DK/RF

d. On the days you use this heating system, do you regularly use it over night?

☐ No
☐ Yes
☐ DK/RF

21. Is there another heating system that is ever used to heat your home? Can you show me how you turn it on? ***(Have them show you what they use, do not read the answers)***

☐ None (No secondary heating system) **[SKIP TO 23]**
☐ Forced air (central warm air furnace with ducts to individual rooms)

a. Is it run off propane, gas or electricity?
   ☐ Gas (from pipes)
   ☐ Electric
   ☐ Bottles/tank LP/Propane (Can I see your propane tank?)
   ☐ Other _____
   ☐ DK/RF

b. How often do you replace/change/clean your filter for this heating system? _____

c. When was the last time the filter was changed? _____

d. Is your home less than 5 years old or have you replaced the heater/HVAC system in the last 5 years? (This have involved major construction)
   ☐ No **[SKIP TO 22]**
   ☐ Yes
   ☐ DK/RF **[SKIP TO 22]**

   i. Does your system have an additional outdoor air intake?
      ☐ No
      ☐ Yes
      ☐ DK/RF

☐ Gas Floor Heater without fan
☐ Baseboard Electric heaters

- ☐ Wall Heaters (with or without fans)
  - ☐ Gas
  - ☐ Electricity
  - ☐ Bottles/tank LP/Propane
  - ☐ Other _____
  - ☐ DK/RF
- ☐ Hot water in floor pipes
  - ☐ Gas
  - ☐ Bottles/tank LP/Propane
  - ☐ Other _____
  - ☐ DK/RF
- ☐ Wood stove/fireplace

  a. Type of stove?
     - ☐ Wood stove/Insert
     - ☐ Fireplace

  b. Fuel type?
     - ☐ Gas
     - ☐ Wood
     - ☐ Manufactured wood product ther manufactured product
     - ☐ Bottles/tank LP/Propane
     - ☐ Other _____
     - ☐ DK/RF
- ☐ Portable space heaters
  - ☐ Gas
  - ☐ Electric
  - ☐ Kerosene
  - ☐ Other: _____
  - ☐ DK/RF

22. This past winter, how often did you use your secondary heating system during the cold months? Would you say: ***(Read categories)***
    - ☐ Most days / Daily
    - ☐ About ½ the days
    - ☐ Not very often
    - ☐ DK/RF

"NOW, I AM GOING TO ASK ABOUT THE TIMES OF THE DAY WHEN YOU USE YOUR SECONDARY HEATING SYSTEM."

a. On the days you use this heating system, do you regularly use it during the morning?

☐ No
☐ Yes
☐ DK/RF

b. On the days you use this heating system, do you regularly use it during the daytime?

☐ No
☐ Yes
☐ DK/RF

c. On the days you use this heating system, do you regularly use it in evening?

☐ No
☐ Yes
☐ DK/RF

d. On the days you use this heating system, do you regularly use it over night?

☐ No
☐ Yes
☐ DK/RF

23. ***(ONLY ASK IF THEY <u>DON'T</u> USE A FIREPLACE/WOOD STOVE FOR HEATING. IF THEY ALREADY TOLD YOU ABOUT FIREPLACE/WOOD STOVE FOR HEATING, MARK "YES" WITHOUT ASKING.)*** Do you have a fireplace or wood stove? Can you show it to me?

☐ No **[SKIP TO 24]**
☐ Yes
☐ DK/RF **[SKIP TO 24]**

a. How many days per year do you use this fireplace/woodstove? _____Days/Year **[If 0, SKIP TO 24]**

b. **DO NOT ASK:** Mark type of stove?

☐ Wood stove/insert
☐ Fireplace
☐ DK/RF

c. What sort of fuel does the fireplace/stove use?

- ☐ Gas
- ☐ Wood
- ☐ Manufactured wood product or other manufactured product
- ☐ Bottles/tank LP/Propane
- ☐ Other _____
- ☐ DK/RF

COOLING/AIR CONDITIONING

24. What do you use to cool your home? Can you show me how you turn it on? (***Have them show you what they use, do not read the answers. If more than one type given, record the one they use the most.)***

- ☐ Nothing/Fan **[SKIP TO 26]**
- ☐ Central Air (with ducts)
- ☐ Individual air conditioner units installed through walls or windows

a. How often do you set it to take in outside air? (If vent is set to "Open"/ "Closed", say: "Right now it is set to open/closed, is it usually like that? If no way to adjust, mark "never".)

- ☐ Always
- ☐ Sometimes
- ☐ Never
- ☐ DK/RF

- ☐ Portable air conditioner unit(s)
- ☐ Swamp or desert cooler units installed through the roof, walls or windows
- ☐ Other: _____
- ☐ DK/RF

25. This past summer, (during the months of May through September), how often did you use air conditioning? Would you say: ***(Read categories)***

- ☐ Most days/ Daily
- ☐ About ½ the days
- ☐ Not very often
- ☐ DK/RF

VACUUM

26. Do you have a vacuum cleaner? Can you show me the vacuum cleaner that you most often use in your home? ***(Mark if there a vacuum cleaner in the home)***

- ☐ No, borrows vacuum **[SKIP TO 29]**
- ☐ No, doesn't own or borrow **[SKIP TO 31]**
- ☐ Yes
- ☐ Yes, but not in home during visit

27. **DO NOT ASK:** Record the brand of the vacuum cleaner _____

28. **DO NOT ASK:** Record the model of the vacuum cleaner _____

29. In general, how often do you use a vacuum cleaner to clean your home?

- ☐ Daily (5-7 times a week)
- ☐ 1-4 times a week
- ☐ 1-2 times a month
- ☐ Every 2-3 months
- ☐ More than once a year (1-2 times a year)
- ☐ Less than once a year
- ☐ DK/RF

30. How often do you change the vacuum bag/empty your vacuum (bagless)?

- ☐ Every time the vacuum is used
- ☐ Every other time the vacuum is used
- ☐ More than once a month
- ☐ 1-2 times a month
- ☐ Every 2-3 months
- ☐ More than once a year (1-2 times a year)
- ☐ Less than once a year
- ☐ DK/RF

COOKING/HEATING QUESTIONS:

"THE NEXT SET OF QUESTIONS ASK ABOUT YOUR STOVE AND OVEN. BY STOVE TOP, I MEAN THE BURNERS FOR POTS AND PANS."

31. Can you show me your stove top? ***(Mark if it is gas or electric.)***

- ☐ Gas
- ☐ Electric **[SKIP TO 34]**
- ☐ DK/RF **[SKIP TO 34]**

a. ***Ask the caretaker to turn on the stove top***: "I would like to determine if your stove top has a continuously burning pilot light, can you please turn on your stove for me?"
[DO NOT ASK: Mark how the **stove top is lit]**

- ☐ Electric starter
- ☐ Lit with a match
- ☐ Continuous burning pilot light
- ☐ DK/RF

32. In general, how many days a week do you use your **stove top** for cooking for more than 1 hour at a time?

_____days/week

33. During the winter months, do you ever use your **stove top** to help heat your home or to take the chill off in the morning?

- ☐ No **[SKIP TO 34]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 34]**

a. During the winter months, how often do you use your **stove top** to help heat your home?

- ☐ Daily (5-7 times a week)
- ☐ 1-4 times a week
- ☐ 1-2 times a month
- ☐ Every 2-3 months
- ☐ More than once a year (1-2 times a year)
- ☐ Less than once a year
- ☐ DK/RF

34. **DO NOT ASK:** Mark if there is a range hood/fan above the **stove top**. Can you turn it on for me? Can I look in the cabinet above?

- ☐ Range hood vented to outside
- ☐ Range hood that blows into kitchen
- ☐ Exhaust Fan
- ☐ None **[SKIP TO 35]**

a. In general, how often do you use the range hood / exhaust fan over your stove top when you are cooking? Would you say: ***(Read categories)***

- ☐ All the time
- ☐ Most of the time
- ☐ About half the time
- ☐ Rarely
- ☐ Never
- ☐ DK/RF

"NOW I'M GOING TO ASK YOU ABOUT YOUR OVEN. BY OVEN, I MEAN THE PART USED FOR BAKING"

35. Can you show me your **oven**/Can I take a look inside your **oven**? ***(Mark if it is gas or electric.)***

- ☐ Gas
- ☐ Electric **[SKIP TO 38]**
- ☐ DK/RF **[SKIP TO 38]**

a. **DO NOT ASK:** Mark how the **oven is lit**. **(*If stove and oven are a combined unit, mark the same answer as in the previous question, 31a. If you are unable to determine the answer from visual inspection, say:*** "Can you please turn on your oven for me?"***)***

- ☐ Electric starter
- ☐ Lit with a match
- ☐ Continuous burning pilot light
- ☐ DK/RF

36. In general, how many days a week do you use your **oven** for cooking for more than 1 hour at a time?

_____days/week

37. During the winter months, do you ever use your **oven** to help heat your home or to take the chill off in the morning?

- ☐ No **[SKIP TO 38]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 38]**

a. During the winter months, how often do you use your **oven** to help heat your home**?**

- ☐ Daily (5-7 times a week)
- ☐ 1-4 times a week
- ☐ 1-2 times a month
- ☐ Every 2-3 months
- ☐ More than once a year (1-2 times a year)
- ☐ Less than once a year
- ☐ DK/RF

OTHER LOCATIONS IN THE HOME

38. Is there a dryer in the home? Can you show it to me?

- ☐ No **[SKIP TO 39]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 39]**

a. **DO NOT ASK:** Mark if the dryer is gas. ***(If not easy to see or determine, ask participant.)***

- ☐ No
- ☐ Yes
- ☐ DK/RF

b. **DO NOT ASK:** Mark if the dryer is vented to the outside

- ☐ No
- ☐ Yes
- ☐ DK/RF

39. Is there a gas water heater in the home? Can you show it to me?

- ☐ No **[SKIP TO 40]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 40]**

40. Is there a portable gas/kerosene heater in the home? Can you show it to me?

- ☐ No
- ☐ Yes
- ☐ DK/RF

MOLD QUESTIONS:

41. Has there <u>ever</u> been a musty or moldy smell inside your home?

- ☐ No **[SKIP TO 42]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 42]**

a. When was the last time you smelled a musty or moldy smell inside your home?

- ☐ Current
- ☐ During the past month
- ☐ During the past 6 months
- ☐ 6-12 months ago
- ☐ More than a year ago
- ☐ DK/RF

42. Has there <u>ever</u> been mold or water damage on any surfaces inside your home? (Do not include mold on food)

- ☐ No **[SKIP TO 43]**
- ☐ Yes
- ☐ DK/RF **[SKIP TO 43]**

	Did you see the mold/water damage in:		When was the last time you saw mold/water damage? Would you say: ***(Read categories)***	What was/is the approximate area of the moldy surface? ***(Show Template)***
	Mold	Water Damage		
Main Living area	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____
Kitchen	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____
Child's Bedroom	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____
Bathroom	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____
Other: _____	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____
Other: _____	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____

* Walls/ceiling-no water = walls and ceilings not near a water source (living rooms, bedrooms, etc)
*All windows/walls/ceilings with water = walls and ceilings near water sources (such as bathroom or near kitchen sink)

STAFF WALKTHROUGH

THE FOLLOWING QUESTIONS ARE OBSERVED BY THE STAFF IN THE HOME.

43. Number of rooms in the home ***(Include kitchen, but not bathroom(s), closets, or halls.)*** _____ rooms

44. Number of bedrooms in the home _____ rooms

45. Location of: ***(You may ask the caretaker to show you these rooms.)***

	Basement (wall up against dirt)	**Ground Floor**	**2nd story and higher (At least 10ft from ground)**
Main Living Area	No Yes	No Yes	No Yes
Kitchen/ Kitchen Area	No Yes	No Yes	No Yes
Child's Bedroom	No Yes	No Yes	No Yes
Child's Bathroom	No Yes	No Yes	No Yes

46. Flooring:

Tile = Includes stone Wood = includes laminate wood and Pergo

	Primary type of Flooring	**Area rug**
Main Living Area	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
Kitchen/ Kitchen Area	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
Child's Bedroom	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
Child's Bathroom	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
	☐ Carpet ☐ Vinyl ☐ Tile ☐ Wood ☐ Other	☐ Yes ☐ No
TOTALS:	___ ___ ___ ___ ___	___ ___

MOVERS QUESTIONNIARE

"THANK YOU FOR PARTICIPATING IN THIS STUDY. THIS INTERVIEW CONSISTS OF QUESTIONS RELATING TO [CHILD'S] HOME ENVIRONMENT."

GENERAL INFORMATION

Visit code (Circle ONE):		**Enrollment**	**Installation**
3-month	**6-month**	**9-month**	**12-month**
15-month	**18-month**	**21-month**	**24-month**
Other:_____			

HHID : _____

LANGUAGE OF INTERVIEW: English 1

Spanish 2

DATE OF INTERVIEW __ __ / __ __ / __ __ __ __
M M D D Y Y Y Y

DATA ENTERED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

DATA EDITED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

ADDRESS FOR THIS INTERVIEW:_____

1. What kind of home does the enrolled child live in?

☐ Single Family Home (Detached House)

☐ Duplex/Triplex

☐ Townhouse/ Row House

☐ Low rise apartment or condo (1-3 floors)

☐ High rise apartment or condo (>3 floors)

☐ Mobile Home/Trailer

☐ Other: _____

2. Is there an enclosed garage attached to this home?

☐ No

☐ Yes

☐ DK/RF

3. What year was your home built? (***If participant is unsure, please have them estimate)***

_____year

4. What is the square footage of your home? (***If participant is unsure, please have them estimate)***

_____ ft^2

5. What is the <u>one main heating system</u> used the most in your home? Can you show me how you turn it on? ***(Have them show you what they use, do not read the answers)***

☐ Forced air (central warm air furnace with ducts to individual rooms)

a. Is it run off propane, gas, or electricity?

☐ Gas (from pipes)

☐ Electric

☐ Bottles/tank LP/Propane (Can I see your propane tank?)

☐ Other: _____

☐ DK/RF

☐ Gas Floor Heater without fan

☐ Baseboard Electric heaters

☐ Wall heaters (with or without fans)

☐ Gas

☐ Electricity

☐ Bottles/tank LP/Propane

☐ Other: _____

☐ DK/RF

☐ Hot water in floor pipes

☐ Gas

☐ Bottles/tank LP/Propane

☐ Other: _____

☐ DK/RF

☐ Wood stove/ fireplace

a. Type of stove?

☐ Wood stove/insert

☐ Fireplace

b. Fuel type?

- ☐ Gas
- ☐ Wood
- ☐ Manufactured wood product other manufactured product
- ☐ Bottles/tank LP/Propane
- ☐ Other: _____
- ☐ DK/RF

☐ Portable space heaters

- ☐ Gas
- ☐ Electric
- ☐ Kerosene
- ☐ Other: _____
- ☐ DK/RF

6. What do you use to cool your home? Can you show me how you turn it on? ***(Have them show you what they use, do not read the answers. If more than one type given, record the one they use the most.)***

- ☐ Nothing/Fan
- ☐ Central air (with ducts)
- ☐ Individual air conditioner units installed through walls or windows
- ☐ Portable air conditioner unit(s)
- ☐ Swamp or desert cooler units installed through the roof, walls or windows
- ☐ Other: _____
- ☐ DK/RF

7. Can you show me your stove top? ***(Mark if it is gas or electric.)***

- ☐ Gas
- ☐ Electric
- ☐ DK/RF

8. Can you show me your **oven**/Can I take a look inside your **oven**? ***(Mark if it is gas or electric.)***

- ☐ Gas
- ☐ Electric
- ☐ DK/RF

9. Flooring:

	Primary type of Flooring	**Area rug**
Main Living Area	☐ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No

Kitchen/Kitchen Area	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
Child's Bedroom	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
Child's Bathroom	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
	□ Carpet □ Vinyl □ Tile □ Wood □Other	□ Yes □ No
TOTALS:	___ ___ ___ ___ ___	___ ___

Table B1. Baseline Questionnaire Part 1 Questions

Q #	Question Text	Answer Choices
Health History		
1	How are you related to the [CHILD]?	Mother (bio or adoptive)
		Father (bio or adoptive)
		Step-mother
		Step-father
		Foster parent
		Grandmother
		Grandfather
		Sibling
		Other family
		Other non-family
1	If other, specify:	Fill in
2	At what age was [CHILD] diagnosed with asthma?	Fill in years
3	Has [CHILD] ever been hospitalized because of asthma?	Yes / No
4	Has [CHILD] EVER had a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu? (For example, when s/he is near a furry animal or around pollen or mold.)	Yes / No
4a	In the past 12 months, has [CHILD] had a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu?	Yes / No
4b	In the past 12 months, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being in contact with FURRY ANIMALS?	Yes / No
4c	In the past 12 months, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being in contact with MOLD or MUSTY SMELL?	Yes / No
4d	In the past 12 months, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around POLLEN?	Yes / No
	What time of the year did [CHILD] have a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being in contact with POLLEN?	
4i	Early spring Early Spring (March-April)	Yes / No
4i	Late Spring (May-June)	Yes / No
4i	Fall (September – October)	Yes / No

Table B1, cont.

Q #	Question Text	Answer Choices
5	Has [CHILD] ever been diagnosed by a doctor as having hay fever or seasonal allergies (allergic rhinitis?)	Yes / No
5a	Has [CHILD] ever received shots to treat his/her allergies?	Yes / No
6	Has [CHILD] ever had an itchy rash that comes and goes for at least 6 months?	Yes / No
7	Has a doctor ever diagnosed [CHILD] with eczema or atopic dermatitis?	Yes / No
8	Has a doctor ever diagnosed [CHILD] with a sinus infection or sinusitis?	Yes / No
8a	Was [CHILD] referred to a specialist to treat this sinus problem?	Yes / No
	Do any of the following make [CHILD]'s asthma symptoms including wheezing, coughing, chest tightness, or shortness of breath worse?	
9	Colds	Yes / No / Never had
9	Sinus Infections	Yes / No / Never had
9	Bronchitis	Yes / No / Never had
9	Pets or other animals	Yes / No / Never had
9	Dust	Yes / No / Never had
9	Aspirin	Yes / No / Never had
9	Smog	Yes / No / Never had
9	Cigarette or cigar smoke	Yes / No / Never had
9	Wood smoke as from a campfire…	Yes / No / Never had
9	Perfumes	Yes / No / Never had
9	Strong smells	Yes / No / Never had
9	Cold air	Yes / No / Never had
9	Exercise	Yes / No / Never had
9	Pollen	Yes / No / Never had
9	Other	Yes / No / Never had
9	If other, specify	Fill in
10	Has a doctor or other health care provider given a written plan for managing [CHILD's] asthma? This is also called an asthma action plan.	Yes / No
11	Does anyone who currently spends time with [CHILD] smoke around him/her, either indoors or outdoors?	Yes / No
	If yes, do they smoke around [CHILD]:	
11a	In the car	Yes / No
11a	In child's house	Yes / No
11a	In another house the child spends time in	Yes / No
11a	In an outdoor location	Yes / No
11a	If another outdoor location, specify:	Fill in

Table B1, cont.

Q #	Question Text	Answer Choices
Pets		
12	Do you have any pets right now?	Yes / No
	Indicate which pets you have, how many of each, whether any spend time indoors, and sleep in child's bedroom:	
12a	Cats	Yes / No
12a	How many cats	Fill in #
12a	Do any spend time indoors?	Yes / No
12a	Do any sleep in child's bedroom regularly?	Yes / No
12a	Dogs	Yes / No
12a	How many dogs	Fill in #
12a	Do any spend time indoors?	Yes / No
12a	Do any sleep in child's bedroom regularly?	Yes / No
12a	Rodents	Yes / No
12a	How many rodents	Fill in #
12a	Do any spend time indoors?	Yes / No
12a	Do any sleep in child's bedroom regularly?	Yes / No
12a	Birds	Yes / No
12a	How many birds	Fill in #
12a	Do any spend time indoors?	Yes / No
12a	Do any sleep in child's bedroom regularly?	Yes / No
12a	Other pets	Yes / No
12a	How many other pets	Fill in #
12a	Do any spend time indoors?	Yes / No
12a	Do any sleep in child's bedroom regularly?	Yes / No
12a	If other, specify the kind of pet:	Fill in
Demographics		
32	What grade is [CHILD] currently enrolled in? (Kindergarten=0)	Fill in grade
33	How would you describe [CHILD]'s race or ethnic background?	Hispanic
		Black or African American
		White
		Asian
		American Indian/Alaskan Native
		Native Hawaiian or other Pacific Islander
		Other
33	If other, specify:	Fill in

Table B1, cont.

Q #	Question Text	Answer Choices
34	Describe YOUR race, nationality, or ethnic background?	Hispanic
		Black or African American
		White
		Asian
		American Indian/Alaskan Native
		Native Hawaiian or other Pacific Islander
		Other
34	If other, specify:	Fill in
35	How many people live in [CHILD]'s home, including [CHILD] and you?	Fill in #
35a	How many of these household members are adults? (18 years and over)	Fill in #
35b	How many of these household members are under the age of 18 years old?	Fill in #
35c	How many of these household members are in preschool/daycare (kids younger than Kindergarten)?	Fill in #
Questions about the primary caregiver		
36	Who is the primary caregiver for [CHILD]?	Mother (bio or adoptive)
		Father (bio or adoptive)
		Step-mother
		Step-father
		Foster parent
		Grandmother
		Grandfather
		Sibling
		Other family
		Other non-family
36	If other, specify:	Fill in
36a	What is the highest grade or school level that the primary caregiver has completed?	Fill in
36b	Is the primary caregiver currently employed?	Yes / No
36c	What is the primary caregiver's marital status?	Married/Co-Habituating
		Divorced/Separated
		Single
		Widowed
		Other
Questions about household		
37	Which of these comes closest to your household income, before taxes for the last calendar year?	Less than $23,000
		Between $23,000 and 46,000
		Between $46,000 and 70,000
		More than $70,000

Table B1, cont.

Q #	Question Text	Answer Choices
38	Is [CHILD] currently covered by health insurance?	Yes / No
38a	Is it a program paid for by:	Your work or your spouse's work
		The government (not including government workers)
		Self-pay
		Other
38a	If other, specify:	Fill in
Child's primary sleeping area		
41	Where does [CHILD] usually sleep?	Own/shared bedroom
		Parent's bedroom
		Family/TV room
		Other
41	If other, specify:	Fill in
42	Has the child's bedroom been painted in the last 6 months?	Yes / No
43	Is there any new furniture that was purchased in the past year in [CHILD]'s bedroom?	Yes / No
43a	Is there particle board/compressed wood furniture?	Yes / No
44	Is there a plastic, vinyl, or other allergy cover encasing [CHILD]'s primary bed mattress or box springs?	Yes / No
44a	If yes, what parts are encase/covered with the allergy cover?	Mattress
		Box Spring
		Pillows
45	How many beds are in the child's bedroom / primary sleeping area?	Beds:
Child's secondary sleeping area		
48	Is there another place in this home where [CHILD] regularly sleeps?	Yes / No
48a	If yes, where?	Parent's bedroom
		Sibling's bedroom
		Other
48a	If other, specify:	Fill in
48b	Typically, how many nights per week does [CHILD] sleep here?	Fill in nights/week:
48c	Typically, how many hours per night?	Fill in hours/night:

Table B2. Baseline Questionnaire Part 2 Questions

Q #	Question Text	Answer Choices
Home observation by staff		
1	What kind of home does the enrolled child live in?	Single Family Home (Detached House)
		Duplex/Triplex
		Townhouse/ Row House
		Low rise apartment or condo (1-3 floors)
		High rise apartment or condo (>3 floors)
		Mobile Home/Trailer
		Other
1	If other, specify:	Fill in
2	What is the primary ground surface covering near the home?	Primarily vegetation or hardscape
		A mix of vegetation and bare dirt
		Primarily bare dirt
		Other
2	If other, specify:	Fill in
3	Is there a door mat in front of the front door?	Yes / No
Home characteristics		
4	Do you rent or own this home?	Rent
		Own
5	How long has [CHILD] lived at this (his/her current) address?	Fill in years
6	Are shoes generally removed when entering the house?	Yes / No
7	Is there a door mat in front of the back door?	Yes / No
		N/A
	Did you have problems with:	
8	Mice	Yes / No
8	Rats	Yes / No
8	Cockroaches	Yes / No
8	Ants	Yes / No
8	Spiders	Yes / No
8	Bed Bugs	Yes / No
8	Other	Yes / No
8	If other, specify	Fill in

Table B2, cont.

Q #	Question Text	Answer Choices
	Is the house within ¼ mile of:	
9	Gas station	Yes / No / Maybe
9	Farm/agriculture	Yes / No / Maybe
9	Industrial facility	Yes / No / Maybe
9	Railroad tracks	Yes / No / Maybe
9	Dry cleaners	Yes / No / Maybe
9	Bus/Truck depot	Yes / No / Maybe
9	Construction	Yes / No / Maybe
9	Waste processing or sewage treatment facility	Yes / No / Maybe
9	Restaurant	Yes / No / Maybe
10	How close is the nearest freeway, major highway, major intersection, or street with heavy traffic?	Immediately in front, behind or beside child's residence
		One block away, length of football field
		2-4 blocks away
		More than 5 blocks away
Window usage		
11	During the COLD months (Dec-Feb), how many days per week do you open more than 1 window or door in YOUR HOME?	Fill in days/week
11a	During the COLD months (Dec-Feb), on days your windows are open, on average, how many hours per day are your windows or doors kept open in YOUR HOME?	Fill in in hours/day
12	During the COLD months (Dec-Feb), how many days per week do you open a window in the CHILD'S BEDROOM?	Fill in days/week
12a	During the COLD months (Dec-Feb), on days when you open a window, on average, how many hours per day is the window kept open in the CHILD'S BEDROOM?	Fill in hours/day
13	During the HOT months (June-Sept), how many days per week do you open more than 1 window or door in YOUR HOME?	Fill in days/week
13a	During the HOT months (June-Sept), on days your windows or doors are open, on average, how many hours per day are your windows kept open in YOUR HOME?	Fill in in hours/day
14	During the HOT months (June-Sept), how many days per week do you open a window in the CHILD'S BEDROOM?	Fill in days/week
14a	During the HOT months (June-Sept), on days when you open a window, on average, how many hours per day is the window kept open in the CHILD'S BEDROOM?	Fill in hours/day

Table B2, cont.

Q #	Question Text	Answer Choices
Other home questions		
15	Is there a bathroom exhaust fan?	Yes / No
15a	How often is it turned on when showers are taken?	Continuously operating fan that is on all the time
		Most all the time
		Sometimes
		Rarely/never
16	Is there an enclosed garage attached to this home?	Yes / No
17	What year was your home built?	Fill in year
18	What is the square footage of your home?	Fill in squared feet
Primary heating system		
19	What is the one main heating system in [CHILD's] home? Would you say:	Forced air (central warm air furnace with ducts to individual rooms)
		Gas Floor Heater without fan
		Baseboard Electric heater
		Wall Heaters without ducts (with or without fans)
		Hot water in floor pipes
		Wood stove/fireplace
		Portable space heaters
19	What fuel does the heating system run on?	Gas
		Electricity
		Bottles/Tank LP/Propane
		Wood
		Manufactured wood product or other manufactured product
		Kerosene
		Other
19	If other, specify:	Fill in
19	FORCED AIR - how often do you replace/change/clean your filter for this heating system? (RECORD RESPONSE IN TIMES PER YEAR)	Fill in times per year
19	FORCED AIR -When was the last time the filter was changed? (RECORD RESPONSE IN MONTHS AGO)	Fill in months ago
19	FORCED AIR -Is your home less than 5 years old or have you replaced the heater/HVAC system in the last 5 years? (This would have involved major construction)	Yes / No
19	FORCED AIR - Does your system have an additional outdoor air intake?	Yes / No
19	WOOD STOVE/FIREPLACE - Type of stove?	Wood stove/insert
		Fireplace

Table B2, cont.

Q #	Question Text	Answer Choices
20	This past winter, how often did you use your main heating system during the cold months?	Most days/Daily
		About 1/2 the days
		Not very often
20a	On the days you use this heating system, do you regularly use it in the morning?	Yes / No
20b	On the days you use this heating system, do you regularly use it during the daytime?	Yes / No
20c	On the days you use this heating system, do you regularly use it in the evening?	Yes / No
20d	On the days you use this heating system, do you regularly use it over night?	Yes / No
Secondary heating system		
21	Is there another heating system that is ever used to heat your home?	None (No secondary heating system)
		Forced air (central warm air furnace with ducts to individual rooms)
		Gas Floor Heater without fan
		Baseboard Electric heater
		Wall Heaters without ducts (with or without fans)
		Hot water in floor pipes
		Wood stove/fireplace
		Portable space heaters
21	What fuel does the secondary heating system run on?	Gas
		Electricity
		Bottles/Tank LP/Propane
		Wood
		Manufactured wood product or other manufactured product
		Kerosene
		Other
21	If other, specify:	Fill in
21	FORCED AIR - how often do you replace/change/clean your filter for this heating system? (RECORD RESPONSE IN TIMES PER YEAR)	Fill in times per year
21	FORCED AIR -When was the last time the filter was changed? (RECORD RESPONSE IN MONTHS AGO)	Fill in months ago
21	FORCED AIR -Is your home less than 5 years old or have you replaced the heater/HVAC system in the last 5 years? (This would have involved major construction)	Yes / No
21	FORCED AIR - Does your system have an additional outdoor air intake?	Yes / No

Table B2, cont.

Q #	Question Text	Answer Choices
21	WOOD STOVE/FIREPLACE - Type of stove?	Wood stove/insert
		Fireplace
22	Typically, how often do you use your secondary heating system during the cold months?	Most days/Daily
		About 1/2 the days
		Not very often
22a	On the days you use this heating system, do you regularly use it in the morning?	Yes / No
22b	On the days you use this heating system, do you regularly use it during the daytime?	Yes / No
22c	On the days you use this heating system, do you regularly use it in the evening?	Yes / No
22d	On the days you use this heating system, do you regularly use it over night?	Yes / No
Fireplace		
23	Do you have a fireplace or wood stove?	Yes / No
23a	How many days per year do you use this fireplace/woodstove?	Days/Year
23b	Type of stove	Wood Stove/Insert
		Fireplace
23c	What sort of fuel does the fireplace use?	Gas
		Wood
		Manufactured wood product or other manufactured product
		Bottles/Tank LP/Propane
		Other
23c	If other, specify:	Fill in
Cooling/air conditioning		
24	Type of air conditioning	Nothing/fan
		Central Air (with ducts)
		Individual units installed through walls or windows
		Portable air conditioner unit
		Swamp or desert cooler
		Other
24	If other, specify:	Fill in
24a	Individual units installed through walls or windows - how often do you set it to take in outside air?	Always
		Sometimes
		Never

Table B2, cont.

Q #	Question Text	Answer Choices
25	This past summer, (during the months of May through September), how often did you use air conditioning?	Most days/Daily
		About 1/2 the days
		Not very often
Vacuum		
26	Is there a vacuum cleaner in this home?	No, borrows vacuum
		No, doesn't own or borrow
		Yes
		Yes, not in home during visit
27	Brand of vacuum cleaner used	Fill in
28	Model of vacuum cleaner used	Fill in
29	In general, how often do you use a vacuum cleaner to clean your home?	Daily (5-7 times a week)
		1-4 times a week
		1-2 times a month
		Every 2-3 months
		More than once a year (1-2 times a year)
		Less than once a year
30	How often do you change the vacuum bag/empty your vacuum (bagless)?	Every time the house is vacuumed
		Every other time the vacuum is used
		More than once a month
		1-2 times a month
		Every 2-3 months
		More than once a year (1-2 times a year)
		Less than once a year
		N/A
Stove Top		
31	Mark if STOVE TOP is gas or electric	Gas
		Electric
		DK/RF
31a	Mark how STOVE TOP is lit	Electric Starter
		Lit with a match
		Continously burning pilot light
32	In general, how many days a week do you use your STOVE TOP for cooking for more than 1 hour at a time?	Fill in days/week:
33	During the winter months, do you ever use your STOVE TOP to help heat your home or to take the chill off in the morning?	Yes / No

Table B2, cont.

Q #	Question Text	Answer Choices
33a	During the winter months, how often do you use your STOVE TOP to help heat your home?	Daily (5-7 times a week)
		1-4 times a week
		1-2 times a month
		Every 2-3 months
		More than once a year (1-2 times a year)
		Less than once a year
34	Mark if there is a range hood/fan above the STOVE TOP.	Range hood vented to outside
		Range hood that blows into kitchen
		Fan
		None
34a	In general, how often do you use the fan over your STOVE TOP when you are cooking?	All of the time
		Most of the time
		About half the time
		Rarely
		Never
Oven		
35	Mark if OVEN is gas or electric	Gas
		Electric
		DK/RF
35a	Mark how OVEN is lit	Electric Starter
		Lit with a match
		Continously burning pilot light
36	In general, how many days a week do you use your OVEN for cooking for more than 1 hour at a time?	Fill in days/week:
37	During the winter months, do you ever use your OVEN to help heat your home or to take the chill off in the morning?	Yes / No
37a	During the winter months, how often do you use your OVEN to help heat your home?	Daily (5-7 times a week)
		1-4 times a week
		1-2 times a month
		Every 2-3 months
		More than once a year (1-2 times a year)
		Less than once a year
Other appliances		
38	Is there a gas dryer in the home?	Yes / No
38a	Mark if dryer is gas	Yes / No
38b	Mark if dryer is vented to the outside	Yes / No

Table B2, cont.

Q #	Question Text	Answer Choices
39	Is there a gas water heater in the home?	Yes / No
39	if they have some other strange water heater, specify	Fill in
39a	Mark if the gas water heater is vented to the outside	Yes / No
40	Is there a portable gas/kerosene heater in the home?	Yes / No
Mold questions		
41	Has there ever been any musty or moldy smell inside your home?	Yes / No
41a	When was the last time you smelled moldy or musty smell inside your home?	Current
		During the past month
		During the past 6 months
		6-12 months ago
		More than a year ago
42	Has there ever been mold or water damage on any surfaces inside your home? (Do not include mold on food)	Yes / No
Mold and water damage were recorded for the main living area, kitchen, child's bedroom, bathroom, and any other rooms noted to have mold. The following questions were asked for each room		
42	Did you see MOLD?	Yes / No
42	Did you see WATER DAMAGE in the kitchen?	Yes / No
42	When was the last time you saw mold/water damage?	Current
		During the past month
		During the past 6 months
		6-12 months ago
		More than a year ago
42	Area of moldy surface	Less than 2 inches by 2 inches
		Greater than 2 x 2 inches but less than 1 square foot
		Greater than 1 square foot
42	If greater than 1 square foot, specify	Fill in
Staff walkthrough tables		
43	Number of rooms in the home (Include kitchen, but not bathroom(s), closets, or halls.)	Fill in #
44	Number of bedrooms in the home	Fill in #
45	Child's bedroom location: Basement / ground floor / 2nd story+	Yes / No
45	Main living area location: Basement / ground floor / 2nd story+	Yes / No
45	Kitchen location: Basement / ground floor / 2nd story+	Yes / No
45	Bathroom location: Basement / ground floor / 2nd story+	Yes / No

Table B2, cont.

Q #	Question Text	Answer Choices
The following questions are asked for the main living area, kitchen, child's bedroom and child's bathroom		
46	Primary Flooring	Carpet
		Vinyl
		Tile
		Wood
		Other
46	Area rug	Yes / No

Table B3. Created Variables for Baseline Questionnaire Part 1

Allergies Ever	If yes to Q4-7 (sneezing, runny/blocked nose, itchy watery eyes when no cold or flu, hay fever/allergies, itchy rash or eczema)
Eczema ever	If yes to Q6 or Q7 (itchy rash in last 6 months, eczema)
Emotion	If other trigger description includes the word “cry”, “mad”, “laugh”, “emotional”, “hyper” (for hyperactive)
Food	If other trigger description includes the word “food”, “watermelon”, “wheat”, “diary” (Included “diary” because assumed it was a misspelling of “dairy”)
Grass	If other trigger description includes the word “grass”
Mold	If other trigger description includes the word “mold”
Outside	If other trigger description includes the word “outside”, “outdoor”
Weather	If other trigger description includes the word “weather”, “climate”, “season”
Humidity	If other trigger description includes the word “moist”, “humidity”
Heat	If other trigger description includes the word “heat”, “hot”, “warm”
Trees	If other trigger description includes the word “tree”, “pine”
Total number of asthma triggers per child	The sum of all trigger variables, including “other” and the created variables listed above.
Smoking around child	Yes and no codes were switched in the original smoking variable (No was coded as 1, Yes was coded as 0) so this variable was created to fix the mistake.
Pets – All furry/feathered pets	Categorizes pet responses into whether or not they have an indoor or outdoor furry or feathered pet (Furry - cats, dogs, rodents, birds, rabbits, chickens). 0.No furry/feathered pet 1.Outdoor furry/feathered pet 2.Indoor furry/feathered pet, does not sleep with child 3.Indoor furry/feathered pet, sleeps with child
Pets - Dogs or Cats	Categorizes pet responses into whether or not they have a cat or a dog 0.No dog or cat 1.Outdoor dog or cat 2.Indoor dog or cat, not sleep with child 3.Indoor dog or cat, sleep with child
Have indoor furry animals and allergies to furry animals in the last 12 months	If indoor furry pet (cat, dog, rodents, bird, rabbit, chicken) and allergies around furry pets in the last 12 months
Child’s race	Categorizes Q33 other responses according to census race definitions. If more than one race listed, added to the mixed group.
Respondent’s race	Categorizes Q34 other responses according to census race definitions. If more than one race listed, added to the mixed group.
Primary caregiver employment	Combines response to Q25 (Are you employed) with response to Q36b (Is primary caregiver employed which is only asked if the primary caregiver is not the interviewee) to get primary caregiver employment

Table B3, cont.

Bedroom painted or compressed wood furniture	If child's bedroom was painted in the last 6 months (yes to Q42) or there is compressed wood furniture that was purchased in the past year in the child's bedroom (yes to Q43a)
Hours per week in second sleeping area	Hours per week spent in second sleeping area, used to categorize participants in the created variable "Primary/Secondary sleeping areas" Nights/week (spent in second sleeping area) * Hours/Night (spent in second sleeping area)
Primary / Secondary sleeping areas	Combines primary sleeping area (Q41) with secondary sleeping area question (Q48), uses created variable "Hours per week in second sleeping area" Own bedroom only Own bedroom / parent's bedroom (20 hours or less) Own bedroom / parent's bedroom (21 - 27 hours) Own bedroom / parent's bedroom (27 hours or more) Own bedroom / another place (20 hours or less) Own bedroom / another place (21 - 27 hours) Parent's bedroom only Parent's bedroom / own room (more than 27 hours per week) Family/TV room only Other

Table B4. Created Variables for Baseline Questionnaire Part 2

Total door mat status	Combines Q3 (door mat in front of front door) with response to Q7 (door mat in front of back door) Front-No Front-Yes; Back-No Front-Yes; Back-Yes or NA
Problems with mice, rats or cockroaches in the last 12 months	If yes to problems with mice, rats or cockroaches in the last 12 months
Distance to closest restaurant	Distance (feet) to closest restaurant – looked up via google maps
Close to sources	Set to 1 if within yes to any Q9 responses (¼ mile of a gas station, farm, industrial facility, railroad tracks, dry cleaners, bus/truck depot, construction, waste processing facility or restaurant)
Hours/week windows open in home during cold months	Combines Q11 and Q11a – Hours/day * Days/Week windows open in home during cold months (December – February)
Hours/week windows open in child's bedroom during cold months	Combines Q12 and Q12a - Hours/day * Days/Week windows open in child's room during cold months (December – February)
Hours/week windows open in home during hot months	Combines Q13 and Q13a - Hours/day * Days/Week windows open in home during hot months (June – September)
Hours/week windows open in child's bedroom during hot months	Combines Q14 and Q14a - Hours/day * Days/Week windows open in child's room during hot months (June – September)
Days/week windows are open 2 hours or more in home during cold months	If windows are open more than 2 hours a day in home during cold months, set to days/week windows are open in home
Days/week windows are open 2 hours or more in child's room during cold months	If windows are open more than 2 hours a day in child's room during cold months, set to days/week windows are open in child's room
Days/week windows are open 2 hours or more in home during hot months	If windows are open more than 2 hours a day in home during hot months, set to days/week windows are open in home.
Days/week windows are open 2 hours or more in child's room during hot months	If windows are open more than 2 hours a day in child's room during hot months, set to days/week windows are open in child's room.
Bathroom exhaust fan	Combines bathroom exhaust question with how often the fan is on (Q15 and Q15a) No bathroom exhaust fan Fan on all the time Fan on most of the time Fan on rarely/never Fan on sometimes Missing

Table B4, cont.

Year home was built	Use year home was built value looked up via Zillow. If no look up value, use self-reported variable. If no information in Zillow and the self-reported value was missing, this variable will be missing.
Square footage of home	Use square footage value looked up via Zillow. If no look up value, use self-reported variable. If no information in Zillow and the self-reported value was missing, this variable will be missing.
Main heating system, type and fuel	Categorizes Q19 main heating system answers into type and fuel Baseboard electric heater Forced air – DK/missing fuel type Forced air - electric Forced air - gas Forced air - propane Gas wall heater Space heaters - kerosene Space heaters - electric Wood stove/fireplace – gas Wood stove/fireplace – wood
Last time filter was changed (months ago)	Converts Q19c into numeric format - number of months ago the filter was changed
Secondary heating, type and fuel	Categorizes Q21 secondary heating system answers into type and fuel None Forced air - electric Forced air - gas Space heaters - electric Wood stove/fireplace - electricity Wood stove/fireplace - gas Wood stove/fireplace - other fuel type Wood stove/fireplace - wood
Fireplace	Combines Q19,Q21,Q23 fireplace responses Does not have fireplace Have fireplace, but use 0 days per year Gas fireplace/woodstove, use >0 days per year Wood fireplace, use >0 days per year Woodstove/manufactured wood/other, use >0 days per year
Fireplace usage - number of days per year using fireplace	Set to days per year fireplace/wood stove is used (Q23a). If no value and fireplace is used as main or secondary heating system, value is based on response to how frequently system is used. If: Most days/daily – set to 90 days/year About ½ the days – set to 45 days/year Not very often – set to 10 days/year If no fireplace, set to 0
Have central cooling system	Set to 1 if central air system is used to cool the home, otherwise, set to 0
Have swamp or desert cooler	Set to 1 if swamp or desert cooler is used to cool the home, otherwise, set to 0

Table B4, cont.

Days per week gas stove top is used for cooking for more than 1 hour at a time	Set to days/week stove top is used for cooking more than 1 hour (Q32) is stove is gas
Days per week gas oven is used for cooking for more than 1 hour at a time	Set to days/week oven is used for cooking more than 1 hour (Q32) is oven is gas
Number of gas appliances in home	Add number of gas appliances in the home. Add 1 for every yes to gas stove, gas oven, gas dryer, gas water heater or gas portable heater.
Musty/moldy smell inside or mold/water damage inside home ever	Set to 1 if yes to musty or moldy smell ever (Q41) or yes to mold or water damage ever (Q42)
Have mold currently	Categorizes mold table into whether or not participant has mold currently Have mold currently Current mold, significant Current mold, not significant No current mold Significant –1 or more rooms that have greater than 1 square foot of mold or 2 or more rooms that have greater than 2x2 inches of mold
Had mold in the past	Categorizes mold table into whether or not participant had mold in the past Had mold in the past Past mold, significant Past mold, not significant No past mold Significant –1 or more rooms that have greater than 1 square foot of mold or 2 or more rooms that have greater than 2x2 inches of mold
Have water damage currently	Categorizes mold table into whether or not participant has water damage currently Have water damage currently Current water damage, significant Current water damage, not significant No current water damage Significant –1 or more rooms that have greater than 1 square foot of mold or 2 or more rooms that have greater than 2x2 inches of mold
Had water damage in the past	Categorizes mold table into whether or not participant has water damage in the past Had water damage in the past Past water damage, significant Past water damage, not significant No past water damage Significant –1 or more rooms that have greater than 1 square foot of mold or 2 or more rooms that have greater than 2x2 inches of mold
Number of people per bedroom	Number of people in household (Q35 in Baseline part 1) / Number of bedrooms in the home (Q44)

Table B4, cont.

Location of living room	Categorizes main living area location Basement Ground Floor 2nd story+ No options marked
Location of kitchen	Categorizes kitchen location Basement Ground Floor 2nd story+ No options marked
Location of child's bedroom	Categorizes child's bedroom location Basement Ground Floor 2nd story+ No options marked
Location of child's bathroom	Categorizes child's bathroom location Basement Ground Floor 2nd story+ No options marked
Have carpet as primary flooring type in at least 1 room in home	Set to 1 if primary flooring type in any rooms in the home is carpet, otherwise set to 0
Have vinyl as primary flooring type in at least 1 room in home	Set to 1 if primary flooring type in any rooms in the home is vinyl, otherwise set to 0

Table B5. Results of Baseline Questionnaire Part 1, Questions 1-12

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
Q1	**Relationship to child**						
	Mother (bio or adoptive)	168	88%	150	87%	18	95%
	Father (bio or adoptive)	20	10%	19	11%	1	5%
	Step-mother	1	1%	1	1%	0	0%
	Grandmother	1	1%	1	1%	0	0%
	Aunt	1	1%	1	1%	0	0%
Q2	**Age diagnosed with asthma**						
	1 year or less	57	30%	47	27%	10	53%
	1.01 - 2 years	29	15%	27	16%	2	11%
	2.01 - 3 years	36	19%	33	19%	3	16%
	3.01 - 4 years	19	10%	17	10%	2	11%
	5 years	19	10%	18	10%	1	5%
	6 - 7 years	21	11%	20	12%	1	5%
	8+ years	10	5%	10	6%	0	0%
Q3	**Ever hospitalized with asthma**						
	No	116	61%	103	60%	13	68%
	Yes	75	39%	69	40%	6	32%
Q4	**Sneezing, runny/blocked nose, itchy/watery eyes ever?**						
	No	18	9%	16	9%	2	11%
	Yes	173	91%	156	91%	17	89%
Q4a	**Sneezing, runny/blocked nose, itchy/watery eyes during last 12 months? [1, 2]**						
	No	8	4%	7	4%	1	5%
	Yes	165	86%	149	87%	16	84%
Q4b	**Sneezing, runny/blocked nose, itchy/watery eyes around furry animals (past 12 months)? [1]**						
	DK	9	5%	7	4%	2	11%
	No	66	35%	60	35%	6	32%
	Yes	98	51%	89	52%	9	47%
Q4c	**Sneezing, runny/blocked nose, itchy/watery eyes around mold (past 12 months)? [1]**						
	DK	41	21%	37	22%	4	21%
	No	66	35%	60	35%	6	32%
	Yes	66	35%	59	34%	7	37%
Q4d	**Sneezing, runny/blocked nose, itchy/watery eyes around pollen (past 12 months)? [1]**						
	DK	9	5%	9	5%	0	0%
	No	17	9%	16	9%	1	5%
	Yes	147	77%	131	76%	16	84%
Q4di	**Pollen - Early spring [1]**						
	DK	1	1%	1	1%	0	0%
	No	14	7%	13	8%	1	5%
	Yes	132	69%	117	68%	15	79%

Table B5, cont.

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
Q4di	**Pollen - Fall [1]**						
	DK	1	1%	1	1%	0	0%
	No	29	15%	26	15%	3	16%
	Yes	117	61%	104	60%	13	68%
Q4di	**Pollen -Late spring [1]**						
	DK	2	1%	2	1%	0	0%
	No	41	21%	36	21%	5	26%
	Yes	102	53%	91	53%	11	58%
	Missing	2	1%	2	1%	0	0%
Q5	**Ever diagnosed with hay fever/seasonal allergies?**						
	No	70	37%	66	38%	4	21%
	Yes	119	62%	104	60%	15	79%
	DK	2	1%	2	1%	0	0%
Q5a	**Received allergy shots to treat allergies? [1]**						
	No	93	49%	81	47%	12	63%
	Yes	26	14%	23	13%	3	16%
Q6	**Itchy rash that comes and goes for at least 6 months?**						
	No	136	71%	123	72%	13	68%
	Yes	55	29%	49	28%	6	32%
Q7	**Ever diagnosed with eczema/atopic dermatitis?**						
	No	107	56%	95	55%	12	63%
	Yes	83	43%	76	44%	7	37%
	DK	1	1%	1	1%	0	0%
	Created Variable: Allergies ever: If yes to Q4-7						
	No	7	4%	6	3%	1	5%
	Yes	184	96%	166	97%	18	95%
	Created Variable: Eczema ever: If yes to Q6 or Q7						
	No	94	49%	83	48%	11	58%
	Yes	97	51%	89	52%	8	42%
Q8	**Ever diagnosed with sinus infection/sinusitis?**						
	No	105	55%	98	57%	7	37%
	Yes	85	45%	73	42%	12	63%
	DK	1	1%	1	1%	0	0%
Q8a	**Referred to a specialist to treat sinus infection? [1]**						
	No	41	21%	33	19%	8	42%
	Yes	42	22%	38	22%	4	21%
	Missing	2	1%	2	1%	0	0%
Q9	**Triggers that make asthma symptoms worse [3]**						
	Colds - Yes	183	96%	164	95%	19	100%
	Sinus infections - Yes	112	59%	97	56%	15	79%
	Sinus infections - N/A	50	26%	47	27%	3	16%
	Sinus infections - DK	2	1%	2	1%	0	0%
	Bronchitis - Yes	110	58%	98	57%	12	63%
	Bronchitis - N/A	58	30%	53	31%	5	26%
	Bronchitis -DK	3	2%	3	2%	0	0%

Table B5, cont.

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
Q9	**Triggers that make asthma symptoms worse (cont.)** [3]						
	Pets or other animals - Yes	89	47%	81	47%	8	42%
	Pets or other animals - N/A	9	5%	8	5%	1	5%
	Pets or other animals - DK	8	4%	7	4%	1	5%
	Dust - Yes	165	86%	147	85%	18	95%
	Dust - N/A	1	1%	1	1%	0	0%
	Dust - DK	5	3%	5	3%	0	0%
	Aspirin - Yes	1	1%	1	1%	0	0%
	Aspirin - N/A	91	48%	80	47%	11	58%
	Aspirin - DK	10	5%	10	6%	0	0%
	Smog - Yes	141	74%	125	73%	16	84%
	Smog - N/A	5	3%	5	3%	0	0%
	Smog - DK	19	10%	18	10%	1	5%
	Cigarette smoke - Yes	106	56%	92	53%	14	74%
	Cigarette smoke - N/A	55	29%	53	31%	2	11%
	Cigarette smoke - DK	10	5%	9	5%	1	5%
	Wood smoke - Yes	97	51%	87	51%	10	53%
	Wood smoke - N/A	34	18%	30	17%	4	21%
	Wood smoke - DK	11	6%	10	6%	1	5%
	Perfumes - Yes	67	35%	58	34%	9	47%
	Perfumes - N/A	6	3%	5	3%	1	5%
	Perfumes - DK	8	4%	7	4%	1	5%
	Perfumes - Missing	2	1%	2	1%	0	0%
	Strong smells - Yes	93	49%	82	48%	11	58%
	Strong smells - N/A	8	4%	7	4%	1	5%
	Strong smells - DK	7	4%	6	3%	1	5%
	Strong smells - Missing	1	1%	1	1%	0	0%
	Cold air - Yes	119	62%	107	62%	12	63%
	Cold air - N/A	1	1%	1	1%	0	0%
	Cold air - DK	5	3%	5	3%	0	0%
	Exercise - Yes	156	82%	141	82%	15	79%
	Exercise - DK	1	1%	1	1%	0	0%
	Pollen - Yes	154	81%	139	81%	15	79%
	Pollen - N/A	1	1%	1	1%	0	0%
	Pollen - DK	13	7%	12	7%	1	5%
	Other - Yes	76	40%	66	38%	10	53%
	Created var: Emotion - Yes	9	5%	9	5%	0	0%
	Created var: Food - Yes	8	4%	7	4%	1	5%
	Created var: Grass - Yes	12	6%	10	6%	2	11%
	Created var: Mold - Yes	2	1%	2	1%	0	0%
	Created var: Outside - Yes	5	3%	3	2%	2	11%
	Created var: Weather - Yes	5	3%	5	3%	0	0%
	Created var: Humidity- Yes	3	2%	3	2%	0	0%

Table B5, cont.

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
Q9	**Triggers that make asthma symptoms worse (cont.) [3]**						
	Created var: Heat - Yes	10	5%	10	6%	0	0%
	Created var: Trees- Yes	6	3%	6	3%	0	0%
	Other: Dirty sheets (2), Carpet, cold water, construction, burning grape vines, dust mites, feather pillows, frying foods, gas BBQ smoke, hair spray, heater, running, stuffed animals, getting sick, swimming, winter						
	Created Variable: Total number of asthma triggers per child: sum of all trigger variables (including created ones listed above)						
	1 - 4	8	4%	8	5%	0	0%
	5 - 8	75	39%	69	40%	6	32%
	9 - 12	81	42%	71	41%	10	53%
	13 or more	27	14%	24	14%	3	16%
Q10	**Have asthma action plan**						
	DK	3	2%	2	1%	1	5%
	No	97	51%	89	52%	8	42%
	Yes	91	48%	81	47%	10	53%
Q11	**Smoking occurs around child [4]**						
	No	153	80%	138	80%	15	79%
	Yes	38	20%	34	20%	4	21%
Q11a	**Smoking in the car with child [1]**						
	No	30	16%	27	16%	3	16%
	Yes	7	4%	6	3%	1	5%
	Missing	1	1%	1	1%	0	0%
Q11a	**Smoking in child's house [1]**						
	No	35	18%	31	18%	4	21%
	Yes	2	1%	2	1%	0	0%
	Missing	1	1%	1	1%	0	0%
Q11a	**Smoking in another house with child [1]**						
	No	9	5%	6	3%	1	5%
	Yes	28	15%	27	16%	3	16%
	Missing	1	1%	1	1%	0	0%
Q11a	**Smoking in an outdoor location with child [1]**						
	No	7	4%	6	3%	1	5%
	Yes	30	16%	27	16%	3	16%
	Missing	1	1%	1	1%	0	0%
Q11a	**Smoking in another location with child [1]**						
	No	34	18%	30	17%	4	21%
	Yes	4	2%	4	2%	0	0%
	Other : Public spaces (2), "Mom smokes outside home", "Grandpa smokes in park and then comes in"						
Q12	**Owns pets**						
	No	66	35%	59	34%	7	37%
	Yes	125	65%	113	66%	12	63%

[1] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

Table B5, cont.

[2] Of the eight people who said "No" to allergy symptoms in the last 12 months, seven answered "Yes" to at least one of the follow up questions about specific allergies in the last 12 months. Thus some of the answers to the follow up questions may not add up to the number of people who said "No" to this question. Likely these participants either misunderstood or did not hear either this question or the follow up questions correctly.

[3] N/A and DK are only listed if some participants responded with those answers. N/A specifically refers to Not Applicable/ Never Had/No Contact

[4] "Yes" and "No" codes were switched in the original smoking variable ("No" was coded as 1, "Yes" was coded as 0) so a new variable was created to fix the mistake. Both the original and the corrected variables will be included in the data dictionary and the data set.

Table B6. Results of Baseline Questionnaire Part 1, Questions #12

		Total households		Indoors	Sleeps in child's room
		(n)	(%)	(n)	(n)
Q12	**Pets ownership by pet type**				
	Cats - Yes	33	19%	30	15
	Dogs - Yes	92	53%	63	8
	Rodents - Yes	9	5%	6	1
	Birds - Yes	13	8%	9	0
	Other - Yes	16	9%	12	0
	Other: Rabbit (6), turtle (3), lizard/bearded dragon (3), chicken (2), fish (2)				

Table B7. Results of Baseline Questionnaire Part 1, Questions 12, Questions 32-33

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
	Created Variable: Pets - All furry/feathered pets (cats, dogs, rodents, birds, rabbits, chickens)						
	No furry/feathered pet	74	39%	66	38%	8	42%
	Outdoor furry/feathered pet	28	15%	25	15%	3	16%
	Indoor furry/feathered pet, does not sleep with child	62	32%	58	34%	4	21%
	Indoor furry/feathered pet, sleeps with child	27	14%	23	13%	4	21%
	Created Variable: Pets - Dogs or Cats						
	No dog or cat	78	41%	70	41%	8	42%
	Outdoor dog or cat	27	14%	24	14%	3	16%
	Indoor dog or cat, does not sleep with child	59	31%	55	32%	4	21%
	Indoor dog or cat, sleeps with child	27	14%	23	13%	4	21%
	Created Variable: Have indoor furry animals and allergies to furry animals in the last 12 months						
	No	143	75%	131	76%	12	63%
	Yes	48	25%	41	24%	7	37%
Q13 - Q31 are included in Table 3.7.2							
Q32	**Grade child enrolled in at start of study**						
	K-1	38	20%	33	19%	5	26%
	2 - 3	68	36%	61	35%	7	37%
	4 - 5	58	30%	54	31%	4	21%
	6+ UP	26	14%	24	14%	2	11%
	Missing	1	1%	0	0%	1	5%
Q33	**Childs Race** [1]						
	Hispanic	92	48%	84	49%	8	42%
	Black or African American	21	11%	18	10%	3	16%
	White	55	29%	49	28%	6	32%
	Asian	5	3%	5	3%	0	0%
	Native Hawaiian or other Pacific Islander	1	1%	1	1%	0	0%
	Mixed	14	7%	13	8%	1	5%
	Other: not specified	3	2%	2	1%	1	5%

[1] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

Table B8. Results of Baseline Questionnaire Part 1, Questions 34-43a

		Total households	
		(n)	(%)
Q34	**Respondents race [1]**		
	Hispanic	81	47%
	Black or African American	19	11%
	White	57	33%
	Asian	6	3%
	Mixed	8	5%
	Other: not specified	1	1%
Q35	**Total people in the home**		
	2 - 4	84	49%
	5 - 6	69	40%
	7 - 9	16	9%
	11 - 12	2	1%
	Missing	1	1%
Q35a	**Adults in the home**		
	1	16	9%
	2	121	70%
	3 - 4	28	16%
	5 - 7	6	3%
	Missing	1	1%
Q35b	**Children under 18 in the home**		
	1 -2	96	56%
	3 -4	64	37%
	5 -8	11	6%
	Missing	1	1%
Q35c	**Pre-School /Daycare age in the home [2]**		
	Missing	13	8%
	0	129	75%
	1	21	12%
	2 -3	9	5%
Q36	**Primary caregiver relation**		
	Mother (bio or adoptive)	151	88%
	Father (bio or adoptive)	15	9%
	Grandmother	4	2%
	Sibling	1	1%
	Other family	1	1%
Q36a	**Primary caregiver's highest grade/school level completed**		
	1st through 5th grade	3	2%
	6th - 8th grade	10	6%
	9th - 11th grade	14	8%
	GED or 12th grade	24	14%
	1 to 3 years of college / technical / voc training / associate	55	32%
	4 years of college / technical / voc training / bachelors	35	20%
	5+ years of college / technical / voc training / grad degree	30	17%
	Missing	1	1%

Table B8, cont.

		Total households	
		(n)	(%)
	Created variable: Primary caregiver employment, combined Q25 + Q36b		
	No	74	43%
	Yes	94	55%
	Missing	4	2%
Q36c	**Primary caregivers marital status**		
	Married/Co-Habituating	125	73%
	Divorced/Seperated	22	13%
	Single	19	11%
	windowed	1	1%
	Other	2	1%
	Missing	3	2%
Q37	**Household income**		
	Less than $23,000	39	23%
	Between $23,000 and 46,000	35	20%
	Between $46,000 and 70,000	25	15%
	More than $70,000	63	37%
	DK/RF	9	5%
	Missing	1	1%
Q38a	**Child covered by health insurance**		
	No	2	1%
	Yes	168	98%
	DK	1	1%
	Missing	1	1%
Q38a	**Health insurance paid by [3]**		
	Your work or your spouse's work	81	47%
	The government	75	44%
	Self-pay	11	6%
	Other	1	1%
	Missing	1	1%
	Other: Insurance paid by both parents work and the government		
Q41	**Primary sleeping area**		
	Own/shared bedroom	154	90%
	Parents' bedroom	15	9%
	Family/TV room	2	1%
	Guest room	1	1%
Q42	**Child's bedroom painted in the least 6 months**		
	No	153	89%
	Yes	16	9%
	DK	1	1%
	Missing	2	1%
Q43	**New furniture purchased in the past year**		
	No	126	73%
	Yes	45	26%
	Missing	1	1%

Table B8, cont.

		Total households	
		(n)	(%)
Q43a	**Compressed wood furniture** [3]		
	No	26	15%
	Yes	14	8%
	DK	1	1%
	Missing	4	2%
	Created variable: Bedroom painted or compressed wood furniture		
	No	144	84%
	Yes	28	16%

[1] Categorized "Other" responses according to census race definitions. If more than one race listed, added to the mixed group.

[2] This question was added after the first group of participants has already completed the questionnaire.

[3] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

Table B9. Results of Baseline Questionnaire Part 1, Questions 44-48

		Entire Data Set		Primary Children		Enrolled Sibling	
		(n)	(%)	(n)	(%)	(n)	(%)
Q44	**Plastic, vinyl or other allergy cover on primary bed**						
	No	154	81%	139	81%	15	79%
	Yes	36	19%	32	19%	4	21%
	Missing	1	1%	1	1%	0	0%
Q44a	**Parts encased with the allergy cover [1]**						
	Mattress	30	16%	26	15%	4	20%
	Box Spring	2	1%	2	1%	0	0%
	Missing	4	2%	4	2%	0	0%
	Created variable: Primary/secondary sleeping areas, combined Q41 and Q48						
	Own bedroom only	151	79%	136	79%	15	79%
	Own bedroom / parent's bedroom (20 hours or less)	4	2%	3	2%	1	5%
	Own bedroom / parent's bedroom (21 - 27 hours)	7	4%	7	4%	0	0%
	Own bedroom / parent's bedroom (27 hours or more)	4	2%	3	2%	1	5%
	Own bedroom / another place (20 hours or less)	2	1%	2	1%	0	0%
	Own bedroom / another place (21 - 27 hours)	4	2%	3	2%	1	5%
	Parent's bedroom only	14	7%	13	8%	1	5%
	Parents' bedroom / own room (more than 27 hours per week)	1	1%	1	1%	0	0%
	Family/TV room only	2	1%	2	1%	0	0%
	Other	2	1%	2	1%	0	0%
	Other: Primary is parent's bedroom, secondary is unlisted (21-27 hours), Primary is guest bedroom, secondary is siblings bedroom (21-27 hours)						

[1] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

Table B10. Results of Baseline Questionnaire Part 2, Questions 1-23

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q1	**House Type**								
	Single Family Home (Detached House)	138	80%	80	74%	58	91%	152	80%
	Duplex/Triplex	10	6%	8	7%	2	3%	11	6%
	Townhouse/ Row House	4	2%	4	4%	0	0%	5	3%
	Low rise apartment or condo (1-3 floors)	15	9%	14	13%	1	2%	17	9%
	Mobile Home/Trailer	5	3%	2	2%	3	5%	6	3%
Q2	**Ground surface near home**								
	Primarily vegetation or hardscape	162	94%	102	94%	60	94%	180	94%
	A mix of vegetation and bare dirt	6	3%	3	3%	3	5%	6	3%
	Primarily bare dirt	3	2%	2	2%	1	2%	4	2%
	Missing	1	1%	1	1%	0	0%	1	1%
Q3	**Door mat in front of the front door**								
	No	32	19%	19	18%	13	20%	39	20%
	Yes	136	79%	88	81%	48	75%	148	77%
	Missing	4	2%	1	1%	3	5%	4	2%
	Created variable: Total door mat status: Combined Q3 and Q7 [1]								
	Front-No	32	19%	19	18%	13	20%	39	20%
	Front-Yes; Back-No	48	28%	27	25%	21	33%	54	28%
	Front-Yes; Back-Yes or NA	88	51%	61	56%	27	42%	94	49%
	Missing	4	2%	1	1%	3	5%	4	2%
Q4	**Rent or own**								
	Rent	66	38%	50	46%	16	25%	75	39%
	Own	106	62%	58	54%	48	75%	116	61%
Q5	**Years child lived at current address**								
	< 1	19	11%	15	14%	4	6%	21	11%
	1 - 2.99	35	20%	26	24%	9	14%	39	20%
	3 - 4.99	35	20%	19	18%	16	25%	38	20%
	5+	81	47%	46	43%	35	55%	90	47%
	Missing	2	1%	2	2%	0	0%	3	2%
Q6	**Shoes generally removed at home**								
	No	103	60%	61	56%	42	66%	113	59%
	Yes	69	40%	47	44%	22	34%	78	41%

Table B10, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q8	**Pests** [2]								
	Mice - Yes	23	13%	15	14%	8	13%	24	13%
	Rats - Yes	13	8%	8	7%	5	8%	14	7%
	Cockroaches - Yes	47	27%	42	39%	5	8%	55	29%
	Cockroaches - DK/RF	1	1%	1	1%	0	0%	1	1%
	Ants - Yes	76	44%	43	40%	33	52%	81	42%
	Spiders - Yes	87	51%	54	50%	33	52%	96	50%
	Bedbugs - Yes	3	2%	2	2%	1	2%	3	2%
	Other - Yes	21	12%	16	15%	5	8%	26	14%
	Other: Earwigs/pincher bugs (5), water bugs (3), beetles (2), aphids, flies, lice, mosquitos, moths, squirrels, termites, wasps, fleas, potato bugs, not listed								
	Created variable: yes to problems with mice, rats or cockroaches								
	No	107	62%	58	54%	49	77%	117	61%
	Mice or rats or cockroaches - Yes	65	38%	50	46%	15	23%	74	39%
Q8	**Home within 1/4 mile of source** [3, 4]								
	Gas Station - Yes	98	57%	66	61%	32	50%	111	58%
	Gas Station - Maybe	3	2%	3	3%	0	0%	4	2%
	Gas Station - DK	2	1%	0	0%	2	3%	2	1%
	Farm - Yes	66	38%	42	39%	24	38%	70	37%
	Farm - Maybe	4	2%	3	3%	1	2%	6	3%
	Industrial Facility - Yes	27	16%	17	16%	10	16%	31	16%
	Industrial Facility - Maybe	6	3%	4	4%	2	3%	8	4%
	Industrial Facility - DK	5	3%	5	5%	0	0%	5	3%
	Industrial Facility - Missing	1	1%	0	0%	1	2%	1	1%
	Railroad - Yes	43	25%	29	27%	14	22%	47	25%
	Railroad - Maybe	4	2%	3	3%	1	2%	4	2%
	Railroad - DK	1	1%	1	1%	0	0%	1	1%
	Drycleaners - Yes	51	30%	32	30%	19	30%	60	31%
	Drycleaners - Maybe	9	5%	5	5%	4	6%	10	5%
	Drycleaners - DK	5	3%	4	4%	1	2%	5	3%
	Bus Truck Depot - Yes	31	18%	19	18%	12	19%	38	20%
	Bus Truck Depot - Maybe	5	3%	3	3%	2	3%	5	3%
	Construction - Yes	58	34%	30	28%	28	44%	63	33%
	Construction - Maybe	5	3%	3	3%	2	3%	5	3%
	Construction - DK	2	1%	2	2%	0	0%	2	1%
	Waste Sewage Facility -Yes	11	6%	7	6%	4	6%	13	7%
	Waste Sewage Facility -Maybe	7	4%	6	6%	1	2%	7	4%
	Waste Sewage Facility - DK	5	3%	3	3%	2	3%	5	3%
	Restaurant - Yes	50	29%	39	36%	11	17%	59	31%

Table B10, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
	Created variable: Close to sources: If yes to any Q8 choices								
	No	14	8%	4	4%	10	16%	16	8%
	Yes	158	92%	104	96%	54	84%	175	92%
Q10	**How close is nearest freeway, highway, major street**								
	Immediately in front, behind or beside child's residence	20	12%	15	14%	5	8%	24	13%
	One block away, length of football field	39	23%	29	27%	10	16%	45	24%
	2-4 blocks away	50	29%	31	29%	19	30%	55	29%
	More than 5 blocks away	62	36%	32	30%	30	47%	65	34%
	Missing	1	1%	1	1%	0	0%	2	1%
	Q11 - Q14 are included in Table B13								
Q15	**Created variable: Bathroom exhaust fan [5]**								
	No bathroom exhaust fan	40	23%	27	25%	13	20%	48	25%
	Fan on when light is on	34	20%	23	21%	11	17%	36	19%
	Fan on most of the time	36	21%	23	21%	13	20%	42	22%
	Fan on sometimes	16	9%	11	10%	5	8%	18	9%
	Fan on rarely/never	44	26%	22	20%	22	34%	45	24%
	Missing	2	1%	2	2%	0	0%	2	1%
Q16	**Enclosed garage attached to home**								
	Yes	116	67%	61	56%	55	86%	129	68%
Q17	**Created variable: Year home was built**								
	Older than 1949	18	10%	13	12%	5	8%	18	9%
	1950s	16	9%	10	9%	6	9%	18	9%
	1960s	13	8%	8	7%	5	8%	14	7%
	1970-1976	18	10%	17	16%	1	2%	22	12%
	1977-1979	5	3%	3	3%	2	3%	6	3%
	1980s	22	13%	13	12%	9	14%	27	14%
	1990s	22	13%	14	13%	8	13%	25	13%
	2000s	49	28%	21	19%	28	44%	52	27%
	2010+	1	1%	1	1%	0	0%	1	1%
	Missing	8	5%	8	7%	0	0%	8	4%
Q18	**Created variable: Square footage of home**								
	500-999 ft^2	20	12%	14	13%	6	9%	23	12%
	1000-1499 ft^2	43	25%	27	25%	16	25%	50	26%
	1500-1999 ft^2	25	15%	17	16%	8	13%	28	15%
	2000-2499 ft^2	34	20%	22	20%	12	19%	36	19%
	2500-3499 ft^2	24	14%	14	13%	10	16%	26	14%
	3500-5500 ft^2	12	7%	1	1%	11	17%	12	6%
	Missing	14	8%	13	12%	1	2%	16	8%

Table B10, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q19	**Created variable: Main heating, type and fuel**								
	Baseboard electric heater	1	1%	1	1%	0	0%	1	1%
	Forced air - DK/missing fuel type	4	2%	3	3%	1	2%	5	3%
	Forced air - electric	81	47%	56	52%	25	39%	90	47%
	Forced air - gas	59	34%	33	31%	26	41%	67	35%
	Forced air - propane	1	1%	1	1%	0	0%	1	1%
	Gas wall heater	13	8%	7	6%	6	9%	14	7%
	Space heaters - kerosene	1	1%	1	1%	0	0%	1	1%
	Space heaters - electric	9	5%	4	4%	5	8%	9	5%
	Wood stove/fireplace - gas	2	1%	1	1%	1	2%	2	1%
	Wood stove/fireplace - wood	1	1%	1	1%	0	0%	1	1%
Q19b	**Forced air - times per year filter is changed [6]**								
	Less than once a year	13	8%	8	7%	5	8%	13	7%
	Annually	22	13%	13	12%	9	14%	26	14%
	2 times per year	34	20%	19	18%	15	23%	36	19%
	3 - 5 times per year	47	27%	32	30%	15	23%	56	29%
	6 - 9 times per year	10	6%	9	8%	1	2%	10	5%
	Monthly or more often	14	8%	10	9%	4	6%	17	9%
	Missing	5	3%	2	2%	3	5%	5	3%
Q19c	**Forced air - last time filter was changed (months ago) [6]**								
	Less than 1 month ago	20	12%	12	11%	8	13%	24	13%
	1 - 3 months ago	66	38%	48	44%	18	28%	72	38%
	3 to 6 months ago	30	17%	15	14%	15	23%	35	18%
	7 - 12 months ago	16	9%	10	9%	6	9%	18	9%
	13 - 24 months ago	4	2%	3	3%	1	2%	4	2%
	24 months ago or more	3	2%	1	1%	2	3%	3	2%
	Missing	6	3%	4	4%	2	3%	7	4%
Q19di	**Forced air - Replaced heater/HVAC system in the last 5 years [6]**								
	DK	4	2%	3	3%	1	2%	5	3%
	No	113	66%	71	66%	42	66%	128	67%
	Yes	17	10%	12	11%	5	8%	18	9%
	Missing	11	6%	7	6%	4	6%	12	6%
Q19di	**Forced air - System has additional air intake [6, 7]**								
	Yes	2	1%	2	2%	0	0%	2	1%
	DK	7	4%	4	4%	3	5%	8	4%
Q20	**Past winter main heating system use**								
	DK/RF	2	1%	0	0%	2	3%	2	1%
	Most days/Daily	83	48%	63	58%	20	31%	92	48%
	About 1/2 the days	36	21%	21	19%	15	23%	43	23%
	Not very often	51	30%	24	22%	27	42%	54	28%

Table B10, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q20	**Primary heating system use**								
Q20a	In the morning - Yes	127	74%	78	72%	49	77%	141	74%
Q20b	In the daytime - Yes	34	20%	22	20%	12	19%	39	20%
Q20c	In the evening - Yes	114	66%	73	68%	41	64%	127	66%
Q20d	Overnight - Yes	99	58%	62	57%	37	58%	112	59%
Q21	**Created variable: Secondary heating, type and fuel [8]**								
	None	119	69%	76	70%	43	67%	135	71%
	Forced air - electric	1	1%	0	0%	1	2%	1	1%
	Forced air - gas	1	1%	1	1%	0	0%	1	1%
	Space heaters - electric	29	17%	17	16%	12	19%	31	16%
	Wood stove/fireplace - electricity	1	1%	1	1%	0	0%	1	1%
	Wood stove/fireplace - gas	10	6%	5	5%	5	8%	10	5%
	Wood stove/fireplace - other fuel type	1	1%	0	0%	1	2%	1	1%
	Wood stove/fireplace - wood	7	4%	5	5%	2	3%	8	4%
	Missing	3	2%	3	3%	0	0%	3	2%
Q20	**Past winter secondary heating system use [6]**								
	Most days/Daily	17	10%	9	8%	8	13%	17	9%
	About 1/2 the days	12	7%	8	7%	4	6%	13	7%
	Not very often	24	14%	15	14%	9	14%	26	14%
Q22	**Secondary heating system use [6]**								
Q22a	In the morning - Yes	21	12%	11	10%	10	16%	23	12%
	In the morning - Missing	1	1%	1	1%	0	0%	1	1%
Q22b	In the daytime - Yes	5	3%	1	1%	4	6%	5	3%
	In the daytime - Missing	1	1%	1	1%	0	0%	1	1%
Q22c	In the evening - Yes	42	24%	27	25%	15	23%	44	23%
	In the evening - Missing	1	1%	1	1%	0	0%	1	1%
Q22d	Overnight - Yes	20	12%	11	10%	9	14%	21	11%
	Overnight - Missing	1	1%	1	1%	0	0%	1	1%
	Created variable: Fireplace (Q19, Q21, Q23)								
	Does not have fireplace	64	37%	47	44%	17	27%	73	38%
	Have fireplace, but use 0 days per year	54	31%	33	31%	21	33%	61	32%
	Gas fireplace/woodstove, use >0 day	26	15%	10	9%	16	25%	26	14%
	Wood fireplace, use >0 days per year	17	10%	10	9%	7	11%	19	10%
	Woodstove/manufactured wood/other, use >0 days per year	11	6%	8	7%	3	5%	12	6%

General note: For questions with no missing data or don't know/refused (DK/RF) responses, these choices are not included in the results table.

Table B10, cont.

[1] Out of the 4 households missing the front doormat question, 3 homes had a doormat in front of their front door and one home did not have a doormat in front of the back door.

[2] Assumed any participants that had missing answer for other pests section did not have a problem with other pests and are listed as "No"

[3] One home was missing answers to all the questions. Answers for that home were determined using google maps.

[4] Spanish version of the questionnaire was missing the restaurant question. Distance to restaurant was looked up for all participants (English and Spanish speaking) using google maps.

[5] Although the question says "Continuously operating fan that is on all the time", our staff misinterpreted it as fan went on whenever the bathroom light was on. By the time we realized the problem, a significant portion of the population had already completed the questionnaire and we continued with the interpretation that the fan was on when the light was on. The staff did not come across anyone who volunteered that their fan was actually on all the time.

[6] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

[7] Of the two participants that said "Yes" to additional air intake, it is likely that only one of the participants understood the question and could potentially have an additional air intake.

- The first home is a 1928 house, recently renovated. Exact wording is "I believe so" and income is more than 70k a year so it is conceivable for the home to have an additional air intake.
- The other home is a 1999 home with 1645 square feet. The participant answered that they have an electric forced air system so it is doubtful that they have a good understanding of heating systems.

[8] Two participants have forced air system as their secondary heating system. The first participant uses electric portable heater as their primary heating system. The second uses a gas fireplace as their primary heating system.

Table B11. Results of Baseline Questionnaire Part 2, Fireplace Usage

	Population by Residence							
	N	**Mean**	**Std Dev**	**25th**	**Median**	**75th**	**90th**	**Max**
Created variable: Fireplace usage	(n)	Days / Year	Days / Year	Days / Year	Days / Year	Days / Year	Days / Year	Days / Year
Number of days per year using fireplace	172	6	16.8	0	0	4.5	16	120

Table B12. Results of Baseline Questionnaire Part 2, Questions 24-46

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q24	**Type of Air conditioning**								
	DK/RF	1	1%	1	1%	0	0%	1	1%
	Nothing/fan	11	6%	8	7%	3	5%	11	6%
	Central Air (with ducts)	135	78%	86	80%	49	77%	152	80%
	Individual units installed through walls or windows	17	10%	7	6%	10	16%	17	9%
	Swamp or desert cooler	8	5%	6	6%	2	3%	10	5%
Q24a	**Individual units installed through walls of windows - Frequency set to take in outside air [1]**								
	DK/RF	3	2%	2	2%	1	2%	3	2%
	Always	6	3%	4	4%	2	3%	6	3%
	Sometimes	1	1%	0	0%	1	2%	1	1%
	Never	6	3%	0	0%	6	9%	6	3%
	Missing	1	1%	1	1%	0	0%	1	1%
Q25	**Air conditioner use during past summer [1]**								
	DK/RF	2	1%	0	0%	2	3%	2	1%
	Most days/Daily	128	74%	87	81%	41	64%	144	75%
	About 1/2 the days	25	15%	10	9%	15	23%	26	14%
	Not very often	6	3%	3	3%	3	5%	8	4%
	Created variable: Have central cooling system								
	No	37	22%	22	20%	15	23%	39	20%
	Yes	135	78%	86	80%	49	77%	152	80%
	Created variable: Have swamp or desert cooler								
	No	164	95%	102	94%	62	97%	181	95%
	Yes	8	5%	6	6%	2	3%	10	5%
Q26	**Have vacuum**								
	No, borrows vacuum	1	1%	0	0%	1	2%	1	1%
	No, doesn't own or borrow	18	10%	13	12%	5	8%	23	12%
	Yes	152	88%	94	87%	58	91%	165	86%
	Yes, not in home during visit	1	1%	1	1%	0	0%	2	1%
Q29	**Vacuum cleaner use [1]**								
	Daily (5-7 times a week)	30	17%	21	19%	9	14%	37	19%
	1-4 times a week	111	65%	66	61%	45	70%	118	62%
	1-2 times a month	12	7%	8	7%	4	6%	12	6%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q30	**Frequency of changing/emptying vacuum bag [1]**								
	DK/RF	2	1%	2	2%	0	0%	3	2%
	Every time the house is vacuumed	48	28%	33	31%	15	23%	51	27%
	Every other time the vacuum is used	21	12%	11	10%	10	16%	24	13%
	More than once a month	17	10%	12	11%	5	8%	18	9%
	1-2 times a month	32	19%	17	16%	15	23%	38	20%
	Every 2-3 months	27	16%	17	16%	10	16%	27	14%
	More than once a year (1-2 times a year)	6	3%	3	3%	3	5%	6	3%
Q31	**Stove top type**								
	Gas	122	71%	60	56%	62	97%	132	69%
	Electric	50	29%	48	44%	2	3%	59	31%
Q31a	**How gas stove top is lit [1]**								
	Electric Starter	115	67%	56	52%	59	92%	124	65%
	Lit with a match	2	1%	1	1%	1	2%	2	1%
	Continuously burning pilot light	4	2%	3	3%	1	2%	5	3%
	Missing	1	1%	0	0%	1	2%	1	1%
Q32	**Created variable: Days per week gas stove top is used for cooking for more than 1 hour at a time [1,2]**								
	0 days/week	15	9%	12	11%	3	5%	17	9%
	1 day/week	11	6%	9	8%	2	3%	11	6%
	2 days /week	12	7%	7	6%	5	8%	14	7%
	3 days/week	11	6%	3	3%	8	13%	11	6%
	4 days/week	11	6%	7	6%	4	6%	12	6%
	5 days/week	12	7%	4	4%	8	13%	12	6%
	6 days/week	4	2%	2	2%	2	3%	4	2%
	7 days/week	45	26%	16	15%	29	45%	50	26%
	Missing	1	1%	0	0%	1	2%	1	1%
Q33	**Gas stove top used for heating home during winter months [1]**								
	No	117	68%	56	52%	61	95%	126	66%
	Yes	4	2%	4	4%	0	0%	5	3%
	Missing	1	1%	0	0%	1	2%	1	1%
Q33a	**Frequency gas stove top used for heating home [1]**								
	1-4 times a week	1	1%	1	1%	1	2%	2	1%
	1-2 times a month	1	1%	1	1%	1	2%	1	1%
	More than once a year (1-2 times a year)	1	1%	1	1%	1	2%	1	1%
	Missing	1	1%	1	1%	1	2%	1	1%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q34	**Range hood/fan above stove top**								
	None	12	7%	4	4%	8	13%	12	6%
	Range hood vented to outside	131	76%	87	81%	44	69%	148	77%
	Range hood that blows into kitchen	11	6%	6	6%	5	8%	12	6%
	Fan	18	10%	11	10%	7	11%	19	10%
Q34a	**Frequency of hood/fan when cooking [1]**								
	All of the time	51	30%	29	27%	22	34%	58	30%
	Most of the time	30	17%	21	19%	9	14%	31	16%
	About half the time	31	18%	21	19%	10	16%	36	19%
	Rarely	29	17%	19	18%	10	16%	34	18%
	Never	13	8%	9	8%	4	6%	13	7%
	Missing	6	3%	5	5%	1	2%	7	4%
Q35	**Oven type**								
	DK/RF	1	1%	1	1%	0	0%	1	1%
	Gas	86	50%	44	41%	42	66%	93	49%
	Electric	84	49%	63	58%	21	33%	96	50%
	Missing	1	1%	0	0%	1	2%	1	1%
Q35a	**How gas oven is lit [1]**								
	DK/RF	3	2%	3	3%	0	0%	3	2%
	Electric Starter	64	37%	24	22%	40	63%	69	36%
	Continuously burning pilot light	17	10%	16	15%	1	2%	19	10%
	Missing	2	1%	1	1%	1	2%	2	1%
Q36	**Created variable: Days per week gas oven is used for cooking for more than 1 hour at a time [1,2]**								
	0 days/week	31	18%	14	13%	17	27%	33	17%
	1 day/week	26	15%	15	14%	11	17%	28	15%
	2 days /week	11	6%	3	3%	8	13%	11	6%
	3 days/week	14	8%	8	7%	6	9%	16	8%
	5 days/week	1	1%	1	1%	0	0%	1	1%
	7 days/week	2	1%	2	2%	0	0%	3	2%
	Missing	1	1%	1	1%	0	0%	1	1%
Q37	**Gas oven used for heating home during winter months [1]**								
	No	82	48%	40	37%	42	66%	89	47%
	Yes	3	2%	3	3%	0	0%	3	2%
	Missing	1	1%	1	1%	0	0%	1	1%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q37a	**Frequency oven is used for heating home [1]**								
	1-2 times a month	2	1%	2	2%	0	0%	2	1%
	More than once a year (1-2 times a year)	1	1%	1	1%	0	0%	1	1%
Q38	**Gas dryer**								
	No dryer	23	13%	21	19%	2	3%	27	14%
	Electric dryer	68	40%	64	59%	4	6%	75	39%
	Gas dryer	81	47%	23	21%	58	91%	89	47%
Q38b	**Dryer vented to the outside [1]**								
	DK	1	1%	0	0%	1	2%	1	1%
	No	9	5%	8	7%	1	2%	10	5%
	Yes	138	80%	78	72%	60	94%	152	80%
	Missing	1	1%	1	1%	0	0%	1	1%
Q39	**Gas water heater**								
	DK	1	1%	1	1%	0	0%	2	1%
	No	16	9%	13	12%	3	5%	18	9%
	Yes	154	90%	93	86%	61	95%	170	89%
	Missing	1	1%	1	1%	0	0%	1	1%
Q40	**Portable gas/kerosene heater**								
	DK	3	2%	2	2%	1	2%	3	2%
	No	163	95%	103	95%	60	94%	182	95%
	Yes	6	3%	3	3%	3	5%	6	3%
	Created variable: Number of gas appliances in home								
	0 gas appliances	10	6%	9	8%	1	2%	12	6%
	1 gas appliance	37	22%	36	33%	1	2%	44	23%
	2 gas appliances	19	11%	15	14%	4	6%	20	10%
	3 gas appliances	53	31%	35	32%	18	28%	57	30%
	4 gas appliances	50	29%	13	12%	37	58%	55	29%
	5 gas appliances	3	2%	0	0%	3	5%	3	2%
Q41	**Musty or moldy smell in home**								
	No	129	75%	77	71%	52	81%	143	75%
	Yes	43	25%	31	29%	12	19%	48	25%
Q41a	**Last time of moldy or musty smell [1]**								
	Current	7	4%	5	5%	2	3%	7	4%
	During the past month	5	3%	4	4%	1	2%	6	3%
	During the past 6 months	10	6%	7	6%	3	5%	12	6%
	6-12 months ago	5	3%	4	4%	1	2%	6	3%
	More than a year ago	14	8%	9	8%	5	8%	15	8%
	Missing	2	1%	2	2%	0	0%	2	1%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q42	**Mold or water damage on any surfaces**								
	No	104	60%	63	58%	41	64%	117	61%
	Yes	68	40%	45	42%	23	36%	74	39%
	Created variable: Musty/moldy smell inside or mold/water damage inside home ever, combine Q41 and Q42								
	No	88	51%	52	48%	36	56%	98	51%
	Yes	84	49%	56	52%	28	44%	93	49%
	Created variable: Have mold currently								
	Current mold, not significant	8	5%	5	5%	3	5%	9	5%
	Current mold, significant	10	6%	8	7%	2	3%	10	5%
	No current mold	154	90%	95	88%	59	92%	172	90%
	Created variable: Had mold in the past								
	No past mold	140	81%	84	78%	56	88%	157	82%
	Past mold, not significant	8	5%	6	6%	2	3%	9	5%
	Past mold, significant	24	14%	18	17%	6	9%	25	13%
	Created variable: Have water damage currently								
	Current water damage, not significant	3	2%	2	2%	1	2%	3	2%
	Current water damage, significant	10	6%	7	6%	3	5%	10	5%
	No current water damage	159	92%	99	92%	60	94%	178	93%
	Created variable: Had water damage in the past								
	No past water damage	136	79%	85	79%	51	80%	150	79%
	Past water damage, not significant	9	5%	4	4%	5	8%	10	5%
	Past water damage, significant	27	16%	19	18%	8	13%	31	16%
Q44	**Number of bedrooms in the home**								
	1 bedroom	1	1%	1	1%	0	0%	2	1%
	2 bedrooms	31	18%	25	23%	6	9%	32	17%
	3 bedrooms	63	37%	43	40%	20	31%	74	39%
	4 or more bedrooms	77	45%	39	36%	38	59%	83	43%
	Created variable: Number of people per bedroom								
	Less than 1 person per bedroom	9	5%	3	3%	6	9%	9	5%
	1 person per bedroom	32	19%	20	19%	12	19%	33	17%
	Between 1 and 2 people per bedroom	93	54%	58	54%	35	55%	106	56%
	2 people per bedroom	24	14%	18	17%	6	9%	27	14%
	Between 2 and 3 people per bedroom	10	6%	5	5%	5	8%	11	6%
	More than 3 people per bedroom	3	2%	3	3%	0	0%	4	2%
	Missing	1	1%	1	1%	0	0%	1	1%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q45	**Created variable: Location of living room**								
	2nd story+	5	3%	4	4%	1	2%	6	3%
	Ground Floor	164	95%	102	94%	62	97%	181	95%
	Missing	2	1%	1	1%	1	2%	2	1%
	No options marked	1	1%	1	1%	0	0%	2	1%
Q45	**Created variable: Location of kitchen**								
	2nd story+	9	5%	5	5%	4	6%	10	5%
	Ground Floor	160	93%	101	94%	59	92%	177	93%
	Missing	2	1%	1	1%	1	2%	2	1%
	No options marked	1	1%	1	1%	0	0%	2	1%
Q45	**Created variable: Location of child's bedroom**								
	2nd story+	45	26%	19	18%	26	41%	48	25%
	Ground Floor	125	73%	88	81%	37	58%	140	73%
	Missing	1	1%	0	0%	1	2%	1	1%
	No options marked	1	1%	1	1%	0	0%	2	1%
Q45	**Created variable: Location of child's bathroom**								
	2nd story+	46	27%	18	17%	28	44%	49	26%
	Ground Floor	123	72%	88	81%	35	55%	138	72%
	Missing	1	1%	0	0%	1	2%	1	1%
	No options marked	2	1%	2	2%	0	0%	3	2%
Q46	**Primary type of flooring - Living room [3]**								
	Carpet	77	45%	55	51%	22	34%	87	46%
	Vinyl	10	6%	7	6%	3	5%	11	6%
	Tile	31	18%	13	12%	18	28%	35	18%
	Wood	38	22%	25	23%	13	20%	40	21%
	Other	13	8%	6	6%	7	11%	15	8%
	Missing	3	2%	2	2%	1	2%	3	2%
Q46	**Primary type of flooring - Kitchen [3]**								
	Carpet	1	1%	1	1%	0	0%	1	1%
	Vinyl	43	25%	36	33%	7	11%	48	25%
	Tile	103	60%	55	51%	48	75%	116	61%
	Wood	15	9%	10	9%	5	8%	15	8%
	Other	10	6%	6	6%	4	6%	11	6%
Q46	**Primary type of flooring - Child's bedroom [3]**								
	Carpet	127	74%	81	75%	46	72%	141	74%
	Vinyl	6	3%	5	5%	1	2%	7	4%
	Tile	6	3%	2	2%	4	6%	8	4%
	Wood	29	17%	18	17%	11	17%	31	16%
	Other	3	2%	2	2%	1	2%	3	2%
	Missing	1	1%	0	0%	1	2%	1	1%

Table B12, cont.

		Population by Residence		Fresno Homes		Riverside Homes		Population by child	
		(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Q46	**Primary type of flooring - Child's bathroom [3]**								
	Missing	3	2%	1	1%	2	3%	3	2%
	Carpet	4	2%	2	2%	2	3%	5	3%
	Vinyl	54	31%	37	34%	17	27%	58	30%
	Tile	99	58%	58	54%	41	64%	112	59%
	Wood	2	1%	2	2%	0	0%	2	1%
	Other	10	6%	8	7%	2	3%	11	6%
Q46	**Area rug if no carpet - Living room [4]**								
	Missing	3	2%	3	59%	0	5%	4	27%
	No	45	26%	26	21%	19	2%	51	13%
	Yes	47	27%	24	0%	23	8%	49	9%
Q46	**Area rug if no carpet - Kitchen [4]**								
	Missing	7	4%	6	7%	1	0%	8	14%
	No	139	81%	83	72%	56	64%	155	3%
	Yes	25	15%	18	1%	7	36%	27	0%
Q46	**Area rug if no carpet - Child's bedroom [4]**								
	Missing	3	2%	2	1%	1	0%	4	31%
	No	25	15%	15	12%	10	0%	28	0%
	Yes	17	10%	10	86%	7	9%	18	65%
Q46	**Area rug if no carpet - Child's bathroom [4]**								
	Missing	15	9%	8	0%	7	59%	16	3%
	No	129	75%	76	2%	53	0%	144	1%
	Yes	24	14%	22	95%	2	56%	26	0%
	Created variable: Have carpet as primary flooring type in at least 1 room in home								
	No	31	18%	20	19%	11	17%	36	19%
	Yes	141	82%	88	81%	53	83%	155	81%
	Created variable: Have vinyl as primary flooring type in at least 1 room in home								
	No	107	62%	63	58%	44	69%	120	63%
	Yes	65	38%	45	42%	20	31%	71	37%

[1] This question is only answered for the portion of the population with a particular answer on a prior question and thus the total is less than 100%

[2] Answers were rounded to the nearest integer

[3] While an "other" choice was provided, it was not specified what kind of other flooring the participants have

[4] These percentages were only calculated if the room did not have carpet.

Table B13. Results of Baseline Questionnaire Part 2, Questions 11-14

		Population by Residence								
		N	**Mean**	**Std Dev**	**10th**	**25th**	**Median**	**75th**	**90th**	**Max**
		(n)	Hours / week	Hours / week	Hours / week	Hours / week	Hours / week	Hours / week	Hours / week	Hours / week
Q11-14	**Created variable: Window questions - Hours/week windows are open**									
	Home - cold months	170	9.1	24	0	0	2	7	24	168
	Child's room - cold months	171	2.5	14	0	0	0	0	4	168
	Home - hot months	171	26.8	40	0	2	10.5	36	70	168
	Child's room - hot months	170	10.6	24.5	0	0	0	9	33.5	168
Q11-14	**Created variable: Window questions - Days/week windows are open 2 hours or more**									
	Home - cold months	170	1.5	2.4	0	0	0	2	7	7
	Child's room - cold months	171	0.4	1.3	0	0	0	0	1	7
	Home - hot months	171	3.5	3	0	0	3	7	7	7
	Child's room - hot months	170	1.6	2.5	0	0	0	2	7	7

APPENDIX C: MATERIALS RELATED TO HEALTH MEASURES

HHID:_____

RECALL QUESTIONNAIRE

GENERAL INFORMATION

Visit code (Circle ONE):			
3-month	**6-month**	**9-month**	**12-month**
15-month	**18-month**	**21-month**	**24-month**

HHID : _____

LANGUAGE OF INTERVIEW: English 1

Spanish 2

DATE OF INTERVIEW __ __ / __ __ / __ __ __ __
M M D D Y Y Y Y

DATA ENTERED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

DATA EDITED BY: __ __ DATE: __ __ / __ __ / __ __ __ __

INTERVIEW WITH THE CAREGIVER:

"THE FOLLOWING QUESTIONS ASK ABOUT THE EFFECT OF [CHILD]'S ASTHMA IN THE LAST TWO WEEKS; THAT IS, THE PAST 14 DAYS, FROM [14 DAYS AGO] TO TODAY." [SHOW CALENDAR.]"

1. During the last 14 days, how many days did [CHILD] have wheezing, tightness in the chest, or cough because of asthma?

   _____ Days

2. During the last 14 days, how many days did [CHILD] have to slow down or stop his/her play or activities due to wheezing or tightness in the chest, or cough because of asthma?

   _____ Days

3. During the last 14 days, how many days did [CHILD] use his/her rescue inhaler during the day for relief of asthma symptoms? Please do not include use of the recue inhaler taken prior to physical activities such as playing sports or exercising.

   _____ Days **[IF 0, SKIP TO 4]**

a. During the last 14 days, on average, on the days [CHILD] used his/her rescue inhaler, how many total puffs or inhalations did he/she use each day?

_____ Puffs

4. During the last 14 nights, how many nights did [CHILD] wake up due to wheezing or tightness in the chest, or cough because of asthma?

_____ Nights **[IF 0, SKIP TO 5]**

a. During the last 14 nights, how many nights did [CHILD] wake up and use a recue inhaler or breathing machine/nebulizer after going to sleep?

_____ Nights

5. How many days was school in session in the last 14 days? [Response cannot be greater than 10 days.]

___ ___ days **[IF 0, SKIP TO 6]**

a. How many times in the last 14 days did [CHILD] miss school due to asthma?

___ ___ times

6. During the last 14 days, how many days has [CHILD] had a cold or a respiratory flu (NOT including the stomach flu)?

_____ Days

7. During the last 14 days, how many days has [CHILD] had a runny or blocked nose?

_____ Days

8. During the last 14 days, how many days has [CHILD] had sneezing or an itchy nose?

_____ Days

9. During the last 14 days, how many days has [CHILD] had red/ itchy eyes, watery eyes or irritated eyes?

_____ Days

10. During the last 14 days, how many days has [CHILD] taken oral anti-histamines for allergies?

_____ Days

11. During the last 14 days, how many days has [CHILD] used prescription allergy eye drops?

_____ Days

12. During the last 14 days, how many days has [CHILD] used a prescription allergy nose spray?

_____ Days

13. During the last 14 days, how many days has [CHILD] taken Tylenol or other forms of acetaminophen?

_____ Days

"THE NEXT QUESTION IS ABOUT MISSING WORK DUE TO [CHILD]'S ASTHMA"

14. Are you currently employed (working for pay)?

☐ No **[SKIP TO 15]**

☐ Yes

☐ DK/RF **[SKIP TO 15]**

a. During the last 14 days, how many hours of work did you miss because of problems associated with[CHILD]'s asthma? [If necessary, review with caretaker the number of hours per week he/she works.]

___ ___ hours **[IF 0, SKIP TO 15]**

i. In general, how many hours per week do you usually work?

___ ___ hours/week

15. During the last 14 days, did any other of [CHILD]'s caregivers miss work because of problems associated with [CHILD]'s asthma?

☐ No **[SKIP TO 16]**

☐ Yes

☐ DK/RF **[SKIP TO 16]**

a. During the last 14 days, how many hours of work did they because of problems associated with [CHILD]'s asthma?

___ ___ hours **[IF 0, SKIP TO 16]**

i. In general, how many hours per week do they usually work?

___ ___ hours/week

HEALTH CARE USE AND RESPIRATORY DISEASE

"THE NEXT FEW QUESTIONS ARE ONES YOU HAVE ALREADY DEALT WITH TO SOME EXTENT SO PLEASE BEAR WITH ME. I AM GOING TO ASK YOU ABOUT THE EFFECT OF [CHILD]'S ASTHMA IN THE LAST 3 MONTHS. WE LAST ASKED YOU THESE QUESTIONS ON (MM/DD/YYYY), APPROXIMATELY 3 MONTHS AGO. FOR THESE QUESTIONS, WE ARE REFERRING TO THE ENTIRE TIME PERIOD BETWEEN (MM/DD/YYYY) AND TODAY."

16. During the last 3 months, because of problems with asthma, how many times has [CHILD] stayed overnight in the hospital?

_____ Times **[IF 0, SKIP TO 17]**

a. When were these visits? (what month/s) ***(Mark all that apply)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

b. Was there a specific identifiable cause of these asthma attack(s) that you are aware of?

☐ No
☐ Yes
☐ DK/RF

i. If YES, specify: _____

17. During the last 3 months, because of problems with his/her asthma, how many times has [CHILD] been seen in the emergency room?

_____ Times **[IF 0, SKIP TO I]**

a. When were these visits? (what month/s) ***(Mark all that apply)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

b. Was there a specific identifiable cause of these asthma attack(s) that you are aware of?

☐ No
☐ Yes
☐ DK

i. If YES, specify: _____

I. Does [CHILD] have regularly scheduled or planned doctor visits for his/her asthma?

☐ No
☐ Yes → Ia. ***(If yes)*** How often does [CHILD] have regularly scheduled or planned doctor visits for his/her asthma?
☐ DK

☐ Monthly
☐ Quarterly
☐ Yearly

18. During the last 3 months, because of problems with asthma, how many times has [CHILD] been seen in the doctor's office or clinic for a sick visit?

_____ Times **[IF 0, SKIP TO 19]**

a. When were these visits? (what month/s) ***(For each visit reported, ask "Was that a visit related to asthma symptoms?" and only record if yes.)***

☐ January	☐ May	☐ September
☐ February	☐ June	☐ October
☐ March	☐ July	☐ November
☐ April	☐ August	☐ December

19. During the last 3 months, how many times has [CHILD] been given steroid pills or liquid, or a steroid shot (such as prednisone)?

_____ Times

20. During the last 3 months, has [CHILD] had: *(read and mark all that apply)*

If "Yes" to any of the following, after each ask:

a. During the last 3 months, how many times has [CHILD] had [Cold/Flu/Sinus Infection/Ear Infection/Pneumonia/Other]?

	Yes	**No**	**DK/ RF**	**Number of Instances**
Cold/ Flu (not stomach flu)				
Bronchitis				
Sinus Infection				
Ear Infection				
Pneumonia→Was it diagnosed by a doctor? ☐ No ☐ Yes ☐ DK/RF				
Any other respiratory infection:				

MEDICATION

"THIS NEXT SECTION IS ABOUT [CHILD]'S MEDICATION USE IN THE PAST 3 MONTHS. AGAIN, WE ARE REFERRING TO THE ENTIRE TIME PERIOD BETWEEN (MM/DD/YYYY) AND TODAY"

21. ***{DATA ENTRY STAFF - LEAVE THIS QUESTION BLANK}***

22. Please tell me (show me) all the medications [CHILD] is currently taking for asthma. ***(Record each medication in the table below, under Medication Name, then read each question below and record the answer for each medication in the table)***

    {DATA ENTRY STAFF – ALWAYS CODE YES FOR NEW MEDS}

    a. How often was [CHILD] directed by his/her doctor to take this medication? You can answer in times per day, as needed or prior to exercise.

    b. How many times per week does [CHILD] actually use this medication?

    c. For his/her rescue inhaler, how many puffs does he/she use at a time?

Medication Name	Prescribed frequency/ instruction (times/day, as needed, prior to exercise)	Typical Frequency (times/ week)	Puffs per time (# or NA)

23. ***(Only ask if they do not have an asthma action plan)*** During the <u>last 3 months</u>, has a doctor or other health care provider given a written plan for managing [CHILD's] asthma? This is also called an asthma action plan.

    ☐ No

    ☐ Yes

    ☐ DK/RF

HOME ENVIRONMENT

"THESE NEXT SET OF QUESTIONS ARE ABOUT THE HOME ENVIRONMENT"

24. During the last 3 months, has there been a large amount of mold (larger than a slice of bread) on any surfaces in the **bathrooms** inside your/this home?
    - ☐ No
    - ☐ Yes
    - ☐ DK/RF

25. During the last 3 months, has there been mold on any surfaces in **any other rooms** inside your/this home? (Do not include mold in the bathroom, or mold on food)
    - ☐ No
    - ☐ Yes
    - ☐ DK/RF

26. During the last 3 months, has there been any musty or moldy smell inside your/this home?
    - ☐ No
    - ☐ Yes
    - ☐ DK/RF

27. During the last 3 months, has there been any dampness, water damage or water leaks inside your/this home?
    - ☐ No
    - ☐ Yes
    - ☐ DK/RF

28. Does anyone who currently spends time with [CHILD] smoke around him/her either indoors or outdoors?
    - ☐ No **[SKIP TO 29]**
    - ☐ Yes
    - ☐ DK/RF **[SKIP TO 29]**

    a. How many days per week does this person smoke around [CHILD?

    _____ days/week

29. Do you still own [# (PET TYPE)] (*Ask for each pet on print out from STS)*?

Pet Type	#	Y	N

30. Do you have any new pets?

☐ No

☐ Yes

☐ DK/RF

a . If yes, ask the following questions:

a. Do you have?		**b. How many new ___ do you have?**	**c. Do your new _____spend time indoors?**	**d. Do your new _____sleep in [CHILD'S] bedroom regularly?**
Cats	No Yes		No Yes	No Yes
Dogs	No Yes		No Yes	No Yes
Rodents	No Yes		No Yes	No Yes
Birds	No Yes		No Yes	No Yes
Other (indoor pets): _____	No Yes		No Yes	No Yes

31. During the past <u>3 months,</u> has there been any wood smoke in your neighborhood due to wood burning?

☐ No

☐ Yes

☐ DK/RF

32. During the past <u>3 months,</u> has there been any unusual or specific events that may have affected [CHILD]'s asthma?

    ☐ No

    ☐ Yes

    ☐ DK/RF

    a. If yes, Specify: _____

33. How is your air cleaner/filtration system working? Please tell us about any problems or concerns you are/ have been having.

_____
_____
_____
_____
_____
_____

MINI PAEDIATRIC ASTHMA QUALITY OF LIFE QUESTIONNAIRE

PATIENT ID

SELF-ADMINISTERED

DATE

Please complete all questions by circling the number that best describes how you have been during the last week as a result of your asthma.

HOW BOTHERED HAVE YOU BEEN DURING THE LAST WEEK BY:

	Extremely Bothered	Very Bothered	Quite Bothered	Somewhat Bothered	Bothered A Bit	Hardly Bothered At All	Not Bothered
1. COUGHING	1	2	3	4	5	6	7
2. WHEEZING	1	2	3	4	5	6	7
3. TIGHTNESS IN YOUR CHEST	1	2	3	4	5	6	7

IN GENERAL, **HOW OFTEN** DURING THE LAST WEEK DID YOU:

	All of the Time	Most of the Time	Quite Often	Some of the Time	Once in a While	Hardly Any of the Time	None of the Time
4. Feel OUT OF BREATH because of your asthma?	1	2	3	4	5	6	7
5. Feel TIRED because of your asthma?	1	2	3	4	5	6	7
6. Have trouble SLEEPING AT NIGHT because of your asthma?	1	2	3	4	5	6	7
7. Feel FRUSTRATED because of your asthma?	1	2	3	4	5	6	7
8. Feel FRIGHTENED OR WORRIED because of your asthma?	1	2	3	4	5	6	7
9. Feel IRRITABLE (cranky/grouchy) because of your asthma?	1	2	3	4	5	6	7
10. Feel DIFFERENT OR LEFT OUT because of your asthma?	1	2	3	4	5	6	7

Updated on 07 March 2011

HOW **BOTHERED** HAVE YOU BEEN DURING THE LAST WEEK DOING:

	Extremely Bothered	Very Bothered	Quite Bothered	Somewhat Bothered	Bothered A Bit	Hardly Bothered At All	Not Bothered
11. PHYSICAL ACTIVITIES (such as running, swimming, sports, walking uphill/upstairs and bicycling)?	1	2	3	4	5	6	7
12. BEING WITH ANIMALS (such as playing with pets and looking after animals)?	1	2	3	4	5	6	7
13. ACTIVITIES WITH FRIENDS AND FAMILY (such as playing at recess and doing things with your friends and family)?	1	2	3	4	5	6	7

DOMAIN CODE:

Symptoms: 1, 2, 3, 4, 5, 6
Emotional Function: 7, 8, 9, 10
Activity Limitation: 11, 12, 13

Instructions for the Asthma Symptom Diary

Please help your child keep this asthma diary for one week. He/she should answer the questions each evening.

All questions should be answered at the end of each day.

Parents/Caregivers- Please help your child answer Questions 1-10. When you are helping your child fill out the diary, read each question and the possible answers to him/her. Circle his/her answer. We want to know how he/she feels about his/her asthma, so please do not answer these questions for him/her.

For Questions 1 and 2, circle either 'Yes' or 'No' under the current day.
For Questions 3, 4 and 5, circle the number that matches his/her choice under the current day.
For Questions 6, 7, and 8, circle either 'Yes' or 'No' under the current day.
For Question 8a, write the number of puffs you used from your rescue inhaler that day, under the current day.

Parents/ Caregivers-Please answer Questions 11-18 yourself. These questions are about your home environment.

For Question 11, circle either 'Open' or 'Closed' under the current day.
For Questions 12, 13, 14, 15, and 16, circle either 'Yes' or 'No' under the current day.
For Questions 17 and 18, write the number of hours your child spent in each location under the current day. Que. 17, record number of hours inside their home only & include sleep hrs. Que. 18, anywhere outdoors. (Question 17 & 18 does not need to add to 24hrs).

At the end of the one week (check one of the following):

____ we will pick up this card from your home. Date:_____

____ please mail this card back to us in the envelope we gave you. Date:_____

Please call us at _____ with any questions.

Date (month / day)							
Day (such as Mon, Tue, etc.)							
Asthma Symptoms: Parent/ Caregivers, please help your child fill this section out each day.							
1. Did you wake up during the night because of your asthma?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
2. Did you wake up and use a rescue inhaler or breathing machine/nebulizer after going to sleep?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
3. . How much do you feel you were bothered by your asthma today? 0 = Not at all 2 = Quite a bit 1 = A little bit 3 = A lot	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
4. Did you cough because of your asthma today? 0 = Not at all 2 = Quite a bit 1 = A little bit 3 = A lot	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
5. Did you wheeze because of your asthma today? 0 = Not at all 2 = Quite a bit 1 = A little bit 3 = A lot	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
6. Did you have to slow down or stop your play or activities because of your asthma today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
7. Did you miss school because of your asthma today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
8. Did you use your rescue inhaler today? Do <u>not</u> include use of the rescue inhaler prior to physical activities such as playing sports or exercising.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
a. If yes, how many puffs did you use? Write the number of puffs in the box.							
9. Did you use your controller (long-term) medication today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

Date (month / day)							
Day (such as Mon, Tue, etc.)							
10. Did you have a cold or cold symptoms today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
Health Care and Home: Parents/caregivers please fill this section out for your child.							
11. Was your child's bedroom door kept open or closed last night?	Open Closed	Open Closed	Open Closed	Open Closed	Open Closed	Open Closed	Open Closed
12. Did anyone smoke in your home today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
13. Was there frying or sautéing on a stove today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
14. Did you have a fire, use a wood burning stove, or burn candles or incense in your home today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
15. Did you use spray cleaning products or spray air freshener in your home today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
16. Were any windows in your home open for more than 2 hours today?	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
17. How many hours did your child spend indoors at home (include sleeping)?							
18. How many hours did your child spend anywhere outdoors today (best guess)?							
Additional Comments: If there is anything else you'd like to tell us about your child's asthma, please write your comments in the space provided.							

QUESTIONS ASSOCIATED WITH SPIROMETRY AND ENO

Questions for individuals completing spirometry

1. Has your child had a respiratory infection or a cold in last the 3 weeks?	☐ Yes	☐ No
2. Has your child used any medicines to help his/her breathing (inhaled bronchodilator), like aerosols, nasal sprays or a nebulizer, in last 3 hours?	☐ Yes	☐ No
3. Has your child smoked any type of tobacco product in last two hours? (only ask if 13 years or older)	☐ Yes	☐ No
4. Has your child done any hard physical exercise, like gymnastics, soccer, swimming, a long walk or jogging, in the last hour?	☐ Yes	☐ No

Questions for individuals completing eNO

1. Within the **last hour** have you smoked a cigarette, cigar, pipe, or used any other tobacco product? (only ask if 13 years or older)	☐ Yes	☐ No
2. Within the **last hour** has your child exercised strenuously?	☐ Yes	☐ No
3. Within the **last hour** has your child had anything to eat or drink?	☐ Yes	☐ No
4. Within the **last three hours** has your child eaten beets, broccoli, cabbage, celery, lettuce, spinach or radishes?	☐ Yes	☐ No
5. Within the **last three hours**, has your child eaten bacon, ham, hot dogs, or smoked fish?	☐ Yes	☐ No
6. Within the **last two days** has your child used any oral or inhaled steroids? This list provides some examples (show hand card).	☐ Yes	☐ No
7. In the **past 7 days**, has your child had cough, cold, phlegm, runny nose, or other respiratory illness? Do not count allergies or hay fever.	☐ Yes	☐ No

Details on Methods for Classifying Medicine

A summary variable was created to determine if the participant was taking asthma controller medication. The number of medicines and the frequency the child takes them are important factors. There are different types of medications with some medications containing two types of medicine. The total score is determined by summing the value of the score from each category below:

- Combined steroid/ bronchodilator controller, twice per day: These medications contain two medicines and are meant to be taken twice a day. If the child takes 10 or more doses per week (2x per day at least 5 days per week) they receive a score of 2, for adequate frequency of 2 medicines. If child takes 5-9 doses per week (most typically 1x per day, 7 days a week) they receive a score of 1, for a half dose of 2 medicines. If they take it less frequently they have a score of zero. Medicines included in the category include: Dulera, fluticasone in combination with salmeterol (Advair) and Symbicort.

- Combined steroid/bronchodilator controller, once a day: These medications contain two medicines and are meant to be taken once a day. If the child takes 5 or more doses per week (1x per day at least 5 days per week) they receive a score of 1. If they take it less frequently they have a score of zero. Medicines included in the category include Breo Ellipta.

- Other inhaled corticosteroid controllers: These medications contain one medicine and are usually meant to be taken twice a day. If the child takes 10 or more doses per week (2x per day at least 5 days per week) they receive a score of 1. If child takes 5-9 doses per week (most typically 1x per day, 7 days a week) they receive a score of 0.5, for a half dose of 1 medicine. If they take it less frequently they have a score of zero. Medicines included in the category include Azmacort, beclomethasone (QVAR), budesonide (Pulmicort), ciclesonide (Alvesco), Flovent, flunisolide (Aespan, Aerobid) and mometasone (Asmanex).

- Other asthma controller medications: The most common of these is montelukast. These are typically to be taken once per day. If the child takes 5 or more doses per week (1x per day at least 5 days per week) they receive a score of 1. If they take it less frequently they have a score of zero. Medicines included in the category include oral dexamethasone, montelukast (Singulair), prednisolone and Spiriva.

As many of the children also suffer from allergies, summary scores were also created for allergy medications. These were divided into two general categories, allergy steroids and antihistamines. For each category, we summed the number of medications and frequency.

- Allergy steroids: These medications contain one medicine and are meant to be taken twice a day. If the child takes 10 or more doses per week (2x per day at least 5 days per week) they receive a score of 1. If child takes 5-9 doses per week (most typically 1x per day, 7 days a week) they receive a score of 0.5, for a half dose of 1 medicine. If they take it less frequently they have a score of zero. Medicines included in the category include:

fluticasone propionate (Flonase, Dymista), fluticasone furuote (Veramyst), furoate (Naxonex), mometasone and Nasacort.

- Antihistaminess: These medications are typically intended to be taken once per day. If the child takes 5 or more doses per week (1x per day at least 5 days per week) they receive a score of 1. If they take it less frequently they have a score of zero. Medicines included in the category include: Brompheniramine (Q-Tapp), cetirizine (Zyrtec), diphenhydromanine (Benadryl, Diphedryl, Diphenist, Q-dryl), fexofenadine (Allegra), fumarate, hydroxyzine, ketotifen, levocetirizine (Xyzal), loratadine (Atadine, Claritin, Wal-itin), promethazine and Patanase.

Information on medications is summarized in Tables C.1-C.3, below

Table C.1: Specific Medications Included in Each Class of Medication

Class	**Typically taken**	**Control score**	**Medicines**
Controller medications			
Combined steroid/ bronchodilator controllers	2x per day	2	Dulera, fluticasone in combination with salmeterol (Advair) and Symbicort.
Inhaled corticosteroid controllers	2x per day	1	Azmacort, beclomethasone (QVAR), budesonide (Pulmicort), ciclesonide (Alvesco), Flovent, flunisolide (Aespan, Aerobid) and mometasone (Asmanex).
Combined steroid/bronchodilator controllers	1x per day	2	Breo Ellipta
Other asthma controller medications	1x per day	1	Oral dexamethasone, montelukast (Singulair), prednisolone and Spiriva.
Allergy Steroids			
Allergy steroids	2x per day	1	Fluticasone propionate (Flonase, Dymista), fluticasone furuote (Veramyst), furoate (Naxonex), mometasone and Nasacort.
Antihistamines			
Antihistamines	1x per day	1	Brompheniramine (Q-Tapp), cetirizine (Zyrtec), diphenhydromanine (Benadryl, Diphedryl, Diphenist, Q-dryl), fexofenadine (Allegra), fumarate, hydroxyzine, ketotifen, levocetirizine (Xyzal), loratadine (Atadine, Claritin, Wal-itin), promethazine and Patanase.

Table C.2: Weights Given for Typical Frequencies Taken for Medicines Typically Prescribed to be Taken 2 Times per Day

2x per day	
Typical frequency per week	Weight
≥10 (≥1.4285 per day)	1
>4 (>0.5714 per day)	0.5
>0	0
0 or "as needed"	0

Table C.3: Weights Given for Typical Frequencies Taken for Medicines Typically Prescribed to be Taken 1 Time per Day

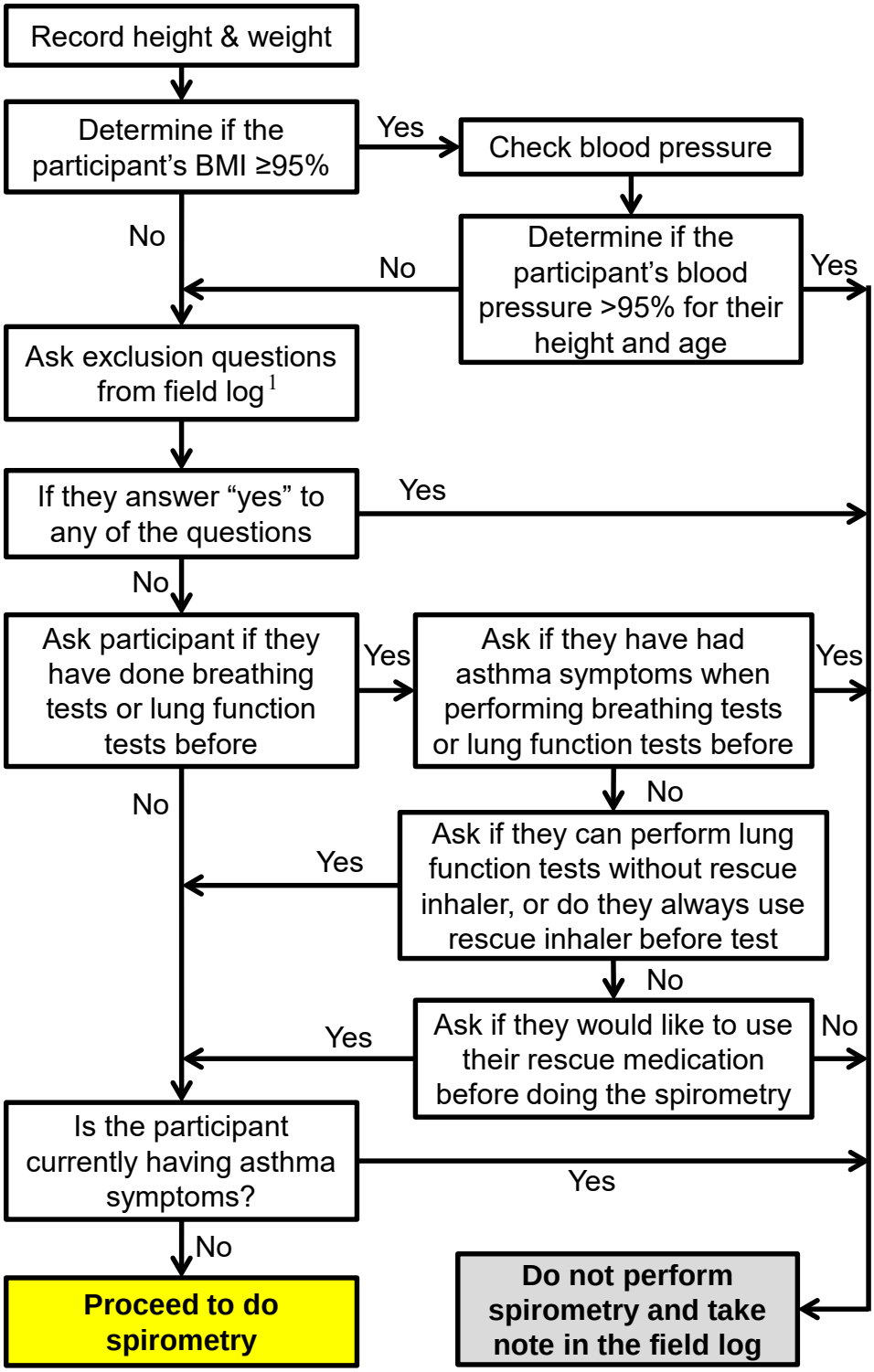
1x per day	
Typical frequency per week	Weight
≥5 (≥0.7142 per day)	1
>0	0
0 or "as needed"	0

Table C.4: Created Variables for Medication Section of Baseline Questionnaire Part 1 and Recall Questionnaire

Controller medication total score	Sum of (Control Score * Weight) of controller medications (Combined steroid/ bronchodilators, once and twice a day, inhaled cortisteroids and other asthma controller medications).
Allergy steroid total score	Sum of (Control Score * Weight) of allergy steroid medications
Antihistamine total score	Sum of (Control Score * Weight) of antihistamine medications

Initially, we had a list of medications the participant was taking at Baseline when we completed the 3-month phone recall. We marked changes on the sheet and recorded new medications being taken. The plan was to take the list of medicines at 3 months to the 6 month visit and so on. We found it more difficult than anticipated to get information on medicine using the list taken at Baseline. Additionally, it was difficult to generate the correct list of medicines being taken at 3 months. Therefore, we began collecting all medication information each time, rather than updating. Due to complications with data collected prior to the switch, all data on medications was checked by an investigator for this time period.

Decision Tree for Conducting Spirometry



[1] Exclusion criteria included chest injury, recent surgery on chest/lungs, or abdomen, retina or other eye surgery, hospitalization for heart problems, or treatment for tuberculosis.

Table C1. Baseline Recall Summary Statistics Tables

Baseline Q# (Recall Q#)		N	Missing N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Number of days in the last 14 days											
Q13 (Q1)	**Red/itchy, watery, irritated eyes**										
	Entire data set	191	0	4.2	4.3	0	1	3	6	12	14
	Primary Child	172	0	4.2	4.2	0	1	3	6	12	14
	Secondary Child	19	0	4.5	4.8	0	1	3	7	14	14
Q14 (Q2)	**Slow down or stop his/her play or activities due to wheezing or tightness in the chest, or cough**										
	Entire data set	191	0	3.4	4.4	0	0	2	5	10	14
	Primary Child	172	0	3.4	4.3	0	0	2	4	10	14
	Secondary Child	19	0	4.2	5.1	0	0	2	7	14	14
Q15 (Q3)	**Used inhaler for relief of asthma symptoms**										
	Entire data set	191	0	2.7	3.8	0	0	1	4	9	14
	Primary Child	172	0	2.8	3.9	0	0	1.5	4	9	14
	Secondary Child	19	0	1.2	2	0	0	0	2	5	6
Q15a (Q3a)	**Total puffs child uses each day** [1]										
	Entire data set	190	1	1.5	1.9	0	0	1.5	2	4	12
	Primary Child	171	1	1.6	1.9	0	0	2	2	4	12
	Secondary Child	19	0	0.6	0.9	0	0	0	2	2	2
	Created Variable: Total number of puffs used in the last 14 days: Q15*Q15a										
	Entire data set	190	1	7.9	14.4	0	0	2	10	20	98
	Primary Child	171	1	8.5	15	0	0	3	12	24	98
	Secondary Child	19	0	2.1	3.5	0	0	0	4	8	12
Q16 (Q4)	**Woke up due to wheezing or tightness in the chest, or cough**										
	Entire data set	191	0	2	3.4	0	0	0	2	5	14
	Primary Child	172	0	1.9	3.3	0	0	0	2	5	14
	Secondary Child	19	0	3.2	4.5	0	0	1	6	10	14
	Created Variable: Number of days of asthma symptoms: Max number of days from Q13, Q14, Q16										
	Entire data set	191	0	5.1	4.6	0	2	3	8	14	14
	Primary Child	172	0	5.1	4.6	0	2	3	8	14	14
	Secondary Child	19	0	5.2	5	0	1	4	10	14	14
Q16a (Q4a)	**Woke up and used a rescue inhaler or breathing machine/nebulizer after going to sleep?** [1]										
	Entire data set	190	1	1.1	2.5	0	0	0	1	4.5	14
	Primary Child	171	1	1.1	2.5	0	0	0	1	4	14
	Secondary Child	19	0	1.2	2.7	0	0	0	1	7	10
	Created Variable: Number of days used inhaler: Max number of days from Q15, Q16a										
	Entire data set	191	0	2.9	3.9	0	0	2	4	10	14
	Primary Child	172	0	3	4	0	0	2	4	10	14
	Secondary Child	19	0	1.8	3	0	0	0	3	7	10

Table C1, cont.

		N	Missing N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Q17a (Q5a)	**Times missed school [1]**										
	Entire data set	186	5	0.3	0.8	0	0	0	0	1	5
	Primary Child	168	4	0.3	0.8	0	0	0	0	1	5
	Secondary Child	18	1	0.4	0.7	0	0	0	1	2	2
	Created Variable: Proportion of days of missing school due to asthma: Q17a/Q17										
	Entire data set	186	5	0	0.1	0	0	0	0	0.2	1
	Primary Child	168	4	0	0.1	0	0	0	0	0.2	1
	Secondary Child	18	1	0.1	0.1	0	0	0	0.1	0.2	0.3
Q18 (Q6)	**Cold or a respiratory flu**										
	Entire data set	191	0	1.1	2.7	0	0	0	1	4	14
	Primary Child	172	0	1.1	2.7	0	0	0	0	4	14
	Secondary Child	19	0	1.4	2.4	0	0	0	2	7	7
Q19 (Q7)	**Runny/blocked nose**										
	Entire data set	191	0	4.2	4.8	0	0	2	7	14	14
	Primary Child	172	0	4	4.7	0	0	2	6.5	14	14
	Secondary Child	19	0	5.6	5	0	2	4	7	14	14
Q20 (Q8)	**Sneezing or an itchy nose**										
	Entire data set	191	0	4.6	5.4	0	0	2	7	14	14
	Primary Child	172	0	4.5	5.3	0	0	2	7	14	14
	Secondary Child	19	0	6	5.9	0	1	4	14	14	14
Q21 (Q9)	**Red/itchy, watery, irritated eyes**										
	Entire data set	189	2	3.6	4.8	0	0	2	5	14	14
	Primary Child	170	2	3.6	4.8	0	0	1.5	5	14	14
	Secondary Child	19	0	4.2	5.1	0	0	2	5	14	14
Q22 (Q10)	**Oral anti-histamines for allergies**										
	Entire data set	191	0	4.7	5.9	0	0	2	14	14	14
	Primary Child	172	0	4.4	5.7	0	0	1	8	14	14
	Secondary Child	19	0	7.5	6.6	0	0	7	14	14	14
Q23 (Q11)	**Prescription allergy eye drops**										
	Entire data set	191	0	0.2	1.2	0	0	0	0	0	14
	Primary Child	172	0	0.2	1.3	0	0	0	0	0	14
	Secondary Child	19	0	0	0	0	0	0	0	0	0
Q24 (Q12)	**Prescription allergy nose sprays**										
	Entire data set	191	0	2.8	5.1	0	0	0	3	14	14
	Primary Child	172	0	2.7	5	0	0	0	2.5	14	14
	Secondary Child	19	0	4.2	5.8	0	0	0	10	14	14

Table C1, cont.

		N	Missing N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Created variables describing fraction of children with cold, allergy symptoms and taking allergy medicine for Q21-24 can be found in Table C2.											
Q25 (Q14)	**Fraction of primary caregivers employed**										
	55% Employed, 43% Not employed										
Q25a (Q14a)	**Hours of missing work for primary caregiver [1]**										
	Entire data set	191	0	2.1	11.9	0	0	0	0	2	112
	Primary Child	172	0	1.4	9.2	0	0	0	0	0	112
	Secondary Child	19	0	7.6	25.5	0	0	0	5	12	112
Q26a (Q15a)	**Hours of missing work for secondary caregiver [1]**										
	Entire data set	190	1	0.2	1.6	0	0	0	0	0	16
	Primary Child	172	0	0.2	1.7	0	0	0	0	0	16
	Secondary Child	18	1	0	0	0	0	0	0	0	0
	Created Variable: The sum of the missing work hours for both primary and secondary caregivers										
	Entire data set	191	0	2.3	12.7	0	0	0	0	4	128
	Primary Child	172	0	1.7	10.4	0	0	0	0	1	128
	Secondary Child	19	0	7.6	25.5	0	0	0	5	12	112
In the last year											
Q27 (Q16)	**Times child has stayed overnight in the hospital**										
	Entire data set	191	0	0.3	1.2	0	0	0	0	0	12
	Primary Child	172	0	0.3	1.2	0	0	0	0	0	12
	Secondary Child	19	0	0.4	1	0	0	0	0	3	3
	Specified reasons: Respiratory infection (3), air quality, allergies, heat exposure, respiratory failure, carpet										
Q28 (Q17)	**Times child has been seen in the emergency room**										
	Entire data set	191	0	1.5	2.8	0	0	0	2	4	25
	Primary Child	172	0	1.5	2.8	0	0	0	2	4	25
	Secondary Child	19	0	1.6	2.5	0	0	1	2	5	10
	Specified reasons: Cold (13), weather (7), allergies (5), cough (5), respiratory infection (5), exercise (3), fires (2), croup (2), playing in the dirt, tumour removed from lungs, respiratory failure, vacuuming, rash/wheezing, dust air heat										
Q29 (Q19)	**Times child has been in the doctor's office or clinic**										
	Entire data set	189	2	4.8	6	1	2	3	6	10	53
	Primary Child	171	1	4.9	6.3	1	2	3	6	10	53
	Secondary Child	18	1	3.9	3.2	0	1	3	6	8	12
Q27 - Q29 season breakdowns of visits are included in a separate table											
	Created Variable: The total number of hospital, ER, and clinic visits: Sum Q27a, Q28a and Q29a										
	Entire data set	191	0	6.6	8	1	2	4	8	13	58
	Primary Child	172	0	6.7	8.3	1	2	4	8	13	58
	Secondary Child	19	0	5.7	5.3	1	1	4	8	13	21

Table C1, cont.

		N	Missing N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Q30 (Q19)	**Steroid pills/steroid shots**										
	Entire data set	191	7.2	45.4	0	0	1	2	4	365	0
	Primary Child	172	7.8	47.8	0	0	1	2	4	365	0
	Secondary Child	19	1.4	1.9	0	0	1	2	6	6	0
Q31 (Q20)	**Cold/Flu – Number of Instances**										
	Entire data set	184	7	3.3	3.1	1	2	3	4	6	24
	Primary Child	166	6	3.4	3.2	0	2	3	4	6	24
	Secondary Child	18	1	2.7	2.1	1	2	2	3	4	10
Q31 (Q20)	**Bronchitis – Number of Instances**										
	Entire data set	189	2	0.6	1.3	0	0	0	1	2	10
	Primary Child	170	2	0.6	1.3	0	0	0	1	2	10
	Secondary Child	19	0	0.7	1.3	0	0	0	1	4	4
Q31 (Q20)	**Sinus Infection – Number of Instances**										
	Entire data set	187	4	0.7	1.3	0	0	0	1	2	8
	Primary Child	169	3	0.7	1.2	0	0	0	1	2	7
	Secondary Child	18	1	1.6	1.9	0	0	1	2	3	8
Q31 (Q20)	**Ear infection – Number of Instances**										
	Entire data set	191	0	0.7	1.2	0	0	0	1	2	10
	Primary Child	172	0	0.7	1.2	0	0	0	1	2	10
	Secondary Child	19	0	0.9	1.3	0	0	0	1	3	4
Q31 (Q20)	**Pneumonia – Number of Instances** [2]										
	Entire data set	190	1	0.2	0.5	0	0	0	0	1	3
	Primary Child	171	1	0.2	0.5	0	0	0	0	1	3
	Secondary Child	19	0	0.3	0.7	0	0	0	0	2	2
Q31 (Q20)	**Other respiratory infection – Number of Instances**										
	Entire data set	188	3	0.1	0.2	0	0	0	0	0	1
	Primary Child	170	2	0.1	0.2	0	0	0	0	0	1
	Secondary Child	18	1	0.1	0.2	0	0	0	0	0	1
	Specified respiratory infections at baseline: Croup, laryngitis, scarlet fever, staph life, upper respiratory infection, whooping cough, tonsillitis										
	Created Variable: Number of times participant had respiratory diseases over one year: Set to 1 if yes to any Q31 choices.										
	Entire data set	180	11	5.5	4.8	1	3	4.5	7	11	36
	Primary Child	162	10	5.4	4.8	1	3	4	7	10	36
	Secondary Child	18	1	6.3	4	2	3	5	9	13	14
Q40a	**Tylenol/Acetaminophen per month** [1]										
	Entire data set	189	2	1.3	2.9	0	0	1	1	3	30.5
	Primary Child	170	2	1.4	3.1	0	0	1	1	3	30.5
	Secondary Child	19	0	1.2	1.5	0	0	1	1	4	6

Table C1, cont.

		N	Missing N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max
Q40a (Q12)	**Tylenol/acetaminophen in the last 14 days [1]**										
	Entire data set	190	1	0.6	1.4	0	0	0	1	2	12
	Primary Child	171	1	0.6	1.4	0	0	0	1	2	12
	Secondary Child	19	0	0.7	1	0	0	0	1	3	3
	Created Variable: Controller medication total score [3]										
	Entire data set	189	2	0.7	0.8	0	0	0.5	1	2	4
	Primary Child	171	1	0.7	0.8	0	0	0.5	1	2	4
	Secondary Child	18	1	0.7	0.7	0	0	0.8	1	2	2
	Created Variable: Allergy steroid total score										
	Entire data set	191	0	0.1	0.3	0	0	0	0	0.5	1
	Primary Child	172	0	0.1	0.3	0	0	0	0	0.5	1
	Secondary Child	19	0	0.1	0.3	0	0	0	0	0.5	1
	Created Variable: Antihistamine total score										
	Entire data set	191	0	0.3	0.5	0	0	0	0	1	3
	Primary Child	172	0	0.3	0.5	0	0	0	0	1	2
	Secondary Child	19	0	0.4	0.8	0	0	0	1	1	3

1 "No" responses to the previous conditional questions are recorded as 0

2 Of those who were diagnosed with pneumonia, 57% responded "yes" to it being diagnosed by a doctor, 5% responded "No" and 38% did not have a response

3 Controller total between 1 and 0.5 because the median was between 1 and 0.5

Table C2. Whether Participants Had a Cold or Flu, Allergy Symptoms, or Took Allergy Medication at Baseline.

	Entire Data Set		Primary Children		Secondary Children	
	(n)	(%)	(n)	(%)	(n)	(%)
Created Variable: Had cold or the flu: Q18>0						
No	142	74%	130	76%	12	63%
Yes	49	26%	42	24%	7	37%
Created Variable: Allergy symptoms: Sum of (Q19,Q20,Q21)>0						
No	32	17%	31	18%	1	5%
Yes	159	83%	141	82%	18	95%
Created Variable: Took allergy medicine: Sum of (Q22,Q23,Q24)>0						
No	73	38%	68	40%	5	26%
Yes	118	62%	104	60%	14	74%

Table C3. Recall Data During Study Summary Statistics Tables

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Number of days in the last 14 days											
Q1	**Wheezing, tightness in the chest, or cough**										
	Entire data set - SHAM	622	2.4	3.6	0	0	1	3	7	14	0
	Entire data set - TRUE	661	3.1	3.9	0	0	2	4	8	14	0
	Primary Child - SHAM	566	2.5	3.7	0	0	1	3	7	14	0
	Primary Child - TRUE	604	3.1	4	0	0	2	4	8	14	0
	Secondary Child - SHAM	56	2	3.1	0	0	0	3	7	14	0
	Secondary Child - TRUE	57	2.8	3.4	0	0	2	5	7	14	0
Q2	**Slow down or stop his/her play or activities due to wheezing or tightness in the chest, or cough**										
	Entire data set - SHAM	621	1.7	3.1	0	0	0	2	5	14	1
	Entire data set - TRUE	661	1.9	3.2	0	0	0	2	6	14	0
	Primary Child - SHAM	565	1.7	3.1	0	0	0	2	5	14	1
	Primary Child - TRUE	604	1.9	3.2	0	0	0	2	6	14	0
	Secondary Child - SHAM	56	1.5	2.9	0	0	0	2	6	14	0
	Secondary Child - TRUE	57	1.8	2.9	0	0	0	3	6	14	0
Q3	**Used inhaler for relief of asthma symptoms**										
	Entire data set - SHAM	622	1.8	3.4	0	0	0	2	6	14	0
	Entire data set - TRUE	661	2.1	3.6	0	0	0	3	7	14	0
	Primary Child - SHAM	566	1.7	3.3	0	0	0	2	6	14	0
	Primary Child - TRUE	604	2.1	3.5	0	0	0	3	7	14	0
	Secondary Child - SHAM	56	2.1	3.8	0	0	0	2	8	14	0
	Secondary Child - TRUE	57	2.5	4.4	0	0	0	2	14	14	0
Q3a	**Total puffs child uses each day** [1]										
	Entire data set - SHAM	616	1.1	2.1	0	0	0	2	4	24	6
	Entire data set - TRUE	648	1.4	2.2	0	0	0	2	4	24	13
	Primary Child - SHAM	561	1.1	2.1	0	0	0	2	4	24	5
	Primary Child - TRUE	591	1.4	2.2	0	0	0	2	4	24	13
	Secondary Child - SHAM	55	1.1	1.7	0	0	0	2	4	6	1
	Secondary Child - TRUE	57	1.3	1.8	0	0	0	2	4	6	0
	Created Variable: Total number of puffs used in the last 14 days: Q15*Q15a										
	Entire data set - SHAM	616	5.9	17.8	0	0	0	4	18	336	6
	Entire data set - TRUE	648	7.1	15.9	0	0	0	6	20	120	13
	Primary Child - SHAM	561	5.8	18.1	0	0	0	4	16	336	5
	Primary Child - TRUE	591	7	15.9	0	0	0	6	20	120	13
	Secondary Child - SHAM	55	7.2	14.7	0	0	0	8	32	56	1
	Secondary Child - TRUE	57	8.7	16.7	0	0	0	8	42	56	0

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Q4	**Woke up due to wheezing or tightness in the chest, or cough**										
	Entire data set - SHAM	621	0.9	2.4	0	0	0	0	3	14	1
	Entire data set - TRUE	661	1.1	2.4	0	0	0	1	3	14	0
	Primary Child - SHAM	565	0.9	2.5	0	0	0	0	3	14	1
	Primary Child - TRUE	604	1.1	2.5	0	0	0	1	3	14	0
	Secondary Child - SHAM	56	0.9	2	0	0	0	0	5	8	0
	Secondary Child - TRUE	57	1	2.2	0	0	0	1	5	10	0
	Created Variable: Number of days of asthma symptoms: Max number of days from Q13, Q14, Q16										
	Entire data set - SHAM	622	2.8	3.9	0	0	1	4	8	14	0
	Entire data set - TRUE	661	3.4	4.1	0	0	2	5	10	14	0
	Primary Child - SHAM	566	2.9	3.9	0	0	1	4	10	14	0
	Primary Child - TRUE	604	3.5	4.1	0	0	2	5	10	14	0
	Secondary Child - SHAM	56	2.2	3.1	0	0	1	3	7	14	0
	Secondary Child - TRUE	57	3	3.5	0	0	2	5	7	14	0
Q4a	**Woke up and used a rescue inhaler or breathing machine/nebulizer after going to sleep? [1]**										
	Entire data set - SHAM	618	0.4	1.6	0	0	0	0	1	14	4
	Entire data set - TRUE	660	0.7	2	0	0	0	0	2	14	1
	Primary Child - SHAM	562	0.4	1.6	0	0	0	0	1	14	4
	Primary Child - TRUE	603	0.7	2	0	0	0	0	2	14	1
	Secondary Child - SHAM	56	0.7	1.6	0	0	0	0	4	6	0
	Secondary Child - TRUE	57	0.7	2	0	0	0	0	3	10	0
	Created Variable: Number of days used inhaler: Max number of days from Q15, Q16a										
	Entire data set - SHAM	622	1.8	3.4	0	0	0	2	7	14	0
	Entire data set - TRUE	661	2.2	3.6	0	0	0	3	7	14	0
	Primary Child - SHAM	566	1.8	3.4	0	0	0	2	6	14	0
	Primary Child - TRUE	604	2.2	3.5	0	0	0	3	7	14	0
	Secondary Child - SHAM	56	2.1	3.8	0	0	0	2	8	14	0
	Secondary Child - TRUE	57	2.5	4.4	0	0	0	2	14	14	0
Q5a	**Times missed school [1]**										
	Entire data set - SHAM	622	0.2	0.7	0	0	0	0	0	9	0
	Entire data set - TRUE	661	0.2	0.9	0	0	0	0	1	10	0
	Primary Child - SHAM	566	0.2	0.7	0	0	0	0	0	9	0
	Primary Child - TRUE	604	0.2	0.9	0	0	0	0	1	10	0
	Secondary Child - SHAM	56	0.3	0.9	0	0	0	0	2	4	0
	Secondary Child - TRUE	57	0.3	0.8	0	0	0	0	1	5	0

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
	Created Variable: Proportion of days of missing school due to asthma: Q4a/Q5a [1]										
	Entire data set - SHAM	622	0	0.1	0	0	0	0	0	1	0
	Entire data set - TRUE	661	0	0.2	0	0	0	0	0.1	5	0
	Primary Child - SHAM	566	0	0.1	0	0	0	0	0	1	0
	Primary Child - TRUE	604	0	0.3	0	0	0	0	0.1	5	0
	Secondary Child - SHAM	56	0	0.1	0	0	0	0	0.2	0.6	0
	Secondary Child - TRUE	57	0	0.1	0	0	0	0	0.2	0.5	0
Q6	**Cold or a respiratory flu**										
	Entire data set - SHAM	621	1.1	2.4	0	0	0	1	4	14	1
	Entire data set - TRUE	661	1.3	2.7	0	0	0	1	5	14	0
	Primary Child - SHAM	565	1.1	2.5	0	0	0	0	4	14	1
	Primary Child - TRUE	604	1.3	2.7	0	0	0	1	5	14	0
	Secondary Child - SHAM	56	1.1	1.9	0	0	0	2	4	7	0
	Secondary Child - TRUE	57	1.2	2.3	0	0	0	1	7	7	0
Q7	**Runny/blocked nose**										
	Entire data set - SHAM	622	3.2	4.5	0	0	1	5	14	14	0
	Entire data set - TRUE	661	3.5	4.5	0	0	2	5	14	14	0
	Primary Child - SHAM	566	3.2	4.5	0	0	1	5	14	14	0
	Primary Child - TRUE	604	3.4	4.5	0	0	2	5	14	14	0
	Secondary Child - SHAM	56	3.4	4.5	0	0	0.5	6.5	10	14	0
	Secondary Child - TRUE	57	4.1	4.3	0	0	3	7	10	14	0
Q8	**Sneezing or an itchy nose**										
	Entire data set - SHAM	622	3.5	4.7	0	0	1	5	14	14	0
	Entire data set - TRUE	661	3.9	4.8	0	0	2	6	14	14	0
	Primary Child - SHAM	566	3.5	4.6	0	0	1	5	14	14	0
	Primary Child - TRUE	604	3.9	4.8	0	0	2	6	14	14	0
	Secondary Child - SHAM	56	3.4	5	0	0	0	5	14	14	0
	Secondary Child - TRUE	57	3.4	4.7	0	0	2	4	14	14	0
Q9	**Red/itchy, watery, irritated eyes**										
	Entire data set - SHAM	622	2.2	3.9	0	0	0	3	7	14	0
	Entire data set - TRUE	660	2.4	3.8	0	0	0	3	8	14	1
	Primary Child - SHAM	566	2.1	3.7	0	0	0	3	7	14	0
	Primary Child - TRUE	603	2.4	3.8	0	0	0	3	8	14	1
	Secondary Child - SHAM	56	3.4	4.9	0	0	0	5.5	14	14	0
	Secondary Child - TRUE	57	2.5	3.9	0	0	0	4	8	14	0

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Q10	**Oral anti-histamines for allergies**										
	Entire data set - SHAM	621	4.7	5.9	0	0	1	13	14	14	1
	Entire data set - TRUE	661	4.6	5.8	0	0	1	12	14	14	0
	Primary Child - SHAM	565	4.6	5.8	0	0	1	10	14	14	1
	Primary Child - TRUE	604	4.4	5.7	0	0	1	10	14	14	0
	Secondary Child - SHAM	56	6.2	6.3	0	0	3.5	14	14	14	0
	Secondary Child - TRUE	57	6.4	6.7	0	0	3	14	14	14	0
Q11	**Prescription allergy eye drops**										
	Entire data set - SHAM	622	0.2	1.4	0	0	0	0	0	14	0
	Entire data set - TRUE	661	0.1	1	0	0	0	0	0	14	0
	Primary Child - SHAM	566	0.2	1.5	0	0	0	0	0	14	0
	Primary Child - TRUE	604	0.1	1.1	0	0	0	0	0	14	0
	Secondary Child - SHAM	56	0	0	0	0	0	0	0	0	0
	Secondary Child - TRUE	57	0.1	0.6	0	0	0	0	0	4	0
Q12	**Prescription allergy nose sprays**										
	Entire data set - SHAM	622	2.8	5.2	0	0	0	2	14	14	0
	Entire data set - TRUE	661	2.9	5.2	0	0	0	3	14	14	0
	Primary Child - SHAM	566	2.7	5.1	0	0	0	2	14	14	0
	Primary Child - TRUE	604	2.7	5.1	0	0	0	2	14	14	0
	Secondary Child - SHAM	56	4.5	5.9	0	0	0	10	14	14	0
	Secondary Child - TRUE	57	4.6	6.1	0	0	0	14	14	14	0
Q13	**Tylenol/acetaminophen**										
	Entire data set - SHAM	619	1.1	2.1	0	0	0	2	3	14	3
	Entire data set - TRUE	660	1	2	0	0	0	1	3	14	1
	Primary Child - SHAM	564	1.1	2.1	0	0	0	1	3	14	2
	Primary Child - TRUE	603	1.1	2	0	0	0	1	3	14	1
	Secondary Child - SHAM	55	0.9	1.5	0	0	0	2	3	7	1
	Secondary Child - TRUE	57	0.9	1.3	0	0	0	1	3	5	0
Created variables describing fraction of children with cold, allergy symptoms and taking allergy medicine for Q9-Q12 can be found in a separate table											
Q14	**Fraction of primary caregivers employed**										
	63% Employed, 37% Not employed										
Q14a	**Hours of missing work for primary caregiver** [1]										
	Entire data set - SHAM	620	0.7	4.7	0	0	0	0	0	80	2
	Entire data set - TRUE	659	0.8	3.6	0	0	0	0	0	48	2
	Primary Child - SHAM	564	0.7	4.8	0	0	0	0	0	80	2
	Primary Child - TRUE	603	0.8	3.6	0	0	0	0	0	48	1
	Secondary Child - SHAM	56	1	4.1	0	0	0	0	0	24	0
	Secondary Child - TRUE	56	1.4	4.4	0	0	0	0	6	24	1

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Q15a	**Hours of missing work for secondary caregiver [1]**										
	Entire data set - SHAM	618	0.1	0.8	0	0	0	0	0	16	4
	Entire data set - TRUE	658	0.2	1.5	0	0	0	0	0	24	3
	Primary Child - SHAM	564	0.1	0.9	0	0	0	0	0	16	2
	Primary Child - TRUE	603	0.2	1.2	0	0	0	0	0	16	1
	Secondary Child - SHAM	54	0	0	0	0	0	0	0	0	2
	Secondary Child - TRUE	55	0.4	3.2	0	0	0	0	0	24	2
	Created Variable: The sum of the missing work hours for both primary and secondary caregivers										
	Entire data set - SHAM	622	0.8	4.8	0	0	0	0	0	80	0
	Entire data set - TRUE	660	1	4	0	0	0	0	0	48	1
	Primary Child - SHAM	566	0.8	4.9	0	0	0	0	0	80	0
	Primary Child - TRUE	604	0.9	3.9	0	0	0	0	0	48	0
	Secondary Child - SHAM	56	1	4.1	0	0	0	0	0	24	0
	Secondary Child - TRUE	56	1.8	5.3	0	0	0	0	8	24	1
In the last year											
Q16	**Times child has stayed overnight in the hospital**										
	Entire data set - SHAM	622	0	0.2	0	0	0	0	0	3	0
	Entire data set - TRUE	661	0.1	0.4	0	0	0	0	0	7	0
	Primary Child - SHAM	566	0	0.2	0	0	0	0	0	3	0
	Primary Child - TRUE	604	0.1	0.4	0	0	0	0	0	7	0
	Secondary Child - SHAM	56	0	0.1	0	0	0	0	0	1	0
	Secondary Child - TRUE	57	0	0	0	0	0	0	0	0	0
	Specified reasons: Bronchitis (3), pollen (2), cold, ear infection, asthma attack, coughing, fires, rhino virus, fever, asthma exacerbation										
Q17	**Times child has been seen in the emergency room**										
	Entire data set - SHAM	621	0.1	0.5	0	0	0	0	0	5	1
	Entire data set - TRUE	660	0.1	0.4	0	0	0	0	0	3	1
	Primary Child - SHAM	565	0.1	0.5	0	0	0	0	0	5	1
	Primary Child - TRUE	603	0.1	0.4	0	0	0	0	0	3	1
	Secondary Child - SHAM	56	0.1	0.5	0	0	0	0	0	3	0
	Secondary Child - TRUE	57	0.2	0.5	0	0	0	0	1	2	0
	Specified reasons: Bronchitis (7), cold (6), fires (3), flu (3), virus (3), coughing (3), out of control asthma (3), weather change (3), weather (2), air quality (2), temperature, fever, throat infection, pheumonia, respiratory infection, infection, dogs or cats, rain, allergies, , no medication, albuterol not effective, side effects of medicine, air ways closing so gave epi pen, pollen, weeds, wind, asthma attack, ears inflamed, chronic sinusitus, environmental trigger, smoke										

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Q18	**Times child has been in the doctor's office or clinic**										
	Entire data set - SHAM	621	0.6	1.3	0	0	0	1	2	12	1
	Entire data set - TRUE	660	0.7	1.3	0	0	0	1	2	12	1
	Primary Child - SHAM	565	0.6	1.3	0	0	0	1	2	12	1
	Primary Child - TRUE	603	0.7	1.3	0	0	0	1	2	12	1
	Secondary Child - SHAM	56	0.6	1.1	0	0	0	1	2	6	0
	Secondary Child - TRUE	57	0.7	1	0	0	0	1	2	5	0
Q16 - Q18 season breakdowns of visits are included in a separate table											
	Created Variable: The total number of hospital, ER, and clinic visits: Sum Q16a, Q17a and Q19a										
	Entire data set - SHAM	622	0.7	1.6	0	0	0	1	2	16	0
	Entire data set - TRUE	661	0.8	1.6	0	0	0	1	3	16	0
	Primary Child - SHAM	566	0.7	1.6	0	0	0	1	2	16	0
	Primary Child - TRUE	604	0.8	1.7	0	0	0	1	3	16	0
	Secondary Child - SHAM	56	0.7	1.6	0	0	0	1	2	9	0
	Secondary Child - TRUE	57	0.8	1.1	0	0	0	1	2	6	0
Q19	**Steroid pills/steroid shots**										
	Entire data set - SHAM	622	0.7	5.5	0	0	0	0	1	91	0
	Entire data set - TRUE	661	0.8	6	0	0	0	0	1	90	0
	Primary Child - SHAM	566	0.7	5.8	0	0	0	0	1	91	0
	Primary Child - TRUE	604	0.9	6.3	0	0	0	0	1	90	0
	Secondary Child - SHAM	56	0.3	1.1	0	0	0	0	1	7	0
	Secondary Child - TRUE	57	0.2	0.5	0	0	0	0	1	2	0
Q20	**Cold/Flu – Number of Instances**										
	Entire data set - SHAM	616	0.7	0.9	0	0	1	1	2	8	6
	Entire data set - TRUE	656	0.8	1	0	0	1	1	2	10	5
	Primary Child - SHAM	561	0.7	0.9	0	0	1	1	2	8	5
	Primary Child - TRUE	599	0.8	1	0	0	1	1	2	10	5
	Secondary Child - SHAM	55	0.6	0.7	0	0	1	1	1	2	1
	Secondary Child - TRUE	57	0.7	0.8	0	0	0	1	2	3	0
Q20	**Bronchitis – Number of Instances**										
	Entire data set - SHAM	619	0.1	0.2	0	0	0	0	0	2	3
	Entire data set - TRUE	658	0.1	0.3	0	0	0	0	0	3	3
	Primary Child - SHAM	563	0.1	0.3	0	0	0	0	0	2	3
	Primary Child - TRUE	602	0.1	0.3	0	0	0	0	0	3	2
	Secondary Child - SHAM	56	0	0.2	0	0	0	0	0	1	0
	Secondary Child - TRUE	56	0	0.3	0	0	0	0	0	2	1

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
Q20	**Sinus Infection – Number of Instances**										
	Entire data set - SHAM	618	0.2	1	0	0	0	0	1	13	4
	Entire data set - TRUE	658	0.2	0.5	0	0	0	0	1	6	3
	Primary Child - SHAM	562	0.2	1	0	0	0	0	1	13	4
	Primary Child - TRUE	602	0.2	0.6	0	0	0	0	1	6	2
	Secondary Child - SHAM	56	0.1	0.3	0	0	0	0	1	1	0
	Secondary Child - TRUE	56	0.1	0.3	0	0	0	0	0	2	1
Q20	**Ear infection – Number of Instances**										
	Entire data set - SHAM	618	0.1	0.4	0	0	0	0	0	4	4
	Entire data set - TRUE	656	0.1	0.4	0	0	0	0	1	5	5
	Primary Child - SHAM	562	0.1	0.4	0	0	0	0	0	4	4
	Primary Child - TRUE	600	0.1	0.4	0	0	0	0	0	5	4
	Secondary Child - SHAM	56	0.1	0.2	0	0	0	0	0	1	0
	Secondary Child - TRUE	56	0.2	0.4	0	0	0	0	1	1	1
Q20	**Pneumonia – Number of Instances [2]**										
	Entire data set - SHAM	617	0	0.1	0	0	0	0	0	2	5
	Entire data set - TRUE	660	0	0.1	0	0	0	0	0	2	1
	Primary Child - SHAM	561	0	0.1	0	0	0	0	0	2	5
	Primary Child - TRUE	603	0	0.1	0	0	0	0	0	2	1
	Secondary Child - SHAM	56	0	0	0	0	0	0	0	0	0
	Secondary Child - TRUE	57	0	0.1	0	0	0	0	0	1	0
Q20	**Other respiratory infection – Number of Instances**										
	Entire data set - SHAM	616	0	0.2	0	0	0	0	0	3	6
	Entire data set - TRUE	656	0.1	0.7	0	0	0	0	0	13	5
	Primary Child - SHAM	560	0	0.2	0	0	0	0	0	3	6
	Primary Child - TRUE	600	0.1	0.8	0	0	0	0	0	13	4
	Secondary Child - SHAM	56	0	0.3	0	0	0	0	0	2	0
	Secondary Child - TRUE	56	0.1	0.5	0	0	0	0	0	3	1
	Specified respiratory infections: Respiratory infection (5), unknown/don't know/unclear (4), strep throat (3), throat infection (2), coughing (2), stomach infection, lung infection, sinus infection, congested chest, congestion drainage, drainage in throat, croup										
	Created Variable: Number of times participant had respiratory diseases over one year: Set to 1 if yes to any Q20 choices.										
	Entire data set - SHAM	612	1.2	4.1	0	0	1	1	2	93	10
	Entire data set - TRUE	649	1.4	3.9	0	0	1	2	3	92	12
	Primary Child - SHAM	557	1.2	4.2	0	0	1	1	2	93	9
	Primary Child - TRUE	593	1.4	4.1	0	0	1	2	3	92	11
	Secondary Child - SHAM	55	0.9	1	0	0	1	1	2	4	1
	Secondary Child - TRUE	56	1.1	1.2	0	0	1	2	3	4	1

Table C3, cont.

		N	Mean	Std Dev	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Max	Missing N
	Created Variable: Controller medication total score [3]										
	Entire data set - SHAM	618	0.6	0.8	0	0	0	1	2	5	4
	Entire data set - TRUE	660	0.7	0.9	0	0	0.5	1	2	5	1
	Primary Child - SHAM	563	0.6	0.8	0	0	0	1	2	5	3
	Primary Child - TRUE	604	0.7	0.9	0	0	0.5	1	2	5	0
	Secondary Child - SHAM	55	0.4	0.6	0	0	0	1	1	3	1
	Secondary Child - TRUE	56	0.6	0.6	0	0	0.5	1	1	2	1
	Created Variable: Allergy steroid total score										
	Entire data set - SHAM	619	0.1	0.3	0	0	0	0	0.5	1	3
	Entire data set - TRUE	661	0.1	0.3	0	0	0	0	0.5	1	0
	Primary Child - SHAM	564	0.1	0.2	0	0	0	0	0.5	1	2
	Primary Child - TRUE	604	0.1	0.2	0	0	0	0	0.5	1	0
	Secondary Child - SHAM	55	0.2	0.3	0	0	0	0.5	0.5	1	1
	Secondary Child - TRUE	57	0.2	0.3	0	0	0	0.5	0.5	1	0
	Created Variable: Antihistamine total score										
	Entire data set - SHAM	619	0.2	0.5	0	0	0	0	1	3	3
	Entire data set - TRUE	661	0.2	0.5	0	0	0	0	1	4	0
	Primary Child - SHAM	564	0.2	0.5	0	0	0	0	1	3	2
	Primary Child - TRUE	604	0.2	0.4	0	0	0	0	1	3	0
	Secondary Child - SHAM	55	0.5	0.7	0	0	0	1	1	3	1
	Secondary Child - TRUE	57	0.5	0.7	0	0	0	1	1	4	0

1 “No” responses to the previous conditional questions are recorded as 0

2 Of those who were diagnosed with pneumonia, 57% responded “yes” to it being diagnosed by a doctor, 5% responded “No” and 38% did not have a response

3 Controller total between 1 and 0.5 because the median was between 1 and 0.5

Table C4. Whether Participants Had a Cold or Flu, Allergy Symptoms, or Took Allergy Medication During Study.

	Entire Data Set		Primary Children		Secondary Children	
	(n)	(%)	(n)	(%)	(n)	(%)
Created Variable: Had cold or the flu: Q6>0						
No - SHAM	462	74%	424	75%	38	68%
No - TRUE	472	71%	430	71%	42	74%
Yes - SHAM	159	26%	141	25%	18	32%
Yes - TRUE	189	29%	174	29%	15	26%
Missing - SHAM	1	0%	1	0%	0	0%
Created Variable: Allergy Symptoms: Sum of (Q7,Q8,Q9)>0						
No - SHAM	174	28%	154	27%	20	36%
No - TRUE	140	21%	130	22%	10	18%
Yes - SHAM	448	72%	412	73%	36	64%
Yes - TRUE	521	79%	474	78%	47	82%
Created Variable: Took allergy medicine: Sum of (Q10,Q11,Q12)>0						
No - SHAM	252	41%	235	42%	17	30%
No - TRUE	266	40%	246	41%	20	35%
Yes - SHAM	370	59%	331	58%	39	70%
Yes - TRUE	395	60%	358	59%	37	65%

Table C5. Mini PAQL Summary Statistics Table

		N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Missing N
How bothered have you been during the last week by:											
Q1	**Coughing**										
	Entire data set - Baseline	185	4.9	1.9	1	2	4	5	6	7	0
	Entire data set - SHAM	562	5.7	1.5	1	3	5	6	7	7	0
	Entire data set - TRUE	589	5.6	1.6	1	3	5	6	7	7	4
	Primary Child - Baseline	167	4.9	1.8	1	2	4	5	6	7	0
	Primary Child - SHAM	512	5.7	1.5	1	3	5	6	7	7	0
	Primary Child - TRUE	541	5.6	1.6	1	3	5	6	7	7	3
	Secondary Child - Baseline	18	4.7	2.2	1	1	4	5	7	7	0
	Secondary Child - SHAM	50	5.4	1.7	1	3	4	6	7	7	0
	Secondary Child - TRUE	48	5.4	1.7	1	3	5	6	7	7	1
Q2	**Wheezing**										
	Entire data set - Baseline	185	5.5	1.8	1	3	4	6	7	7	0
	Entire data set - SHAM	559	6.2	1.3	1	4	6	7	7	7	3
	Entire data set - TRUE	584	6.1	1.4	1	4	6	7	7	7	9
	Primary Child - Baseline	167	5.5	1.8	1	3	4	6	7	7	0
	Primary Child - SHAM	509	6.2	1.3	1	4	6	7	7	7	3
	Primary Child - TRUE	538	6.1	1.4	1	4	6	7	7	7	6
	Secondary Child - Baseline	18	5.9	1.5	2	4	5	6.5	7	7	0
	Secondary Child - SHAM	50	6.1	1.5	1	4	5	7	7	7	0
	Secondary Child - TRUE	46	6	1.6	2	4	5	7	7	7	3
Q3	**Tightness in your chest**										
	Entire data set - Baseline	185	5.7	1.7	1	3	5	7	7	7	0
	Entire data set - SHAM	557	6.1	1.5	1	4	6	7	7	7	5
	Entire data set - TRUE	583	6	1.5	1	4	5	7	7	7	10
	Primary Child - Baseline	167	5.7	1.7	1	3	5	7	7	7	0
	Primary Child - SHAM	507	6.1	1.5	1	4	6	7	7	7	5
	Primary Child - TRUE	537	6	1.5	1	4	5	7	7	7	7
	Secondary Child - Baseline	18	5.7	1.9	1	2	4	7	7	7	0
	Secondary Child - SHAM	50	5.8	1.6	2	3	4	7	7	7	0
	Secondary Child - TRUE	46	6.1	1.5	1	4	6	7	7	7	3

Table C5, cont.

		N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Missing N
In general (because of asthma), how often during the last week did you:											
Q4	**Feel out of breath**										
	Entire data set - Baseline	184	4.9	1.8	1	2	4	5	7	7	1
	Entire data set - SHAM	562	5.7	1.5	1	4	5	6	7	7	0
	Entire data set - TRUE	591	5.6	1.6	1	3	5	6	7	7	2
	Primary Child - Baseline	166	5	1.8	1	2	4	5	7	7	1
	Primary Child - SHAM	512	5.8	1.5	1	4	5	6	7	7	0
	Primary Child - TRUE	543	5.6	1.6	1	3	5	6	7	7	1
	Secondary Child - Baseline	18	4.8	2	1	1	3	5	7	7	0
	Secondary Child - SHAM	50	5.4	1.7	1	3.5	4	6	7	7	0
	Secondary Child - TRUE	48	5.5	1.7	1	3	4.5	6	7	7	1
Q5	**Tired**										
	Entire data set - Baseline	184	5.2	1.9	1	2	4	6	7	7	1
	Entire data set - SHAM	562	6	1.4	1	4	5	7	7	7	0
	Entire data set - TRUE	591	5.9	1.5	1	4	5	7	7	7	2
	Primary Child - Baseline	166	5.2	1.9	1	2	4	6	7	7	1
	Primary Child - SHAM	512	6	1.4	1	4	5	7	7	7	0
	Primary Child - TRUE	543	5.9	1.5	1	4	5	7	7	7	1
	Secondary Child - Baseline	18	5.1	2.2	1	1	3	6	7	7	0
	Secondary Child - SHAM	50	5.8	1.5	2	4	5	6	7	7	0
	Secondary Child - TRUE	48	5.9	1.7	1	4	5	7	7	7	1
Q6	**Trouble sleeping**										
	Entire data set - Baseline	182	5.4	1.9	1	2	4	6	7	7	3
	Entire data set - SHAM	562	6.1	1.5	1	4	6	7	7	7	0
	Entire data set - TRUE	590	6.1	1.6	1	4	6	7	7	7	3
	Primary Child - Baseline	164	5.4	1.9	1	2	4	6	7	7	3
	Primary Child - SHAM	512	6.2	1.4	1	4	6	7	7	7	0
	Primary Child - TRUE	542	6.1	1.5	1	4	6	7	7	7	2
	Secondary Child - Baseline	18	5.3	1.9	2	2	3	6	7	7	0
	Secondary Child - SHAM	50	6	1.6	1	3.5	6	7	7	7	0
	Secondary Child - TRUE	48	6	1.7	1	3	5	7	7	7	1
	Sum of symptom responses: sum Q1-Q6										
	Entire data set - Baseline	182	31.6	8.2	6	20	26	34	38	41	3
	Entire data set - SHAM	557	35.8	6.9	9	26	33	38	41	42	5
	Entire data set - TRUE	582	35.3	7.3	9	26	32	38	41	42	11
	Primary Child - Baseline	164	31.6	8	6	20	25.5	34	38	41	3
	Primary Child - SHAM	507	36	6.8	9	26	33	38	41	42	5
	Primary Child - TRUE	536	35.3	7.2	9	26	32	38	41	42	8
	Secondary Child - Baseline	18	31.5	9.6	9	14	26	35.5	38	41	0
	Secondary Child - SHAM	50	34.6	7.8	10	24	31	37	41	42	0
	Secondary Child - TRUE	46	34.8	8.3	12	18	29	39	41	42	3

Table C5, cont.

		N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Missing N
Q7	**Frustrated**										
	Entire data set - Baseline	184	5.4	1.9	1	2	4	6	7	7	1
	Entire data set - SHAM	561	6.3	1.4	1	4	6	7	7	7	1
	Entire data set - TRUE	590	6.2	1.5	1	4	6	7	7	7	3
	Primary Child - Baseline	166	5.4	1.9	1	2	4	6	7	7	1
	Primary Child - SHAM	511	6.3	1.4	1	4	6	7	7	7	1
	Primary Child - TRUE	542	6.2	1.5	1	4	6	7	7	7	2
	Secondary Child - Baseline	18	5.6	2.1	1	2	5	7	7	7	0
	Secondary Child - SHAM	50	6.3	1.5	1	4	6	7	7	7	0
	Secondary Child - TRUE	48	6.1	1.4	2	4	6	7	7	7	1
Q8	**Frightened or worried**										
	Entire data set - Baseline	183	5.6	2	1	2	4	7	7	7	2
	Entire data set - SHAM	560	6.5	1.1	1	5	6	7	7	7	2
	Entire data set - TRUE	589	6.4	1.2	1	5	6	7	7	7	4
	Primary Child - Baseline	165	5.6	2	1	2	5	7	7	7	2
	Primary Child - SHAM	510	6.5	1.1	1	5	6	7	7	7	2
	Primary Child - TRUE	542	6.4	1.2	1	5	6	7	7	7	2
	Secondary Child - Baseline	18	5.4	2.1	1	1	4	7	7	7	0
	Secondary Child - SHAM	50	6.5	1.2	2	5	7	7	7	7	0
	Secondary Child - TRUE	47	6.2	1.4	1	4	5	7	7	7	2
Q9	**Irritable**										
	Entire data set - Baseline	184	5.9	1.5	1	4	5	7	7	7	1
	Entire data set - SHAM	561	6.4	1.3	1	5	6	7	7	7	1
	Entire data set - TRUE	590	6.2	1.4	1	4	6	7	7	7	3
	Primary Child - Baseline	166	5.9	1.5	1	4	5	7	7	7	1
	Primary Child - SHAM	511	6.4	1.2	1	5	6	7	7	7	1
	Primary Child - TRUE	543	6.3	1.4	1	4	6	7	7	7	1
	Secondary Child - Baseline	18	6.2	1.3	3	4	6	7	7	7	0
	Secondary Child - SHAM	50	6.2	1.5	1	4.5	6	7	7	7	0
	Secondary Child - TRUE	47	6.1	1.5	1	3	6	7	7	7	2
Q10	**Different of left out**										
	Entire data set - Baseline	184	5.9	1.9	1	2	5.5	7	7	7	1
	Entire data set - SHAM	562	6.5	1.3	1	5	7	7	7	7	0
	Entire data set - TRUE	591	6.4	1.4	1	4	6	7	7	7	2
	Primary Child - Baseline	166	5.8	1.9	1	2	5	7	7	7	1
	Primary Child - SHAM	512	6.4	1.3	1	5	7	7	7	7	0
	Primary Child - TRUE	543	6.4	1.3	1	4	6	7	7	7	1
	Secondary Child - Baseline	18	6.2	1.6	2	3	6	7	7	7	0
	Secondary Child - SHAM	50	6.6	1.2	1	6	7	7	7	7	0
	Secondary Child - TRUE	48	6.3	1.5	1	4	6	7	7	7	1

Table C5, cont.

		N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Missing N
	Sum of emotional function responses: sum Q7-Q10										
	Entire data set - Baseline	183	22.8	5.8	4	15	19	25	28	28	2
	Entire data set - SHAM	559	25.6	4.2	4	20	25	28	28	28	3
	Entire data set - TRUE	586	25.2	4.4	8	19	24	27	28	28	7
	Primary Child - Baseline	165	22.8	5.9	4	15	19	25	28	28	2
	Primary Child - SHAM	509	25.6	4.1	4	20	25	28	28	28	3
	Primary Child - TRUE	540	25.2	4.4	8	19	24	27	28	28	4
	Secondary Child - Baseline	18	23.3	5.5	12	15	19	26	28	28	0
	Secondary Child - SHAM	50	25.5	4.5	8	21	25	27.5	28	28	0
	Secondary Child - TRUE	46	24.8	4.6	11	17	22	27.5	28	28	3
How bothered have you been during the last week doing:											
Q11	**Physical activities**										
	Entire data set - Baseline	183	4.6	1.9	1	2	3	5	6	7	2
	Entire data set - SHAM	558	5.6	1.6	1	3	5	6	7	7	4
	Entire data set - TRUE	586	5.4	1.7	1	3	4	6	7	7	7
	Primary Child - Baseline	166	4.6	1.9	1	2	3	5	6	7	1
	Primary Child - SHAM	509	5.6	1.6	1	3	5	6	7	7	3
	Primary Child - TRUE	538	5.4	1.7	1	3	4	6	7	7	6
	Secondary Child - Baseline	17	3.9	1.9	1	1	3	4	5	7	1
	Secondary Child - SHAM	49	5.5	1.7	1	3	5	6	7	7	1
	Secondary Child - TRUE	48	5.2	1.9	1	2	4.5	6	7	7	1
Q12	**Being with animals**										
	Entire data set - Baseline	181	6.1	1.5	1	4	6	7	7	7	4
	Entire data set - SHAM	559	6.5	1.1	1	5	7	7	7	7	3
	Entire data set - TRUE	586	6.4	1.3	1	5	6	7	7	7	7
	Primary Child - Baseline	164	6.1	1.6	1	4	6	7	7	7	3
	Primary Child - SHAM	510	6.5	1.1	1	5	6	7	7	7	2
	Primary Child - TRUE	538	6.3	1.3	1	5	6	7	7	7	6
	Secondary Child - Baseline	17	6.8	0.6	5	6	7	7	7	7	1
	Secondary Child - SHAM	49	6.4	1.4	1	4	7	7	7	7	1
	Secondary Child - TRUE	48	6.5	1.2	1	5	7	7	7	7	1
Q13	**Activities with friends and family**										
	Entire data set - Baseline	183	5.5	1.8	1	3	4	6	7	7	2
	Entire data set - SHAM	560	6.2	1.3	1	4	6	7	7	7	2
	Entire data set - TRUE	588	6	1.4	1	4	6	7	7	7	5
	Primary Child - Baseline	166	5.5	1.7	1	3	4	6	7	7	1
	Primary Child - SHAM	510	6.2	1.3	1	4	6	7	7	7	2
	Primary Child - TRUE	539	6.1	1.5	1	4	6	7	7	7	5
	Secondary Child - Baseline	17	5.4	2.1	1	1	5	6	7	7	1
	Secondary Child - SHAM	50	6.1	1.5	1	4	5	7	7	7	0
	Secondary Child - TRUE	49	5.9	1.4	2	3	5	7	7	7	0

Table C5, cont.

		N	Mean	Std Dev	Min	10th Pctl	25th Pctl	Median	75th Pctl	90th Pctl	Missing N
	Sum of activity limitation responses: Sum Q10-Q13										
	Entire data set - Baseline	181	16.2	4	3	11	14	17	19	21	4
	Entire data set - SHAM	555	18.2	3.3	4	14	17	19	21	21	7
	Entire data set - TRUE	583	17.8	3.6	3	13	16	19	21	21	10
	Primary Child - Baseline	164	16.2	4	3	11	14	17	19	21	3
	Primary Child - SHAM	507	18.3	3.2	6	14	17	19	21	21	5
	Primary Child - TRUE	536	17.8	3.6	3	13	16	19	21	21	8
	Secondary Child - Baseline	17	16	3.6	9	9	14	17	18	20	1
	Secondary Child - SHAM	48	18	3.9	4	12	17	19	21	21	2
	Secondary Child - TRUE	47	17.7	3.4	8	12	15	19	21	21	2

APPENDIX D: PILOT REPORT

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Pilot Results

BENEFITS OF HIGH EFFICIENCY FILTRATION TO CHILDREN WITH ASTHMA

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Disclaimer

The statements and conclusions in this report are those of the authors from the University of California and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with the material reported herein is not to be construed as actual or implied endorsement of such products.

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1. Study Goals and Objectives

The goals of this pilot study are to:

1. Determine if participants have difficulty answering any questionnaire questions so that modifications can be made prior to the main study. This will be done by observing the participants while they answer the questionnaire questions.

2. To test that each individual protocol works well in the home to determine if there are any changes that need to be made. We will also track how long each activity takes to determine if there are any aspects of the protocols that could be modified to reduce time in the participant home, and thus participant burden.

3. To observe how effectively all of the protocols can be conducted by the two field staff to determine if there are any changes that need to be made in the distribution of work or other logistical items to increase efficiency of the home visits.

4. To obtain information related to the QA/QC evaluation of both the environmental and health measures.

We review the basic project outline and goals before presenting the results for the pilot study. In this study, 200 asthmatic children between 6-12 years living in non-smoking homes in regions with high outdoor air pollution, specifically Fresno and Riverside counties, will be enrolled in a randomized placebo cross-over trial to evaluate the effectiveness of high efficiency filtration of indoor air in reducing their exposure to PM and ozone and their asthma symptoms. One intervention group will have modifications of their central system filtration to enable the installation of a high efficiency filter. The second intervention group will have high efficiency portable air cleaners placed in the child's bedroom and in the main living area that reduce particles, ozone, and VOCs. Improvements in asthma symptoms will be evaluated in a cross-over design, with each participant receiving true air filtration for a year and a placebo for a year, allowing us to isolate the improvements related to the air filtration.

The objectives and study plan are briefly as follows:

1. In homes of children with asthma, determine the extent to which the use of a) high efficiency central system filtration, and b) high efficiency portable air cleaners reduces indoor concentrations of PM0.2, PM2.5, and PM10, the resulting personal exposures, and the extent to which filtration reduces indoor concentrations of ozone.

   To meet this objective, air pollution will be recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true filter periods. Air quality will be measured as one-week integrated indoor and outdoor samples of $PM_{2.5}$, PM_{10}, $PM_{0.2}$ (representing ultrafine particulate matter), and during high ozone seasons, ozone.

   As a sub-study of Objective 1, filters to reduce ozone and VOC will be installed in the

homes receiving the high efficiency portable air cleaners. We will evaluate if there are further reductions in ozone as a result of the filters.

Additionally, a sub-study will be conducted on 25 – 30 participants who will be asked to wear personal PM2.5 monitors for 48-hour periods while indoor and outdoor air pollutant measurements are being obtained to evaluate the impact of filtration on personal exposure to PM2.5.

From the data collected, we will first compare indoor concentrations of pollutants between periods with true and sham filtration, and with the pre-intervention measurements, and second, compare indoor/outdoor (I/O) ratios of pollutant concentrations between the true filtration and sham periods, in order to estimate the reduction of indoor air pollution levels.

2. Determine the extent to which the use of a) high efficiency filtration in central systems and b) high efficiency portable air cleaners reduces asthma symptoms, emergency room (ER) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.

   To meet this objective, health outcomes, including symptoms, unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, respiratory infections, etc., will be collected by questionnaires every three months. Health measurements, such as peak exhaled flow, spirometry, and exhaled nitric oxide (eNO) will be obtained during the true and sham periods.

   With the data collected, we will compare health care utilization, medicine use, symptoms, peak flow, and eNO between the sham and true filtration periods. We will also compare these outcomes with the pre-intervention period.

In the course of obtaining data to meet the above objectives, the following objective also will be met:

3. In homes of children with asthma, measure indoor and outdoor concentrations of PM0.2, PM2.5, PM10, and ozone, and resulting indoor and personal exposures

   To meet this objective, the distribution of indoor concentrations and resulting indoor and personal exposures from the pre-intervention period will be determined as this represents the typical indoor exposure to children with asthma. The two one-week integrated samples collected with the sham filter in place to meet objective 1, above, will also represent typical indoor concentrations. Finally, the personal exposure monitoring described above under Objective 1 will also provide PM2.5 exposure measurements for a subset of the children.

This study will provide superior air filtration, either installing high efficiency filters in central systems or installing stand-alone air cleaners, in regions with high outdoor air pollution levels. The sample size will be larger than in many of the previous studies that evaluated filtration.

Filtration utilization will be monitored and improvements in indoor air will be quantified. Should this project find that both central system filtration and stand-alone air filtration units result in lower indoor air pollution and lower prevalence of asthma symptoms, these interventions could reduce health costs associated with asthma care.

2. Methods

2.1 Overview

The pilot involved both a pre-pilot and pilot phases. Everything needed to conduct the study was developed and obtained prior to the pre-pilot. We ordered all the equipment and supplies. We assembled equipment and supply kits to take into the home. The data entry system was tested. All air quality measure protocols and field logs were developed. All health endpoint questionnaires and field logs were developed. All the sampling equipment, protocols and logs, and questionnaires were tested in the pre-pilot and pilot study in accordance with the goals of the pilot:

1. To determine if participants had difficulty answering any questionnaire questions so that modifications can be made prior to the main study. This was done by observing the participants while they answered the questionnaire questions.

2. To test if each protocol worked well in the home and to determine if there were any changes that need to be made. We also tracked how long each activity takes to determine if there were any aspects of the protocols that could be modified to reduce time in the participant home, and thus participant burden.

3. To observe how effectively all of the protocols can be conducted by the two field staff and to determine if there were any changes that need to be made in the distribution of work or other logistical items to increase efficiency in the home.

4. To obtain information related to the QA/QC evaluation of both the environmental and health measures.

2.1.1 Pre-pilot Study

The pre-pilot was conducted in one convenience home to confirm the logistics of following all protocols. No actual samples were collected in the pre-pilot. A one-day trip was made to the home to go through all activities of the four types of different visits listed in Table 1. The staff left and reentered the home between each visit. Sampling equipment was set up and taken down without collecting actual samples. Health measurements were conducted on a parent rather than a child (to reduce logistic restraint) without recording data. For all questionnaires, we had one staff watching the participants' response and recording questions they had or facial expressions that would indicate they might be confused by the question, or any other verbal or nonverbal cues

that they did not understand the questions. An example of a nonverbal cue would be an unusual facial expression.

We did not feel it was necessary to repeat activities that occurred in multiple visits and thus activities conducted are a reduced version of all items to be tested in the pilot study (Table 2). We note that the MiniPAQLQ was not conducted as there was not a child at the visit.

Table 1. List of visit types and activities to be conducted in the pre-pilot

visit types	activities to be conducted
Consent Visit (30 minutes)	• *Written Informed Consent Obtained*
Enrollment Visit (2 hours)	• *Baseline Questionnaire Part 1 (including Recall Questionnaire)* • *Spirometry* • *Measure height and weight* • *Set-up air quality monitoring equipment (PM and ozone)* • *Begin 1-week peak flow monitoring* • *Begin 1-week symptom diary*
Intervention Visit (2 hours)	• *Take down air quality monitoring equipment* • *Review one-week symptom diary in person with participant* • *Baseline Questionnaire Part 2* • *Collect peak flow meter* • *eNO measurements* • *Install and instruct participant on use of stand-alone air cleaner* • *Install Mattress pad cover*
Filtration Evaluation Take-down Visit (2 hours)	• *Record air cleaner usage information* • *Collect dust sample*

The pre-pilot was conducted by Rebecca Moran (laboratory and field manager) and Maryam Shahin (staff member), and observed by Dr. Bennett (PI), May Wu (QA/QC officer) and Katya Roudneva (staff member). Maryam Shahin was responsible for interviewing the participant to complete the questionnaires and taking health measurements, and Rebecca Moran was responsible for setting up/taking down air samplers and assisted Maryam when necessary. While they conducted the protocols, Dr. Bennett observed the participant interview and health measurements and Dr. Wu observed the air sampling and dust collection. Katya also observed the air sampling procedure.

A debriefing was held after the pre-pilot test to discuss how well the protocols operated in the field. Based on the problems with flow encountered in the field, Dr. Bennett made adjustments to some sections of the sampling protocol and questionnaires, which are discussed in detail in the Results section. We tested if these adjustments made things go more smoothly in the pilot study.

2.1.2 Pilot Study

The goal of the pilot study was to see if there are any problems in the sampling procedures, how long each activity takes, whether participants have problems with any questionnaire questions, diaries, etc., and any other problems that need to be addressed, and to assure all QA/QC criteria will be met. Once the protocols had been demonstrated to work well in the pre-pilot, a pilot study was conducted in three convenience homes in Northern California. The homes have children within the specified age range (6-12 years) with doctor-diagnosed asthma. We note that all children had much less severe asthma than children in the main study will have, and so for this reason health results are not expected to be in the same range as actual participants.

The goal was to complete three visits in each pilot home as listed in Table 2, including the consent and enrollment visit, the combined intervention and filtration evaluation set-up visit (one week after the enrollment visit), and the filtration evaluation take-down visit (one week after the filtration evaluation set-up visit). Visits were combined where possible to minimize participant burden as it is more difficult for the pilot participant to have us in their homes for multiple visits.

We placed two portable air cleaners in participants' homes, one in the child's bedroom and one in the main living area, during the intervention visit and they remained there for the filtration sampling week. Integrated one-week air pollution samples were collected in each household, with one measurement prior to intervention and one during the filtration periods. We collected peak flow measurements simultaneously with symptom diary only for one week and only collected the symptom dairy for the other week.

Table 2. List of visit types and activities to be conducted

visit types	activities to be conducted
Combined Consent and Enrollment Visit (2 hours)	• *Written Informed Consent Obtained* • *Baseline Questionnaire Part 1* • *Recall Questionnaire* • *MiniPAQLQ* • *Spirometry* • *Measure height and weight* • *Set-up air quality monitoring equipment (PM and ozone)* • *Begin 1-week peak flow monitoring* • *Begin 1-week symptom diary*
Combined Intervention and Filtration Evaluation Set-up Visit (1 hour)	• *Baseline Questionnaire Part 2* • *Remove air quality samples (only samplers removed not pump boxes)* • *Review one-week symptom diary in person with participant* • *Collect peak flow meter* • *eNO measurements* • *Install and instruct participant on use of stand-alone air cleaner* • *Install Mattress pad covers*

	• *Set up air quality monitoring (PM and ozone, only new samplers installed using the same pump boxes)* • *Set up personal exposure measurement* • *Record air cleaner usage information* • *Recall Questionnaire* • *MiniPAQLQ* • *Begin 1-week symptom diary*
Filtration Evaluation Take-down Visit (2 hours)	• *Take-down air quality monitoring equipment* • *Record air cleaner usage information* • *Review symptom diary with participant* • *Collect Dust sample*

Note: While the recall and miniPAQLQ have been integrated into the Baseline Questionnaire Part 1, for ease of administration, we discuss them as if they are separate to indicate how many times that information is collected.

As listed in Table 3, we collected 6 sets of outdoor PM and ozone. We also collected 3 sets of indoor samples of PM and ozone without filtration, and 3 sets with filtration. All indoor PM samples, 3 sets of the outdoor PM samples, and 2 sets of the ozone samples were collected in duplicate. Indoor temperature and relative humidity were also recorded. We asked if participating children between 9 and 12 years old would collect personal PM 2.5 samples during the second week, beginning at the filtration evaluation set-up visit. As per main study, we only collected personal exposure samples on children 9 to 12 years old. All of the environmental samples were analyzed.

Table 3: Air Samples Planned to be Collected in the Pilot Study.

Pilot Samples	Number of Samples	Number of Duplicates	Number of Blanks
Indoor PM2.5, no filtration	3	3	3
Indoor PM0.2, PM0.2-2.5, PM 2.5-10, PM 10, no filtration	3	3	3
Indoor PM2.5, with filtration	3	3	3
Indoor PM0.2, PM0.2-2.5, PM 2.5-10, PM 10, with filtration	3	3	3
Outdoor PM2.5	6	3	0
Outdoor PM0.2, PM0.2-2.5, PM 2.5-10, PM 10	6	3	0
Personal PM2.5	2	0	0
Indoor ozone, no filtration	3	0	2
Indoor ozone, with filtration	3	0	0
Outdoor ozone	6	2	0

The Baseline Questionnaire (part 1) was administrated at the enrollment visit and the Baseline Questionnaire (part 2) was administrated at the intervention visit. While the recall and MiniPAQLQ have been integrated into the Baseline Questionnaire Part 1 for ease of administration, we discuss them in this pilot report as if they are separate to indicate how many times that information is collected. At both the enrollment visit and the filtration evaluation set-up visit, a two-week parent recall questionnaire, and MiniPAQLQ (a child recall questionnaire) were collected, and the participant was given a one-week symptom diary. Exhaled NO and spirometry were measured once, following the schedule in Table 2. Although eNO will be measured at all take-down visits in the main study, we felt it was too much burden to ask participants to collect this measure twice in a one-week period. The health information collected during the pilot is summarized in Table 4. Note that the recall periods of the two two-week parent recall questionnaire partially overlapped. For all questionnaires, someone was watching the participants' response and recorded any questions they have that indicate they might be confused by the question, or any other verbal or nonverbal cues that they did not understand the questions.

Table 4: Health Data Planned to be Collected in the Pilot Study.

Health information collected	Number collected
Baseline Questionnaire Part 1	3
Baseline Questionnaire Part 2	3
Recall Questionnaire	6
MiniPAQLQ	6
Spirometry	3
eNO measurement	3
1-week peak flow monitoring	3
1-week symptom diary	6

The pilot study was conducted by the same personnel as the pre-pilot, with the staff alternating between the various roles and evaluator so all protocols were conducted by three different people. All visits were timed. A meeting was held after each day to discuss any problems that were incurred in following the protocols or concerns regarding the questionnaire. Ideas for modifications that may make the process more efficient were also discussed.

We reported on the fraction of samples over the LOD, measured concentrations, QA/QC parameters, and visit times. A qualitative evaluation of how smoothly the visits went is provided in the results.

Slight modifications made to the protocols or procedures during the pilot are presented in the results. Additional recommendations for modifications are also made.

2.2 Environmental Measurements

2.2.1 Indoor and Outdoor PM measurements

Indoor and outdoor air was measured for PM 0.2, PM 0.2-2.5, PM 2.5-10, and PM2.5 for one week. PM 0.2, PM 0.2-2.5 and PM 2.5-10 was collected using a cascade impactor (Demokritou

et al., 2001; Lee et al., 2006) with a constant sample flow of 5 Liter per minute (LPM). PM 0.2 mass was collected on a Teflon filter and the PM 0.2- 2.5 and PM 2.5- 10 mass was collected on PUF substrates. PM 10 was determined by summing the mass across the stages. Air flow was measured at the start and end of each sampling event using an electronic piston volumetric gas flow meter Bios 520 (Bios international, New Jersey). A one-week integrated PM 2.5 sample was collected using an impaction-based PEM for PM 2.5 designed for 1.8 LPM flow collected on a Teflon filter (Demokritou et al., 2001).

The samplers were placed in the pump boxes to prevent access by small hands that may take an interest in the samplers (Figure 1). The pump boxes were designed to hold one 5 LPM Cascade Sampler with two Medo pumps VPO125- 7 LPM (MEDO, Roselle, IL), one 1.8 LPM PEM with one Medo pump VPO140 -3 LPM (MEDO, Roselle, IL), and connect them to the sampling inlet. The inlets are 0.625 inch inside diameter, made of aluminum. The tubes are in the shape of a candy cane, with a gentle, swept 180^{o} turn near the top. Each sampler has its own inlet tube. The pump boxes are also equipped with a flow control valve Milli-Mite 1300 Series 1315G4B (Hoke, Spartanburg, SC) for each sampler, a two-channel timer Talento 992+ (RS, Northamptonshire, UK), and an exhaust system. In the case of a power outage, the pumps would turn back on when the power comes back on with this control timer. When the timer is launched with the launching program, each pump has its own hour meter to record elapsed time. Identical boxes and inlets were used indoors and outdoors.

(a) (b)

Figure 1. Pump boxes set up indoors (a) and the inside view of the pump box (b)

Indoor samplers were placed on a wooden base in the main living area of the home. The goal was to locate the samplers at least 30 cm away from any wall, if possible. If this was not possible, samplers were placed as far from the wall as possible. We also tried to avoid placing the samplers behind furniture, near windows, near combustion sources (i.e., fireplaces in use),

near the door to the garage, near sources of water (such as in the bathroom or near the kitchen sink), directly under a light, or in the air-stream from ventilation inlets or outlets. The locations selected were easily accessible and useable for subsequent occasions.

For outdoor samplers, pump boxes were supported by a tripod. The goal was to locate them away from walls or other surfaces, trees, sprinklers or other water sources, garage or drive way, trucks, busses, cars or other internal combustion engines. Generally, we tried to achieve a distance of 1 m or more from vertical surfaces. During the main study, samplers may sometimes be set-up on a balcony, which may not meet these criteria, if that is the only outdoor location available. In this case, the tripod and sampling box will be located as far from the wall as possible. The outdoor location must have access to power with the cord secured to ground.

PM filters (from both the cascade impactor and PEM) and PUFs were weighed before and after sampling at the University of Wisconsin, State Laboratory of Hygiene (WSLH). Filter and PUF weighing requires strict control of temperature and relative humidity, that is, weighing should be ideally conducted at RH of 40±3% for filters and at RH of 35±3% for PUFs. Usually, filters were equilibrated at least 12 hours before weighing, and PUF were equilibrated 48 hours before weighing. To account for the impact of subtle environment change during weighing, a check standard was weighed after every 10 filters, and a mass control filter/PUF was weighed after every 10 filters or every 5 PUFs. The final sample filter weight will be adjusted by the average mass change of all mass control filters in the weighing session. For each group of 5 sample PUFs, the final sample PUF weight will be adjusted by the average mass change of the two mass control weights bracketing the 5 PUFs.

The detailed description of filter and PUF handling can be found in the Appendix A1, SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly, SOP for Personal Environmental Monitors (PEMS) Cleaning, Assembly, and Disassembly, SOP for Indoor/Outdoor Air Quality Field Sampling, and Wisconsin Weighing Protocol, as well as Appendix A7, Procedure for handling PM filter and PUFs, in the QA/QC plan. PM concentrations were calculated using the difference of the filter/PUF weight before and after sampling, divided by the total sampling volume (sampling flow rate averaged between start and end flow measurements × sampling period).

2.2.2 Indoor and Outdoor Ozone

One-week integrated ozone measurements were collected indoors and outdoors using a passive Ogawa badge (OGAWA & Co., Pompano Beach, FL). For both indoor and outdoor samplers, the badges were placed into the inlet stream of the Harvard 5 LPM cascading impactor (Figure 2), which drew air across the face of the sampler. One-week integrated NO_2 measurements will also be made at some visits during the main study using a passive Ogawa badge, however, this compound was not measured in the pilot study.

Figure 2. Position of Ogawa badge in the inlet stream.

Ogawa filters were sent to Research Triangle Institute (RTI) (Durham, North Carolina) for analysis. Mass of nitrate was extracted and quantified. We calculated ozone concentrations based on the equations described in the Ogawa sampler protocol. The sampling rate for ozone is constant, each filter having a sampling rate of 11.4 ml O_3/min (outdoor) or 8.9 ml O_3/min (indoor). For indoor sampling inadequate air movement causes a decrease in the sampler collection rate. We used two filters that were analyzed together and thus we summed the sampling rates of two filters, resulting in a total sampling rate of 22.8 ml O_3/min (outdoor) and 17.8 ml O_3/min (indoor). Outdoor ozone concentration was calculated using the following equation.

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{22.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6} M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6 \mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

Multiplying the constants in the equation, we get 17.30, substituting:

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 17.30$$

Indoor Ozone concentration is calculated using the following equation.

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{17.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6} M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6 \mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

Multiplying the constants in the equation, we get 22.16, substituting:

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 22.16$$

2.2.3 Reflectance

We estimated indoor and outdoor levels of black carbon (which is primarily emitted in the outdoor environment) by measuring reflectance on the PM2.5 filters. This allows us to determine the reduction of particles of outdoor origin. Reflectance was measured using an EEL43M Smoke Stain Reflectometer (Diffusion Systems Ltd., London, UK), and transformed into an absorption coefficient according to ISO 9835 (ISO, 1993). Reflectance was measured before and after a filter is used. The reflectance value of the unused filter served as a reference level and was deducted from the value measured after the filter was used. The difference of the reflectance value corresponds to the actual black carbon collected on the filter. The indoor/outdoor ratio of black carbon was calculated, allowing for an estimation of particles of outdoor origin in the indoor air. Details on reflectance measurements can be found in the QA/QC Plan Appendix A1, SOP for Reflectance Analysis.

2.2.4 Surface Dust Measurements

We also collected a surface dust sample using a DUSTREAM^{TM} sampler (Indoor Biotechnologies, Charlottesville, NC) for future analysis of endotoxin allergens. Details on dust collection can be found in the QA/QC Plan Appendix A1, SOP for Vacuum Dust Sample Collection.

2.2.5 Personal PM Measurements

We asked if participating children between 9 and 12 years old would collect personal PM 2.5 samples during the second week, beginning at the filtration evaluation set-up visit. Specifically, we collected 48-hour PM 2.5 personal samples during the filtration period using a Harvard PM 2.5 PEM with a 4LPM flow rate. Pumps (BGI 400, Waltham, MA) run off of 48-hour batteries so that they would turn off after 48-hours and were collected at the end of the one-week period when we collected the indoor and outdoor samplers. Filters were handled the same way as indoor and outdoor PM filters and PUFs. The pump was kept in the backpack and the sampler inlet was attached on the backpack in the breathing zone. Participants were asked to wear the backpack and keep the backpack with them wherever they went during the sampling period. The backpack was placed on a table in the room that the child slept in while they slept. PM mass was calculated also in the same way as stated above. More details on personal PM measurements can be found in the SOP for PEM Personal Sampling.

In the main study, an Actical accelerometer (Phillips Electronics, NV), a device designed to record human movement which contains a biaxial piezoelectric accelerometer sensor to record physical motion in two planes, will be placed in the backpacks, to record motion, allowing us to determine if the backpacks are actually worn by participants. We will review the Actical data to determine if participants are complying with the protocol. However, we were waiting for an update of the software, so did not use the Acticals in the pilot study. We will test them on ourselves prior to use.

2.2.6 Temperature and Relative Humidity

Indoor temperature (T) and relative humidity (RH) were collected using HOBO U23-001 data loggers (Onset Corp., Cape Cod, MA) while air pollution measurements were being conducted indoors. In the main study, we will record outdoor temperature and relative humidity from the nearest ambient monitoring station or the nearest other location where reliable T and RH data are collected. We did not test this protocol in the pilot since the homes were in a different region. Details on obtaining temperature and relative humidity can be found in the QA/QC Plan Appendix A1, SOP for Calibration, Verification, and Maintenance of the Temperature/Relative Humidity (T/RH) Meter and SOP for Downloading Temperature and Relative Humidity Data.

2.3 Health Outcome Measurements

The primary measure of health effects is symptom days per 14 day period. Secondary measures include unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, respiratory infections, peak exhaled flow, spirometry, and eNO. In the pilot study, symptoms, unplanned utilization of the healthcare system, and short-term rescue drug medication use were recorded twice. Spirometry, exhaled nitric oxide, and peak exhaled flow were conducted once.

2.3.1 Questionnaires

Health outcomes were obtained through the use of three questionnaires, a two-week recall administered to the parent, a Mini Pediatric Asthma Quality of Life Questionnaire (MiniPAQLQ) completed by the child, and a one-week symptom diary with the child answering questions on the symptoms and medicine use and the parent answering questions relevant for environmental exposures. In addition, a Baseline Questionnaire administrated in two parts at the enrollment and intervention visits covers background health information and housing conditions.

2.3.1.1 Recall questionnaire administered to parent

The first portion of the recall questionnaire determines the number of days of symptoms, rescue medicine use and missed days of school/work, and is based on questions used in the inner-city asthma study (ICAS) and additional studies conducted by those researchers (Busse et al., 2011; Mitchell, 2012; Morgan et al., 2004). The second portion of the questionnaire obtains information about use of control medication and the questions were developed by the UC Davis team. There are also a number of questions related to allergies based on Nelson et al., (2011) interspersed throughout the first two sections. The third portion of the questionnaire obtains information about unplanned health care utilization and was modified from a questionnaire developed by the American Academy of Pediatrics. Finally, there are a limited number of questions related to environmental exposures that were developed at UC Davis.

Many health outcome variables and health covariates were extracted from the responses to this questionnaire. The major health outcome variables include

- Number of days with asthma symptoms over the recall period. We determined the maximum number of days during the two-week recall period with symptoms, defined as the largest value among the following three variables: (i) number of days with wheezing, tightness in the chest, or cough because of asthma, (ii) number of days that the child had to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough, or (iii) number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough. This method of counting "symptom days" has been used in the National Cooperative Inner-City Asthma Study (Evans et al., 1999). Multiple symptom types were considered, as different individuals experience different symptoms from their asthma.

- Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during the monitoring period, which is the greater number between daytime use and nighttime use in the Recall Questionnaire.

- Total number of puffs of using rescue inhaler during a recall period, which equals days that the participating child use their rescue inhaler/puffer during the day for relief of asthma symptoms × number of puffs/inhalations that the participating child use each day.

- Days of missed school due to asthma, expressed as a proportion of days of missed school versus the total number of school days during a recall period.

- Days of missed work for parents due to the child's asthma, expressed as the proportion of days of missed work relative to the total number of work days during a recall period.

- Unplanned health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma
    - overnight hospitalization
    - emergency room visit
    - clinic visit
    - receiving steroid treatment

- Number of times having respiratory diseases

- Allergy combined score: is composed of allergy symptoms score and allergy medicine score. Our allergy questions were based on an existing instrument. The existing instrument included six allergy symptoms, including runny nose, blocked nose, sneezing, itchy nose, gritty feeling/ red/itchy eyes, and watery eyes, each scored on a 4-point scale (0, no symptoms; 1, mild symptoms; 2, moderate symptoms; or 3, severe symptoms). The instrument also included four asthma symptoms, including cough, wheeze, chest tightness/shortness of breath, and exercise-induced symptoms, also scored on a 4-point scale. In the existing instrument, the daily scores were averaged to create a daily symptom score. This was then added to a daily medicine score which included three allergy medicines (antihistamine, ocular antihistamine, and nasal corticosteroid) and one asthma medicine (oral steroid).

Our instrument asks for the number of days of combined symptoms, namely "runny or blocked nose", "sneezing or an itchy nose", "red/itchy eyes, watery eyes or irritated eyes", as well as allergy medicine use of "oral anti-histamines for his/her allergies", "prescription allergy eye drops" and "a prescription allergy nose spray". The responses are in the format of the number of days the symptom was experienced. We assign 2 points to each day the participant reported the symptom category and sum up all symptom categories to get an allergy symptoms score. Each category of allergy medicine is considered 1 point per day, and the sum of all allergy medicines is the allergy medicine score. The allergy symptom and medicine scores are then summed and divided by 14 days, the length of the recall period. We do not include the asthma symptoms or asthma medicine in our allergy score since we are evaluating asthma as our primary outcome.

2.3.1.2 Recall questionnaire Administered to Child

The MiniPAQLQ was administered to the child as part of the recall questionnaire. This survey covered a one-week period. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ) is a validated tool developed to assess the impact of symptoms on quality of life. It is part of the suite of questionnaires often referred to as the Juniper questionnaires. As the original PAQLQ is quite long, a shorter version was recently developed, called the MiniPAQLQ. This instrument was recently validated against the PAQLQ, with moderate to strong correlation (r=0.50-0.94) with PAQLQ (Wing et al., 2012). Reliability was strong for the MiniPAQLQ (ICC>0.91). The responsiveness index value for the MiniPAQLQ (1.05) was higher than that of the original PAQLQ (0.90). These results provide confidence that the MiniPAQLQ is valid, reliable and responsive to change and suitable for use for long-term monitoring in clinical trials. This instrument was used in its entirety.

The 13 questions in the MiniPAQLQ are divided into three domains: 1) symptoms: question 1-6; 2) emotional function: question 7-10; 3) activity limitation: question 11-13. Each question is given a score between 1 and 7. Individual questions are equally weighed. The overall MiniPAQLQ score is the mean of the response to each of the 13 questions, ranging between 1 and 7. The domains are analyzed in exactly the same way, namely add the responses for each of the items in the domain and then divided by the number of questions in the domain. This is the standard scoring system that has been developed for use with the instrument.

2.3.1.3 Symptom diary

Many of the questions on the symptom diary were taken from the inner-city asthma study. The symptom areas recorded are the same as in the recall questionnaire. In addition to symptoms, the participant's parent or guardian was also requested to record information related to potential air pollution sources and household air exchange. Those questions were developed by the UC Davis team.

The symptom diary will typically be administered for two consecutive weeks in the main study, but was administered for only one week pre-intervention and one week during the intervention for the pilot study.

Major health outcome variables extracted from the responses to this questionnaire were:

- Number of days with asthma symptoms over one-week period. From the one-week symptom diary, we obtained the number of "symptom days" with any of the following: waking up during the night, coughing, wheezing, or have to slow down or stop activities because of asthma during the diary-recording period. A day is considered a symptom day if they answered one, two, or three in their numeric response for a given question. We combined the answers for these four questions to provide a comparable measure to that provided in the Recall Questionnaire.

- Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during a one-week period. If either or both nighttime use or daytime use was marked yes in the Symptom Diary, the day was counted.

- Number of puffs in total did the participating child use during a one-week period. This was obtained as a sum of how many puffs were used each day in the Symptom Diary over the one-week recall period.

- Days of missed school due to asthma, expressed as a proportion of days of missed school versus the total number of school days during a one-week period.

- The overall condition of asthma, recorded as continuous integers indicating how bothered the participant was by their asthma (0-not at all /1-a little bit / 2-quite a bit / 3-a lot) and expressed as the average value over a one-week period.

2.3.1.4 Baseline Questionnaire

The Baseline Questionnaire begins with a series of questions regarding the history of the child's asthma and asthma management. Demographic information was also obtained. There are a number of questions about potential exposures the child may have, including items such as smoking, pets, mold, new furnishings, and cooking and cleaning practices. Questions related to the air exchange such as window usage and heating and cooling practices were also asked.

2.3.2 Quantitative Health Measures

2.3.2.1 Exhaled Nitric Oxide (eNO)

Exhaled nitric oxide provides a measure of airway inflammation. eNO was collected using the NIOX MINO (Aerocrine AB, Solna, Sweden), a handheld unit appropriate for field applications, according to the American Thoracic Society (ATS) and European Respiratory Society (ERS)

guidelines (Baraldi et al., 2002). The ATS/ERS 2005 statement recommends collection of two eNO measurements and averaging the two values at each study visit, and we followed this protocol. Participants were given 6 attempts to complete two successful measurements. This measure was collected at the participant's home. Children were asked to blow into the device at 50 ml/sec as recommended. eNO collection is flow rate dependent and the NIOX MINO has visual clues to ensure the eNO levels are measured at this flow rate in children. eNO was collected following each air-monitoring period. eNO data were recorded on the field log. Details on eNO measurements can be found in the QA/QC Plan Appendix A1, SOP for Exhaled Nitric Oxide Measurement.

2.3.2.2 Spirometry

Pulmonary function was measured using an AstraTouch™ Spirometer, developed by SDI Diagnostics (Easton, MA). This spirometer is compliant with the American Thoracic Society spirometry standards. It records actual volume-time tracings. The participant may take up to 6 attempts to complete 3 acceptable tests. When properly programmed, the spirometer will save the three best attempts for each participant.

Volume-time tracings can be downloaded from the spirometer. A list of measures including peak expiratory flow (PEF), forced vital capacity (FVC), forced expiratory volume at 1.0 second (FEV1), FEV1/FVC, and forced expiratory flow 25–75% (FEF 25–75) were obtained, and all measures were considered as outcomes. All parameters can also be expressed as a percentage of the expected value. The percentage of the expected value was determined by comparing the actual value to the distribution of values for children of the same age and height, using the data from NHANES (Hankinson et al., 1999). This allows us to account for changes as children grow. For each measure, the participants' best attempt of all acceptable attempts that they made will be reported in the study. So, for example, if their best FEV1 was on their first attempt and their best total volume was on their second attempt we would take the FEV1 from the first attempt, and the total volume from their second attempt.

Obtaining reliable spirometry that meets all criteria for acceptability and reproducibility in children with asthma is difficult. Asthma itself has the potential to increase the variability of lung function measures at a given test session (e.g., post-inhalation bronchoconstriction). It is also well know that young children cannot maintain a forced vital capacity maneuver for 6 seconds, the minimum duration criterion for adult testing.

Acceptability and reproducibility criteria for children have been previously established and we utilize those criteria (Mortimer et al., 2003). The acceptability criteria are as follows:

- Back-extrapolated volume must be < 150 mL or 5% of the FVC
- Time to peak flow must be < 120 ms
- No abrupt ending (abrupt ending occurs when < 100 mL of volume is accumulated in the 0.5-s interval preceding end of test)

The reproducibility criteria for children are as follows:

- The current PEF and the previous largest PEF from an acceptable effort must be within 20%
- The current FEV1 and the previous largest FEV1 from an acceptable effort must be within 10%
- The current FVC and the previous largest FVC from an acceptable effort must be within 10%

In addition, the curve must pass visual quality control. Dr. Schenker reviewed the tracings for acceptability.

Some common errors that lead to a maneuver being deemed technically unsatisfactory include:

- Slow start (which will inflate the FEV1 by moving the extrapolated start time to the right)
- Coughing during the first second
- Premature termination of effort (1 second plateau absent)
- Extra inhalations/hesitations/variable effort/Valsalva maneuver (glottis closure)
- Leaks around the mouthpiece
- Obstructed mouthpiece

An acceptable test is free from all six listed errors. As a minimum, a useable test has to be free from the first two errors listed above (no slow start and no coughing during the first second). A test may be usable but not acceptable. Ideally we want acceptable tests, but if after **six** attempts only useable tests (that are not acceptable) were recorded, we used results based on the three best useable trials, noting that the data is less reliable.

Three acceptable maneuvers are needed to determine reproducibility. The two highest values for FVC and FEV_1 taken from acceptable forced expiratory maneuvers must show minimal variability (within 150 milliliters of the second highest FVC and FEV_1). It is also important to inspect the volume-time curves to determine if the size and shapes of the curves are reproducible. Details on spirometry measurements can be found in the QA/QC Plan Appendix A1, SOP for Spirometry and Anthropometry.

2.3.2.3 Peak Expiratory Flow Rate (PEFR)

Participants were given a Piko electronic Peak Flow meter (nSpire Health Inc., Longmont, CO) and asked to use it two times a day (morning and evening) for one week, with three attempts per time period. The best of the three PEFR values is automatically saved on the instrument, eliminating either transcription errors or reporting false data if there is poor compliance. We took note if there was more than a 15% difference between any one attempt and the child's average level obtained during the week, as this may potentially indicate another household member used the meter or reflect a problem with how the meter was used. This measure was collected for a one-week period prior to intervention. We also determined if the participant used the Piko twice per day as asked. Data were directly downloaded from the Piko. Details on peak flow measurements can be found in the QA/QC Plan Appendix A1, SOP for PIKO Peak Flow Meter.

PEFR is expressed as three measures: 1) a morning PEFR is the highest PEFR value for each morning and then averaged across one week; 2) an evening PEFR is the highest PEFR value for each evening and then average across one week; 3) a morning-evening PEFR variability is evening PEFR minus morning PEFR as a percentage of evening PEFR, and then average across one week.

2.3.2.4 Height and Weight

We recorded height and weight using a scale and stadiometer. The measurements obtained were used to calculate Body Mass Index (BMI). Details on height and weight measurements can be found in the QA/QC Plan Appendix A1, SOP for Spirometry and Anthropometry.

2.4 Database evaluation

Prior to pilot, all questions in the questionnaire were filled out with representative data and we confirmed the exported values were the same as the imputed values. This procedure was also followed for the pilot data. All data for calculations were exported from the database, allowing us to confirm all formats are appropriate. We also tried to confirm that questionnaire data was exported in a way compatible with needs outlined in statistical analytical plan.

2.5 Quality Control Samples

2.5.1 Quality Control Samples for Environmental Measurements

For environmental samples, field blanks and duplicates were collected in the pilot study. As shown in Table 3, all indoor PM samples had a blank collected. Two indoor ozone blanks were collected. All indoor PM samples, 3 sets of the outdoor PM samples, and 2 sets of the ozone samples were collected in duplicate.

2.5.1.1 Precision

Precision was measured using co-located samples. Precision calculations between each pair of co-located samples were conducted by finding the difference between the sample pairs and dividing by their average.

For a co-located pair, x_i, y_i, sample x_i > LOD and sample y_i > LOD, the precision for a single sample was expressed as a percent difference, CV_i,

$$CV_i = \left| \frac{x_i - y_i}{(x_i + y_i)/2} \right|$$

Each individual duplicate percent difference is reported. The overall precision was determined by taking the average of all individual percent difference values for the pilot study.

2.5.1.2 Blanks

The measured mass of each blank sample is reported, along with the mean value and standard deviation of all values. The mass is also converted to a concentration value by dividing by the appropriate nominal volume.

2.5.2 Quality Control Measures for Health Measurements

Based on the acceptability criteria, number of acceptable samples for each health measurement was obtained and the completeness of the measurements was recorded.

3. Summary of Pre-Pilot and Pilot Households

As per the pilot plan, we conducted sampling on one pre-pilot household and three pilot households. All households were convenience samples. To maintain confidentiality of the households, households are referred to only by the county they are in. The households are described below.

Pre-Pilot Household- This is a single family house constructed in 1920s, located in suburban Yolo County. This single-story house has 2 bedrooms and 1 bathroom, with an area of approximately 1,000 sq ft. This house is occupied by a married couple and one child. The pre-pilot was conducted on June 13, 2013. The floor is primarily hardwood. The house had both central heat and central air. It was not near any busy roads.

Household 1- This is a rented one-story single family home in Sacramento County. Based on public records, the house was built in 1940s with an area of approximately 1,000 sq ft. The house is equipped with a gas wall heater and a portable air conditioner, and is primarily carpeted. This house is in an urban/suburban setting, around 2-4 blocks away from a busy road, and about 1 mile from several gas stations and a dry cleaner. The participating child in this household is about 11 years old. By observation, the child appeared to have a developmental delay. As indicated in the Symptom Diary, a window was open >2 hours on three days in the first monitoring week and on four days in the second monitoring week.

Household 2 - This is a two-story single family house in suburban Placer County, owned by the participating family. The house was built in 1999 with an area of approximately 2,350 sq ft. The house has forced air system for both heating and air conditioning, and is primarily carpeted. This house is one block away from a major roadway, about 1 mile from freeway, about ¼ mile from a dry cleaner. The participating child in this household is 10 years old. As indicated in the Symptom Diary, a window was open >2 hours on one day in the first monitoring week, and on no days in the second monitoring week.

Household 3 – This is a rented two-story unit within an apartment complex in suburban Yolo County. The unit was located in a building housing three units. It was built in 2005, with an area of 1250 sq ft. It equipped with central heating and air conditioning with forced air. The home is primarily carpeted. It is located within ¼ mile from farm/agriculture fields and is more than five blocks from any busy roads. The participating child in this household is 12 years old. As indicated in the Symptom Diary, no windows were open >2 hours on any day in the first monitoring week, and a window was open >2 hours on three days in the second monitoring week.

4. Results

4.1 Summary of pre-pilot results

4.1.1 Consent Visit (30 minutes)

Time is expressed in units of hour (h), minute (m), and second (s) below. They were recorded for our planning purposes and are likely to change over the course of the study.

- Introduction (6m 30s)
    - Introduce ourselves and greet the participant.
- Consent form (15m 30s)
    - We read the consent form to the participant and paused several times to ask the participant if she had any questions and to answer the participant's questions. The time spent on reading the consent form felt rather long but nothing can be done about this.
    - When we read the consent form to the participant, the participant was confused by the wording in one section. When describing what the participant will be asked to do in the study, the IRB requires specific language stating the maximum potential number of activities, but not stating that this is the most likely number of activities as the participant may drop out at any time. For example, "Allow study staff to come to your home, at prearranged times, for 1-2 hours up to 8 times in a two year period." However, we are not permitted to change the wording of the consent form, as it is required by the IRB to follow the specific format. To alleviate this confusion, we plan to provide participants with a hard copy of the visit schedule. We will explain the actual anticipated schedule in addition to reading the consent form.
    - The participant asked about the size of the stand-alone air cleaner. We plan to provide participants with a picture of the air cleaner next to a reference object to show its size.
    - At the end of the consent form, there is a line for the parent to sign the form, but the wording on the consent form is "Signature of Subject". This is confusing, as the

parent who signs this parental consent form is not the subject. We cannot change the wording, as the wording is required by IRB. We plan to verbally explain to the participants that they sign the form on behalf of the child while pointing to the place they sign.

- To set up future payment for the reimbursements of electricity to the participant, we need to fill out a check request form. While filling in the form, we asked the participant's social security number (SSN) for payment purposes. The participant paused to ask why we need the SSN. We explained it is the university's policy to have the payee's SSN before making any payment. We plan to add an option in the check request form, allowing participants to choose whether they prefer to be reimbursed for electricity charges by a gift card (which does not require a SSN) or reimbursed by cash (requires a SSN).

- After finishing the consent form, we asked to schedule the next visit. The participant asked if she can prepare dinner while answering questions during that visit. We informed the participant we would cooperate with the participant's activities as much as we can.

- Symptom Diary (4 m)
  - We showed the participant the Symptom Diary. She looked at it quickly and asked a question about the last two questions (discussed below). We are not sure if they read all of the questions and only had a question about the last question, or if they only read the last question. We felt we should allow time and ask to participant to read all of the questions or offer to read the questions to the participants and will plan to do this during the pilot and main study to assure they have no questions on the symptom diary.

  - The second to the last question, Q17 in the Symptom Diary asks "How many hours did your child spend indoors at home?" and the Q18 asks "How many hours did your child spend outdoors today?" The participant asked if they were to report on time spent outdoors at home as in the previous question, or outdoors in general. As we will now be reading all the questions to the participant, we will specify that we mean all time spent outdoors.

4.1.2 Enrollment Visit (1 hour 30 minutes)

Overall, in this visit, the questionnaire and health measurements took a longer amount of time than the air sampler set-up, so we plan to make some modifications to our questionnaire and procedures, including 1) moving the home walkthrough section to the intervention visit, 2) rearranging the questionnaire to make it flow better and reduce walking from room to room, and 3) having the air sampler set-up staff set up the stadiometer, the portable device for measuring height. Hopefully, after these modifications, the time needed for both staff will be balanced and the total visit time will be shortened. We will test our modified procedure in the pilot study.

- Introduction (3 m)

- Baseline Questionnaire (40 m)

  - We plan to make a question by question (Q by Q) for the Baseline Questionnaire after the pilot study. While we read the questions to the participant, the participant asked questions when they were not clear what was being asked. We are collecting these questions from participants during the pre-pilot and pilot and will address them in the Q by Q as these are likely questions the participants will have. The Q by Q is to make sure our responses are consistent across staff to all participants.

  - Question Q9 in the Baseline Questionnaire (shown below) asks if anything listed in the table makes the child's wheezing problems worse. As we went through the list, we realized that a participant may have never been exposed to or had the listed trigger. For example, the child may have never have bronchitis. Also, they may not be sure if the trigger worsens symptoms. We therefore modified the table by adding the two columns, "never had" and "Don't know". In addition, the participant looked confused when we asked whether "cold air" and "smog" make her child's wheezing problems worse.

    9. Do any of the following make [CHILD]'s wheezing problems worse? ***(Read all categories)***

	No	**Yes**
Colds		
Sinus infections		
Bronchitis		
Pets or other animals		
Dust		
Aspirin		
Smog		
Cigarette smoke		
Wood smoke, as from a campfire, fireplace or wood burning stove		
Strong smells		
Perfumes		
Cold air		
Exercise		
Pollen		
Wind		
Other (specify) :		

  - Question Q9b of the Pre-intervention Recall Questionnaire asks
    9b. During the <u>last 14 days</u>, how many hours did you miss from work because of problems associated with your child's asthma? [If necessary, review with caretaker the number of hours per week he/she works.]

    ___ ___ hours

The participants questioned if we need to count the work days missed by her spouse. We are addressing this by adding a question about other caregivers missing work days because of the child's asthma.

During the last 14 days, did any other of [CHILD]'s caregivers miss work because of problems associated with [CHILD]'s asthma?

☐ No [SKIP]

☐ Yes

a. During the last 14 days, how many hours did they miss from work because of problems associated with [CHILD]'s asthma?

___ ___ hours

i. In general, how many hours per week do they usually work?

___ ___ hours/week

- Question Q13 of the Pre-intervention Recall Questionnaire asks
  13. During the last 14 days, how many days has your child had a gritty feeling/ red/ itchy eyes or watery eyes? _____ Days

  The participant looked confused by the statement "gritty feeling eyes". We had similar concerns when practicing the questionnaire among ourselves. We rephrased the question to list more common symptoms first, distracting participants' attention from the statement, "gritty feeling eyes".

  13. During the last 14 days, how many days has your child had a red/itchy/watery eyes, or a gritty feeling in their eyes? _____ Days

- Question Q15 of the Pre-intervention Recall Questionnaire asks
  15. During the last 14 days, how many days has your child taken oral anti-histamines?
  _____ Days
  Since children may take anti-histamines for other reasons or the participant may not know what anti-histamines are used for, we want to make clear that we are asking about use for allergies, so we rephrased the question to

  15. During the last 14 days, how many days has your child taken oral anti-histamines for allergies? _____ Days

- Question Q18 of the Pre-intervention Recall Questionnaire asks about overnight stays in the hospital, and then Question Q19 asks about emergency room visit. Then question Q19c (shown below) asks about overnight stays in the hospital that resulted from emergency room visits. We feel Q19c is similar to Q18a (shown below), therefore, we decided to remove Q19c.
  19c. How many times did any of these emergency room visits result in an overnight stay at the hospital? _____ Times

i. When were these visits? (what month/s)

☐ January

☐ February

☐ etc.

18a. During the last year, because of problems with asthma, how many times has your child stayed overnight in the hospital? _____ Times

a. When were these visits? (what month/s)

☐ January

☐ February

☐ etc.

- Question Q19c of the Baseline Questionnaire asks the primary caregiver's current marital status, as shown below.

19c. What is his/her (or yours) current marital status?

☐ Married/ Co-habituating

☐ Divorced / Separated

☐ Single

☐ Widowed

☐ Separated

☐ Other : _____

The participant looked uncomfortable when answering this question about marriage status. The participant is married. We are not clear why she looked uncomfortable and do not plan to make any change at this time.

- It took us 21 minutes to finish the questions before the home walkthrough part. The home walkthrough part took an additional 25 minutes. We feel that including both portions of the Baseline Questionnaire is too long for the participant. As a result, we plan to move the majority of the home walkthrough part of the questionnaire to the Intervention Visit. The only exception would be questions on the child's bedroom, because we need to determine the size of mattress so that we can bring the right size mattress cover at the intervention visit. We do not see any reason that any of the participant answers to the home walkthrough will change as a result of having had the air in their home sampled for one week.

- Questions Q43-45 of the Baseline Questionnaire ask about the location of each room, mold presence in different rooms, and type of flooring in each room, for example,

44. Mold:

	Evidence of moisture or leaks?	Mold/ Mildew on Ceiling?	Mold/ Mildew on Walls?	Mold/ Mildew on Window?	Musty Smell?	Approximate size (sq ft)
Child's Bedroom	No Yes	No Yes	No Yes	No Yes	No Yes	
Main Living Area	No Yes	No Yes	No Yes	No Yes	No Yes	

To reduce unnecessary walking back and forth in the participants' houses, we decided to print these questions on a separate page, so that we can easily put answers on that page whenever we walk in that room. At the end of the walkthrough, we will confirm that the questions have been answered for each room.

- During the Baseline Questionnaire interview, we walked back and forth into different rooms and places of the participant's house when answering different questions. We also felt that some questions would be just as easily asked without being in the room, and moved those to the beginning to avoid making the participant stand for so long. We felt it is necessary to rearrange the questionnaire so that it flows better and questions about one room can be answered in one trip to that room. Also, when we asked about secondary heating, the participant told us they used the stove for heating, so we moved the questions about using your stove for heating to follow the heating questions.

- Question Q27b of the Baseline Questionnaire asks
  27. What is the one main heating system used the most in your home? Can you show it to me? ***(Have them show you what they use, do not read the answers)***

  ☐ Forced air (central warm air furnace with ducts to individual rooms)
  ☐ Gas (from pipes)
  ☐ Electricity
  ☐ Bottles/tank LP/Propane
  ☐ Other _____
  ☐ DK/RF

  a. How often do you replace/change/clean your filter for this heating system?
  _____Times per year

  b. Does your system have an additional outdoor air intake?
  ☐ No
  ☐ Yes
  ☐ DK/RF

The participant was very confused about the outdoor air intake. She thought she had outdoor air intake, but it was very clear she didn't know what an outdoor air intake was. We feel this will be a difficult and confusing question for many of the participants, and they are probably not going to be able to give us a correct answer. In addition, we anticipate only very few homes of children with uncontrolled asthma will have an outdoor air intake. We think the vast majority of homes with an outdoor air intake will be new homes (less than 5 years old) or homes that installed a new central system within the last five years and thus added a question to determine if the home or central system is new, and only ask the question on an outdoor air intake.

- Question Q28 of the Baseline Questionnaire, shown below, asks about the use of the main heating system. The participant was confused when we asked about use "during the day", "during the evening" and "during the night" one right after another. We feel it would be helpful if we could give participants an overview of what time periods we are going to ask about before asking them one by one, so we added a statement "I'm going to ask about use during the day, evening, and nighttime" before Q28a.

28. Typically, how often do you use your main heating system during the cold months?

- ☐ Most days
- ☐ About ½ the days
- ☐ Not very often
- ☐ DK/RF

I'm going to ask you about the use during the day, evening, and nighttime.

a. On the days you use this heating system, do you use it during the day?

- ☐ No
- ☐ Yes
- ☐ DK/RF

b. On the days you use this heating system, do you use it during the evening?

- ☐ No
- ☐ Yes
- ☐ DK/RF

c. On the days you use this heating system, do you use it during the night?

- ☐ No
- ☐ Yes
- ☐ DK/RF

As noted above, we also felt that the order of the questions in the home walkthrough portion of the Baseline Questionnaire needed to be adjusted. We have reordered the questions and conducted that portion of the questionnaire in a staff member's home to confirm the flow of the questionnaire and found that it was improved.

- Measuring height and weight (17 m)

  - We measured the height using a stadiometer (Figure 3) and measured the weight using a scale. BMI was calculated after the height and weight were obtained.

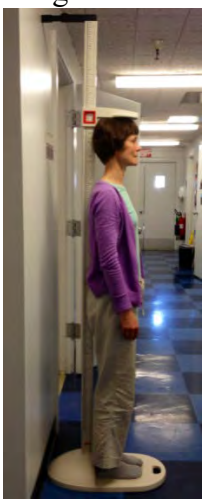

Figure 3. Measuring height using a stadiometer

  - The set-up of the stadiometer took 5 minutes, longer than we expected. As shown in Figure 3, the stadiometer has a base that is placed against the baseboard, and an extension at the top that is placed against the wall. The pre-pilot home had an extremely wide quarter round adjacent to the baseboard, making the back of the stadiometer too far from the wallboard for the extension at the top to touch the wall. We tried to set up the stadiometer at several places around the home, which took some time. Ultimately, we placed it in a doorway to alleviate the problem created by the quarter round. We expect this may be a common problem in participants' homes and will make a note in the protocol that a door way can be used if it cannot be set up against a wall.

    Since completing the questionnaire and health measures takes longer than the air sampler set-up, it is more efficient to have the staff who sets up air samplers set up the stadiometer, specifically, the stadiometer will be set up while the air sampler pumps are warming up.

  - Once the equipment was set-up, measuring height and weight went well and took 11 minutes.

- It took us 4 minutes to calculate the BMI. BMI must be calculated at the visit because for obese children, we must check the blood pressure to determine if we can conduct spirometry. The calculator we currently use was not very efficient as intermediate values needed to be written down. We plan to order a different calculator, which can be programed with the BMI formula, saving time and reducing the chance for errors.

- Spirometry (13m 30s)
  - Spirometry went very well.
  - The mouthpiece of the spirometer comes in a sealed plastic bag. The participant is given the bag so they can open it themselves and thus they are the only one who touches it. It may be difficult for children to open the bag. We will add a pair of scissors to the toolbox, so participants can use them when needed. This also applies to eNO and peak flow measurements. Both have mouthpieces that come in sealed plastic bags.

- Show the participant how to measure peak flow (8m 30s)
  - Demonstration of the peak flow measurement went very well.

- Schedule next visit (2m)

The tasks above were completed by one staff member and the total time for the tasks was 1 hour and 30 minutes. The following activities were conducted by the other staff member.

- Air sampler set-up (1h 7m)
  - Air sampler set-up was done by another staff concurrently while the questionnaire and health measurements were collected. Below is the time spent on each task:
    - ✓ It took 10 minute to bring equipment into the home, unpack it, and get ready to set up the equipment.
    - ✓ It took 27 minute to turn on all pumps for warm-up, chose sampler locations indoors and outdoors, and set up the tripod outdoors.
    - ✓ It took 30 minute to set-up air samplers indoors and outdoors, including filling out field logs, checking flow rates, installing samplers, turning on the pump boxes, and positioning the pump boxes.
  - When we turned on the pumps to warm up in the home, we left the pump boxes open, and the noise drew the participant's attention. In the future, we will close the pump boxes while the pumps are warming up to eliminate noise.
  - We interrupted the questionnaire to ask the participant about the sampler location and which potential locations would be acceptable. We also needed to ask how to assess the yard. We plan to move these questions to the initial conversation, so that conducting the questionnaire will not be interrupted.
  - When selecting the sampling location outdoors, it occurred to us that there is the possibility some apartments will not have a balcony or outdoor space. We note that in a limited number of cases, we may not be able to set up an outdoor sampler. This would exclude the participant from analyses involving the I/O ratio, but not from analysis involving the indoor concentration. Analyses involving the I/O ratio are very well powered and thus this will not impact our ability to determine changes due to

added filtration. For PM2.5, we may also consider using the average value from other monitors collected at the same time as PM2.5 does not vary that much within a region.

- The current instructions on the field sampling protocol indicate that we place the Ogawa sampler in the inlet stream before the PM sampler is set up. However, when operating in the field, we felt it would be more efficient to measure flow rates of all pumps for the PM samplers before setting up the Ogawa sampler. We plan to revise the protocol.

4.1.3 Intervention Visit (1 hour)

- Introduction (1m)

- Collect Symptom Diary and Piko device (5m)

- Baseline Questionnaire Part II (22m)
  - There were no problems with any of the questions in the Baseline Part II. As noted previously, we plan to move additional questions to part II. We anticipate that this will bring the total length of time to 40 minutes

- eNO measurement (13m 30s)
  - Our plan was to start with eNO measurement in this visit, however, after we turned on the NIOX MINO, we remembered it requires up to 30 minutes to warm up. We need to change the eNO protocol to turn the NIOX MINO on for warm-up, start the questionnaire, and then conduct the eNO measurement.
  - In the pre-pilot house, the power outlet was a little bit too far from where we sat for the interview, so we ended up holding the MINO in an awkward position while the participant was completing the test. Will we bring a power extension cord in the future for the NIOX MINO.
  - The NIOX MINO makes an unexpected funny sound, and the participant laughed during the first trial. We will play the demo mode to get them familiar with the sound prior to the testing.

The total time for the first staff member was 40 minutes 30 seconds. The following activities were conducted by the other staff member, and the total time for the second staff was 55 minutes.

- Air sampler Takedown (25m)
  - The air sampler take-down was done by another staff concurrently with the questionnaire and eNO measurement. Air sampler take-down includes taking down Ogawa and HOBO, measuring flow rates, turning off pumps, and filling out all the field logs. For the outdoor sampler, we also need to take down the tripod and tape placed on the extension cord.

- Set-up Stand-alone Air Cleaner (20m)

- There were no problems setting up the stand-alone air cleaner in the main living area.
- The participant had to move some toys for us to place the air cleaner in the child's room.

- Install Mattress Pad Cover (10m)
  - There were no problems installing the mattress pad cover.

4.1.4 Filtration Evaluation Take-down Visit Activities

Activities conducted include:
- Record air cleaner usage information (2m)

- Dust Collection (25m)
  - Tasks include measuring the bed and floor, selecting the area to be vacuumed, vacuuming, and putting the bedding back in place. Among these tasks, measuring the bed and floor took most of the time.
  - Dust collection went well.

4.1.5 Time evaluation for Filtration Evaluation Set-up and Take-down visits

Based on the time each item took in the Enrollment and Intervention visits, we have estimated the time for each of these visits below. We indicated if staff "A" or "B" had primary responsibility for the activity. Total visit time is based on the field staff with a longer time needed for their responsibilities. A few minutes are added for the introduction and other pleasantries.

Filtration Evaluation Set-up Visit (1 hour 10 minutes)	• *Set up air quality monitoring (PM and ozone) (1h 7m)* "A" • *Record air cleaner usage information (2m)* "B" • *Recall questionnaire (8m)* "B" • *MiniPAQLQ (5m, estimate)* "B" • *Begin 1-week symptom diary (3m)* "B" • *Begin 1-week peak flow monitoring (2m)* "B"
Filtration Evaluation Take-down Visit (55 minutes)	• *Record air cleaner usage information (2m)* "B" • *Take-down air quality monitoring equipment (25m)* "A" • *eNO measurements (13m 30s)* "B" • *Review symptom diary with participant (4m)* "B" • *Collect peak flow monitor (1m)* "B" • *Collect Dust sample (25m)* "A"

We note that based on current time estimates for the Filtration Evaluation Set-up visit, the staff conducting the air quality measurements has a longer time commitment than the staff interacting with the participant. We anticipate the air sampler set-up time may be reduced somewhat, but it will likely often be longer than the direct participant interaction activities. In these cases, the staff interacting with the participant will help once they have completed their activities.

Likewise in the take-down visit, the primary air sampler staff will take down the indoor sampler and then begin dust collection. If the second staff completes interactions with the participant, they will take-down the outdoor air sampler while the dust is being collected.

4.2 Summary of pilot results

4.2.1 Overview

Due to a problem with our IRB submission, some changes were made to the scheduled visits. In some cases, an extra visit was conducted to collect the air samplers from the pump boxes, and in one case, the first-week sample period was extended to 12 days. We conducted four visits in pilot home #1, three visits in pilot home #2, and four visits in pilot home #3. Table 5 indicates the elements that actually occurred at each visit.

Due to the fact the different elements took place on different visits, we present the pilot results by the instrument being used for data collection, rather than the visit number.

It is very common for participants to reschedule appointments. Pilot home #2 called 30 minutes before their visit to ask us to come one hour later, but we were already on the way to their home, so we ended up waiting in a parking lot for an hour. Pilot home #3 rescheduled twice for the first visit and reschedule twice for the third visit. The child in the pilot home #3 started a dog walking business without informing the parent, so she was only present at the second visit for 30 minutes. Surprises like this may occur in the main study.

We additionally had some changes from our original plan in terms of who conducted the specified tasks and who observed for each visit. Ms. Shahin, who was scheduled to administer the questionnaires and conduct the health measures had to go out of town for a family emergency and could not participate in the later visits. Ms. Moran, who had trained Ms. Shahin, or Dr. Bennett conducted the questionnaires or health measures, with either Dr. Bennett or Ms. Moran observing. Dr. Wu, originally scheduled to observe, cannot drive in the dark and most visits were in the evening, and therefore, she was not able to go as she would have been unable to get home. Observing was conducted by either Dr. Bennett or Ms. Moran. Dr. Wu will serve as the QA/QC observer in the main study and her inability to drive in the dark will not be a problem, as she will always be in the car with another staff member in the field. Further, some visits were rescheduled to the weekend, limiting staff availability when we only had two staff, one staff did everything and the other observed. For the main study, we will have two teams of two plus back-up staff in case of illness or vacation. All will be well trained.

The combined consent and enrollment visits were conducted on July 18th for pilot home #1 and #2 and on July 19th for pilot home #3. We had a debriefing after the first two visits and made necessary adjustments to the questionnaires and protocols, so that the modifications could be tested in the third visit. In the first two visits, Ms. Shahin conducted questionnaire interviews and health measurements and Dr. Bennett observed. Ms. Moran was in charge of air sampling set-up. Ms. Roudneva also helped with the air sampling set-up in pilot home #2, because the air sampling set-up in pilot home #1 took longer than we expected and we had both indoor and outdoor duplicate PM sampling in pilot home #2. In the visit to pilot home #3, Ms. Shahin

conducted questionnaire interviews and health measurements and Ms. Moran observed. Dr. Bennett conducted the air sampling set-up with Ms. Roudneva's assistance, so she could see firsthand how the equipment worked in a field setting. The staffing for the remaining visits is listed in Table 5. There were a few switches in who conducted vs. who observed on specific tasks. Specifically, Ms. Moran collected the dust sample at pilot homes #1 and #2, and Dr. Bennett conducted the Baseline Interview Part 2 at pilot home #3.

Table 5. Activities occurred at each pilot visit

	Pilot home #1 - Sacramento County	Pilot home #2 - Placer County	Pilot home #3 - Yolo County
Visit 1	**Consent and enrollment visit** (conducted on July 18th by Ms. Moran, Shahin and Roudneva, observed by Dr. Bennett) • *Written Informed Consent Obtained* • *Baseline Questionnaire Part 1 (including Recall Questionnaire)* • *MiniPAQLQ* • *Set-up air quality monitoring equipment (PM and ozone)* • *Begin 1-week peak flow monitoring* • *Begin 1-week symptom diary*	**Consent and enrollment visit** (conducted on July 18th by Ms. Moran, Shahin and Roudneva, observed by Dr. Bennett) • *Written Informed Consent Obtained* • *Baseline Questionnaire Part 1 (including Recall Questionnaire)* • *MiniPAQLQ* • *Spirometry* • *Set-up air quality monitoring equipment (PM and ozone)* • *Begin 1-week peak flow monitoring* • *Begin 1-week symptom diary*	**Consent and enrollment visit** (conducted on July 19th by Ms. Shahin and Roudneva and Dr. Bennett, observed by Ms. Moran) • *Written Informed Consent Obtained* • *Baseline Questionnaire Part 1 (including Recall Questionnaire)* • *MiniPAQLQ* • *Spirometry* • *Set-up air quality monitoring equipment (PM and ozone)* • *Begin 1-week peak flow monitoring* • *Begin 1-week symptom diary*
Visit 2	(collected on July 26th) • *Take down air quality monitoring equipment* (no interviews conducted)	**Intervention and filtration evaluation set-up visit** (conducted on July 29th by Ms. Shahin and Roudneva, observed by Ms. Moran) • *Take down air quality monitoring equipment* • *Review one-week symptom diary in person with participant* • *Collect peak flow meter* • *Install and instruct participant on use of stand-alone air cleaner* • *Install Mattress pad covers* • *Set up air quality monitoring (PM and ozone)* • *Begin 1-week symptom diary*	(collected on July 26th) • *Take down air quality monitoring equipment* (no interviews conducted)

Visit 3	**Intervention and filtration evaluation set-up visit** (conducted on Aug. 1st by Ms. Moran and Shahin, observed by Dr. Bennett) • *Install and instruct participant on use of stand-alone air cleaner* • *Set up air quality monitoring (PM and ozone)* • *Baseline Questionnaire Part 2* • *Recall Questionnaire* • *MiniPAQLQ* • *eNO measurements* • *Review symptom diary* • *Collect peak flow* • *Install Mattress pad cover* • *Begin 1-week symptom diary*	**Filtration evaluation take-down visit** (conducted on Aug. 5th by Ms. Moran and Roudneva, observed by Dr. Bennett) • *Take-down air quality monitoring equipment* • *Baseline Questionnaire Part 2* • *Recall questionnaire* • *MiniPAQLQ* • *Record air cleaner usage information* • *eNO measurments* • *Review symptom diary with participant* • *Collect Dust sample*	**Intervention and filtration evaluation set-up visit** (conducted on Aug. 3rd by Ms. Moran and observed by Dr. Bennett) • *Install and instruct participant on use of stand-alone air cleaner* • *Set up air quality monitoring (PM and ozone)* • *Baseline Questionnaire Part 2* • *Recall Questionnaire* • *MiniPAQLQ* • *eNO measurements* • *Review symptom diary* • *Collect peak flow* • *Begin 1-week symptom diary*
Visit 4	**Filtration evaluation take-down visit** (conducted on Aug. 8th by Ms. Roudneva and observed by Ms. Moran) • *Take-down air quality monitoring equipment* • *Record air cleaner usage information* • *Review symptom diary with participant* • *Collect Dust sample*	No 4th visit	**Filtration evaluation take-down visit** (conducted on Aug. 9th by Ms. Roudneva and observed by Dr. Bennett) • *Take-down air quality monitoring equipment* • *Record air cleaner usage information* • *Review symptom diary with participant* • *Collect Dust sample*

4.2.2 Baseline Questionnaire Part 1

We note that we moved questions as a result of the pilot. All questions are referenced by the number in the questionnaire used in the pilot. Revised questions are listed with the number in the final instrument.

- Question Q4a (shown below) needs a skip pattern. We realized that if a child did not have a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu in the last 12 months, the answers to Q4b (which asks whether the child had these symptoms after being in contact with furry animals), Q4c (which asks whether the child had these symptoms after been in contact with mold) and Q4d (which asks whether the child had these symptoms after been in contact with pollen) will be "No". Therefore, we decide to add a skip pattern, that is, if one answers "No" to Q4a, they will skip Q4b, Q4c, Q4d to Q5.

  4a. During the **<u>past 12 months</u>**, has [CHILD] had a problem with sneezing, runny or blocked nose, or itchy/watery eyes when s/he did not have a cold or the flu?

  ☐ No → skip to question 5

  ☐ Yes

☐ DK/RF

4b. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around or in contact with furry animals?

4c. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around mold or a musty smell?

4d. During the **past 12 months**, has [CHILD] had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after being around pollen?

- Question Q9 (shown below) asks if anything listed in the table makes the child's wheezing problems worse.

10. Do any of the following make [CHILD]'s wheezing problems worse? ***(Read all categories)***

	Yes	No	Never Had	DK/RF
Colds				
Sinus infections				
Bronchitis				
…..				
Other (specify) :				

The child participant in pilot home #3 has cough predominant asthma rather than wheezing predominant asthma. When her mom was answering this question, the participant thought many items make her asthma worse because she coughs when that exposure occurs. As the intent of the question is to determine triggers, we revised it to "Do any of the following make [CHILD]'s asthma symptoms including wheezing, coughing, chest tightness or shortness of breath worse?

- Question Q11 of the Baseline Questionnaire asks about medication. This question did not go smoothly. It is very common that patients do not follow their doctor's directions for taking medicines. They may use long-acting controller medicine as rescue medicine or use short-acting rescue medicine as controller medicine. After the first two pilot visits, we slightly modified the medications section.

  However, we continued to have problems collecting information on the medicine in pilot home #3. Now we have decided to write down all of the medicines that they use and then go through all of the questions related to each medicine one by one, rather than to try to collect information based on type of medication.

In addition, since participants may need to bring the medications to the room to recall the details, we have decided to move this section right before the questions on child's bedroom, to reduce unnecessary walking back and forth in the participants' house.

We have adjusted the medication section to ask the following questions:

Please tell me (show me) all the medications [CHILD] is currently taking for asthma: ***(Record each medication in the table below, under Medication Name, then read each questions below and record the answer for each medication in the table)***

a. How often was [CHILD] directed by his/her doctor to take this medication? You can answer in times per day, as needed, or prior to exercise.

b. How many times per week does [CHILD] use this medication?

c. For his/her rescue inhaler, how many puffs does he/she use at a time?

- Question Q17 and Q18 (shown below) ask about use of rescue inhaler to relief asthma symptoms.

17. During the last 14 days, how many days did your child use their rescue inhaler during the day for relief of asthma symptoms? Please do not include use of the recue inhaler taken prior to physical activities such as playing sports or exercising.

_____ Days

18. On average, on the days your child used their rescue inhaler, how many puffs/inhalations did your child use each day?

_____ Puffs

One of our pilot participants had her son use the rescue inhaler on two days prior to going to camp where the child would be running around a lot and he was starting to show symptoms, and then also used it at the end of the day because he did show symptoms. Another pilot participant always uses her rescue inhaler regularly before running, but if she's playing other sports she only uses it if her asthma "seems worse".

We realized that defining use prior to sports as preventative or due to symptoms is sometimes difficult to quantify. We are going to add specification on this to our Q by Q to obtain consistency. If the participant always uses the inhaler prior to the specified activity, we will consider it preventative. If it is only sometimes used before that activitiy, depending on condition of asthma, it will be considered to relieve symptoms.

- Question Q27 asks

13. During the last 14 days, how many days has your child had a red/itchy/watery eyes, or a gritty feeling in their eyes? _____ Days

As we encountered in the pre-pilot, the participant looked confused by the statement "gritty feeling eyes". We rephrased the question to

During the last 14 days, how many days has [CHILD] had red/ itchy eyes, watery eyes, or irritated eyes?

The parent in pilot home #1 was annoyed when answering questions on hospitalizations in the last year, as she has told the interviewer that her child had never been hospitalized in a previous question. However, we cannot skip these questions, as for some participants, they are relevant. We decided to add a screener before Q30, as shown below.

"THE NEXT FEW QUESTIONS ARE ONES YOU HAVE ALREADY DEALT WITH TO SOME EXTENT, SO BEAR WITH ME. I NEED TO ASK THE QUESTIONS JUST AS THEY ARE WODED HERE, AND I WOULD LIKE YOU TO GIVE ME THE ANSWER TO MAKE SURE WE HAVE IT RIGHT. I AM GOING TO ASK YOU ABOUT THE EFFECT OF [CHILD]'S ASTHMA IN THE LAST YEAR."

- Question 35 (shown below) asks about doctor visits due to asthma. The participants had a hard time only reporting doctor visits that related to asthma. We're going to add to our questionnaire that each time they report a doctor visit we are going to confirm that the visit was related to an increase in their child's asthma symptoms.

  During the last year, because of problems with asthma, how many times has your child been seen in the doctor's office or clinic for a sick visit?

- Question Q42d asks about the employment status of the primary caregiver. Since we have asked the respondent's employment status in Q31, we decide not to ask this question if the respondent is the child's primary caregiver.

- Question Q43 asks if there is a secondary caregiver. In pilot home #1, the respondent (parent) said both sides of the grandparents help take care of the child, and had difficulty identifying one person. In pilot home #2, the mother stated both parents were the primary caregiver, and ultimately selected the parent as the primary caregiver. However, when we asked about other caregivers, they forgot the father but starting talking about grandparents. We gently reminded them about the father, who was sitting at the table. This resulted in a lively family debate about whether or not the father actually did more than the grandparents. The father was ultimately selected as the other caregiver. The participant in pilot home #3 had no problem with this question as she administers questionnaires as part of her job. However, given that the first two households had difficulty answering the secondary caregiver question, combined with the fact that we already know if the primary caregiver is either married or cohabitating versus single or divorced, we do not think that question adds much information. We do find out the education level of the secondary caregiver which can be used as a measure of socioeconomic status, but this will not impact how

the participant responds to having clean air, but rather just serves to define the population. We have a question in the questionnaire asking about household income level which is a good measure of socioeconomic status. Therefore, given our time constraints, we plan to remove the questions about the secondary caregiver.

4.2.3 Baseline Questionnaire Part 2

- Q4 asks about whether a participant's home was rented or owned. ARB suggested we reword the question as follows:

  Before: Is your home rented or owned?

  ☐ Rented

  ☐ Owned

  ☐ DK/RF

  After: Do you rent or own this home?

  ☐ Rented

  ☐ Owned

  ☐ DK/RF

- Q5 and Q6 (shown below) ask about the year when the home was built and the square footage of the home. The first pilot participant appeared to have difficulty in providing this information, and from previous experience people living in apartments usually do not know the year when the building was built. We would like to start the questionnaire with easier questions, so that participants do not feel discouraged. Therefore, we moved these two questions to a later part of the questionnaire.

  What year was your home built? ***(If participant is unsure, please have them estimate)***

  _____ year

  What is the square footage of your home? ***(If participant is unsure, please have them estimate)***

  _____ ft^2

  We also note that when we compared answers to available public records, one participant's answers were not very accurate. We plan to confirm responses with public records in cases where the public records are available online.

- Q8 and 9 (shown below) ask about the number of rooms in the home. We decided to move them to the walkthrough section and determine the information by inspection.

How many rooms are in the home? ***(Include kitchen, but not bathroom(s), closets, or halls.)***

_____ rooms

How many bedrooms are in the home?

_____ rooms

- Q13 (shown below) asks participants to estimate the distance to the nearest major road. Most participants cannot estimate the distance correctly. For example, one participant said the distance was 1 mile, and when we asked her to convert to blocks, she said 2 blocks. Instead to asking participants to estimate, we moved this question into the section of "home observation by staff". We will have the field staff answer this question. This can also be verified with an online GIS tool.

13. How close is the nearest freeway, major highway, major intersection, or street with substantial traffic?

☐ Immediately in front, behind or beside child's residence

☐ One block away, length of football field

☐ 2-4 blocks away

☐ More than 5 blocks away (more than ¼ mile)

☐ DK/RF

For Q14, likewise, participants also had a difficult time estimating if they were ¼ mile from the items in the list. Therefore, we want to add "maybe" as an answer choice. That way, if participants know the item is nearby, but are uncomfortable estimating if it is within ¼ mile, we have an option. Then we can look up the exact distance with an online GIS tool.

14. Is your home within ¼ mile of: ***(Read categories)***

	Yes	Maybe	No	DK/RF
Gas station				
Farm/ agriculture				
Industrial facility				
Railroad tracks				
Dry Cleaners				
Bus/Truck Depot				
Construction				
Waste processing or sewage treatment facility				

We used Google Map to determine accuracy of the responses. In pilot home #1, they listed gas station, dry cleaner, and bus depot, while in reality, they were about 1 mile from a dry cleaner and gas stations, and they were not near a bus depot but rather several bus stops. Home #2 reported to near dry cleaner and they indeed were about

¼ mile from a dry cleaner. Home #3 reported to near farm/agriculture field, which is also true.

- The use of the stove top and oven section, Q19-23, was moved and merged with kitchen section in the walkthrough part of the questionnaire, Q31-37 in the revised version. We created new answer options to the stove and oven questions, which are clearer.

  We added more instructions to have the staff observe the type of the range hood/fan over the stove top. One participant's home has a kitchen fan above the stove top. Another participant noted that his sister-in-law's house had a range hood that blew back into the kitchen. We updated the answer choices to give more choices.

  31. Can you show me your stove top? ***(Mark if it is gas or electric.)***

  ☐ Gas
  ☐ Electric **[Skip to]**
  ☐ DK/RF **[Skip to]**

  a. ***Ask the caretaker to turn on the stove top*:** "I would like to determine if your stove top has a continuously burning pilot light, can you please turn on your stove for me?" **[DO NOT ASK:** Mark how the **stove top is lit]**

  ☐ Electric starter
  ☐ Lit with a match
  ☐ Continuous burning pilot light
  ☐ DK/RF

  34. DO NOT ASK: Mark if there is a range hood/fan above the **stove top**. Can you turn it on for me? Can I look in the cabinet above?

  ☐ Range hood vented to outside
  ☐ Range hood that blows into kitchen
  ☐ Fan
  ☐ None **[Skip to]**

  "Now i'm going to ask you about your oven. By oven, I mean the part used for baking"
  35. Can you show me your **oven**/Can I take a look inside your **oven**? ***(Mark if it is gas or electric.)***

  ☐ Gas
  ☐ Electric **[Skip to]**
  ☐ DK/RF **[Skip to]**

a. **DO NOT ASK:** Mark how the **oven is lit**. **(*If stove and oven are a combined unit, mark the same answer as in the previous question, 35a. If you are unable to determine the answer from visual inspection, say:*** "Can you please turn on your oven for me?"***)***

☐ Electric starter

☐ Lit with a match

☐ Continuous burning pilot light

☐ DK/RF

The mold section, Q24-26, was modified to combine the walkthrough and recall sections of the questionnaire, Q41-42 in the revised version. The table that followed Q25 was updated. We added a column for water damage and combined and added a few new answer options.
Q24 was slightly reworded to make clear we are asking about the smell, not mold. One participant thought we were asking about mold again when they heard the question with the original wording.

Before: Has there ever been any moldy or musty smell inside your home?

After: Has there ever been any musty or moldy smell inside your home?

Below is an example of before and after change to the table.

Before

	Did you see the mold in:	When was the last time you saw mold? Would you say… **(Read categories)**	What was the approximate area of the moldy surface? (show templates, go to each room and have participant show you area to help estimate size) **(Read categories)**
Kitchen	☐ No ☐ Yes ☐ DK/RF	☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____

After

	Did you see the mold/water damage in: Mold Water Damage	When was the last time you saw mold/water damage? Would you say: ***(Read categories)***	What was/is the approximate area of the moldy surface? ***(Show Template)***

Kitchen	☐ No ☐ Yes ☐ Walls/ceiling-no water ☐ All windows/walls/ ceilings-w/water ☐ DK/RF	☐ No ☐ Yes ☐ DK/RF	☐ Current ☐ During the past month ☐ During the past 6 months ☐ 6-12 months ago ☐ More than a year ago ☐ DK/RF	☐ Less than 2 inches by 2 inches ☐ Greater than 2 x 2 inches but less than 1 square foot ☐ Greater than 1 square foot specify:_____

- Q27a asks how often the bathroom exhaust fan is turned on when showers are taken. We note that in many cases, the child will listen into the interview and may interject their own opinions on the answer. Our protocol is for us to take the parent's answer, which may or may not be the same as the child's answer. In one home, the child answered never, but the parent said always because the fan is on the same switch as the light. Based on the protocol, we took the parent's answer, but we realized later that the parent was incorrect. When we did the walkthrough, we noticed the fan and light were on different switches. We note that participants will sometimes provide inaccurate answers and we may or may not discover the true answer. No changes are being made, and we will continue to take the parent's answer when there is a difference.

- Q29 and Q31 ask about use of the heating system. (The two questions worded similarly, so only Q29 is shown below as an example.) We made several changes in this section.

  We originally asked the participant to show us the heating system, but it is hard to "show" a forced air system. One participant pointed to the vent, and the participant said he cannot show us the system because it is in the attic. We reworded to "Can you show me how you turn it on?", so that we can either see the heater or the thermostats, which can tell us the type of the heating system without leaving the participant with an unclear instruction. We also decided to directly ask the participants whether the heating system is run on gas or electricity. If participants did not know the answer with certainty, staff will ask additional questions to try to correctly ascertain this information or do a visual inspection if necessary. This is detailed in our Q by Q.

  Before:
  28. What is the <u>one main heating system</u> used the most in your home? Can you show it to me? ***(Have them show you what they use, do not read the answers)***

  ☐ Forced air (central warm air furnace with ducts to individual rooms)
  ☐ Gas (from pipes)
  ☐ Electricity
  ☐ Bottles/tank LP/Propane
  ☐ Other _____
  ☐ DK/RF

c. How often do you replace/change/clean your filter for this heating system?
_____Times per year

After:
19. What is the <u>one main heating system</u> used the most in your home? Can you show me how you turn it on? ***(Have them show you what they use, do not read the answers)***

☐ Forced air (central warm air furnace with ducts to individual rooms)

a. Is it run off propane, gas or electric?
- Gas (from pipes)
- Electric
- Bottles/tank LP/Propane (Can I see your propane tank?)
- Other _____
- DK/RF

b. How often do you replace/change/clean your filter for this heating system?

_____

The question 29b and 31b ask about the frequency of changing filter, we original had a unit, "times per year", but participants gave answers in different types of units. To save time needed to convert units during the interview, we decided to write down what they reported and convert units later during the data input.

- For Q30 (now Q20) and Q32 (now Q22), we changed "typically" to "this past winter", so that participants would have a clearer idea about what we are asking. We also added a question about use in the morning as it was noted by the participant in home #1, and was an appropriate answer for the other two participants as well. We also revised the preamble before the specific questions on the time periods because with four time periods to mention, it began to be a bit of a tongue twister. The revised Q30 is shown below, and Q32 is reworded in a similar way.

20. This past winter, how often did you use your main heating system during the cold months? Would you say: ***(Read categories)***

☐ Most days/Daily

☐ About ½ the days

☐ Not very often

☐ DK/RF

"Now, I am going to ask about the times of the day when you use your primary heating system."

a. On the days you use this heating system, do you regularly use it in the morning?

☐ No
☐ Yes
☐ DK/RF

- Q33 asks about other use of fireplace or wood stove. In the one home that had a fireplace, the participant asked what we meant by "purposes other than heating". We realized this was a difficult question to answer, as "entertainment" or similar words can conjure up either images of the family sitting around the fireplace or have a romantic connotation. We have reworded the question to avoid this wording. In doing so, we are now only asking about non-heating use for participants who do not use the fireplace for heating. We feel that if they use it for heating, heating use will outweigh non-heating use.

  Before:
  33. Do you ever use a fireplace or wood stove for purposes other than heating? Can you show it to me?

  ☐ No **[Skip to]**
  ☐ Yes
  ☐ DK/RF **[Skip to]**
  ☐ N/A

  a. Would you say you use a fireplace or wood stove for purposes other than heating more than 20 days out of the year?

  ☐ No
  ☐ Yes
  ☐ DK/RF

  After:
  23. ***(Only ask if they <u>don't</u> use a fireplace/wood stove for heating)*** Do you have a fireplace or wood stove?

  ☐ No **[Skip to]**
  ☐ Yes
  ☐ DK/RF **[Skip to]**

  a. How many days per year do you use this fireplace or wood stove?

- Q34 asks about the air conditioner or window unit. We re-formatted the question because the two questions seemed repetitive. Also, one participant had a portable air conditioning unit, which was added as an answer choice.

  Before:

34. Does your home have an air conditioner or window units?

☐ No **[Skip to]**

☐ Yes

☐ DK/RF **[Skip to]**

a. What do you use to cool your home? (***Have them show you what they use, do not read the answers)***

☐ Central Air (with ducts)

☐ Individual air conditioner units installed through walls or windows

i. Can you take me there to show me? How often do you set it to take in outside air? (For example, vent setting on >Open=) Would you say… (Right now its set to__, is it usually like that?)

☐ Always

☐ Sometimes

☐ Never

☐ DK/RF

☐ Swamp or desert cooler units installed through the roof, walls or windows

☐ Other: _____

☐ DK/RF

After:

24. What do you use to cool your home? Can you show me how you turn it on? (***Have them show you what they use, do not read the answers)***

☐ Nothing/Fan **[Skip to]**

☐ Central Air (with ducts)

☐ Individual air conditioner units installed through walls or windows

a. How often do you set it to take in outside air? (If vent is set to "Open"/ "Closed", say: "Right now it is set to open/closed, is it usually like that?)

☐ Always

☐ Sometimes

☐ Never

☐ DK/RF

☐ Swamp or desert cooler units installed through the roof, walls or windows

☐ Portable unit

☐ Other: _____

☐ DK/RF

- Q47 asks about flooring information. We removed specifying the carpet type (loop/plush/shag or other) from the table, so that we do not need to walk to every room. Some participants did not want us to walk into their master bedroom, so we just verbally discussed what type of floor in the room.

4.2.4 Recall Questionnaire

- We moved a question originally in the medication section to the front, as it asks about the last 14 days.

  14. During the last 14 days, how many days has [CHILD] taken Tylenol or other forms of acetaminophen? _____
  Days

- The Q13 asks if the caregiver was employed. In one home, the participant indicated that the question seemed random; therefore, we added an explanation phrase.

  "***The next question is about missing work due to [child]'s asthma***"
  Are you currently employed (working for pay)?

  ☐ No [SKIP]
  ☐ Yes
  ☐ DK/RF

- Q14 asks if any other caregivers missed work. One participant thought we were asking about the daycare when we asked "other caregivers", so we added some examples of other caregivers.

  During the last 14 days, did any other of [CHILD]'s caregivers (for example, another parent, aunt, or grandparent) miss work because of problems associated with [CHILD]'s asthma?

- Q15 (shown below) asks if there is any change to the child's medication. We then get out a paper obtained from the subject tracking database that lists each medicine they were taking the last time we talked to them and ask if they are still taking each of the medications. We then ask if they have started taking any new medications. We felt this question sounds like we did not believe what the participant said if they told us there were no changes, so we removed Q15. Now we just review old and new medications.

  i. Have there been any changes to [CHILD]'s medication in the past 3 months?

  ☐ No
  ☐ Yes

☐ DK/RF

ii. Is [CHILD] still taking the following medications? *(use list obtained from tracking system and mark the Y/N boxes next to each medication list from the previous interview)*

The new Q17 is

Please tell me (show me) any new or other medications that [CHILD] is currently taking for asthma.

☐ No new meds **[SKIP TO]**

☐ Yes, new meds

This question is followed by the table and questions to record the new medications.

- Q28 and Q29 ask about mold in participants' homes. We slighted reworded and changed the order of these two questions, so that we ask only about the bathroom first, and the rest of the house in the second question, rather than the other way around, which was awkward.

Before:
28. During the last 3 months, has there been mold on any surfaces inside [CHILD]'s home? (Do not include mold in the bathroom, or mold on food)

☐ No

☐ Yes

☐ DK/RF

29. During the last 3 months, has there been a large amount of mold on any surfaces in the bathrooms inside [CHILD]'s home?

☐ No

☐ Yes

☐ DK/RF

After:
25. During the last 3 months, has there been a large amount of mold (larger than a slice of bread) on any surfaces in the **bathrooms** inside your/this home?

☐ No

☐ Yes

☐ DK/RF

26. During the last 3 months, has there been mold on any surfaces in **any other rooms** inside your/this home? (Do not include mold in the bathroom, or mold on food)

☐ No

☐ Yes

☐ DK/RF

Below is a summary of health outcome data collected in Recall Questionnaires. The Recall Questionnaire collected in the first visit was part of the Baseline Questionnaire 1, and the recall period for unplanned health care use and occurrence of respiratory disease was the past year. The week 2 Recall Questionnaire would be the one used in the rest of the study and the recall period for unplanned health care use and occurrence of respiratory disease was the past 3 months.

Table 6 Summary of health outcome collected in Recall Questionnaires in pilot

Questions	Home#1 week 1 No filtration	Home#1 week 2 With filtration	Home#2 week 1 No filtration	Home#2 week 2 With filtration	Home#3 week 1 No filtration	Home#3 week 2 With filtration
Number of days with asthma symptoms during the last 14 days	0	0	2	1	0	1
Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during the last 14 days	0	0	2	0	0	0
Total number of puffs of using rescue inhaler during the last 14 days	0	0	4	0	0	0
Days of missed school due to asthma during the last 14 days	No school	No school	No school	No school	No school	No school
Days of missed work for parents due to the child's asthma during the last 14 days	0	0	0	0	0	0
Unplanned health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma during the last year (pre-intervention visit) or during the last 3 months (filtration evaluation takedown visit)						
Stay overnight in the hospital	0	0	0	0	0	0
Visit emergency room	0	0	0	0	0	0
Visit doctor's office or clinic for a sick visit	0	0	2	0	0	0
Number of times having respiratory diseases during the last year (pre-intervention visit) or during the last 3 months (filtration evaluation takedown visit)	0	0	2	0	2	0
Average daily allergy combined score	0	0	0.9	0	0	0.2

4.2.5 Symptom Diary

The participant from the pilot home #2 was not clear if she was meant to include sleeping hours or not. She also was not clear if she was doing just her home or inside any home and

acknowledged her responses may not be consistent. We will do more to stress what times to record in our oral instructions and will improve our written descriptions by adding the bold italics as follows:

How many hours did your child spend indoors ***at your home*** (please include sleeping time)?

The Symptom Diaries for pilot home #1 and #3 were complete for both weeks of the study. The participant from the pilot home #2 missed one question one day in the first-week Symptom Diary. When we reviewed the symptom diary with the participant, they were able to fill in the missing data point. The participant also missed three days in the second-week Symptom Diary. We reviewed the diary with the participant to obtain the answers. The participant was very confident of their answers. The participant in home #3 noted that it was more difficult to remember to do the Symptom Diary without the peak flow meter, but nonetheless, did not forget any days.

It took about 5 minutes to explain the Symptom Diary in the enrollment visit and 3-4 minutes to go over the Symptom Diary with participants when we picked up the diaries.

Below is a summary of health outcome data collected in Symptom Diaries.

Table 7 Summary of health outcome collected in Symptom Diaries in pilot

Questions	Home#1 week 1 No filtration	Home#1 week 2 With filtration	Home#2 week 1 No filtration	Home#2 week 2 With filtration	Home#3 week 1 No filtration	Home#3 week 2 With filtration
Number of days with asthma symptoms over one-week period.	0	0	2	0	0	2
Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during a one-week period	0	0	0	0	0	0
Number of puffs in total did the participating child use during a one-week period.	0	0	0	0	0	0
Days of missed school due to asthma	No school	No school	No school	No school	No school	No school
The overall condition of asthma, recorded as continuous integers indicating how bothered the participant was by their asthma (0-not at all /1-a little bit / 2-quite a bit / 3-a lot) and expressed as the average value over a one-week period	0	0	2 days level 1 reported	0	0	2 days level 1 reported

4.2.6 MiniPAQLQ

The MiniPAQLQ was answered by the child participants. We observed that children sometimes have different answers than their parents. In two of the homes, the parent questioned the child on their responses. We told the parent that children often have slightly different answers than their

parents, and that is why we ask both parents and children. After we told the parent that, in both cases the parent no longer questioned the child on their responses. We feel that our prepared response worked well and will continue to use it. The MiniPAQLQ usually took about 3-6 minutes to complete.

Table 8. MiniPAQLQ scores reported in pilot (ranging from 1 to 7, with 7 as the best condition)

Domain	Home#1 week 1 No filtration	Home#1 week 2 With filtration	Home#2 week 1 No filtration	Home#2 week 2 With filtration	Home#3 week 1 No filtration	Home#3 week 2 With filtration
Symptom score	7	7	6.5	6.83	6.83	4.67
Emotional function score	7	7	6.25	7	7	6
Activity limitation score	7	7	6	6.67	5	5
Overall	7	7	6.3	6.8	6.5	5.2

4.2.7 Spirometry

The spirometer broke on the way to pilot home #1 due to the poor suspension of the cargo van rented for the first day of the pilot. We now have a bag with a thick foam pad for the spirometer, so that it won't bounce in transit. In addition, we will use a mini cargo van in the main study, which is built based on car chassis providing a much gentler ride. The broken spirometer worked after a few days. We will check to make sure it is still performing well prior to using it in the main study.

Unfortunately, we needed to use our second spirometer which was not configured to save all maneuvers, but rather saved only the best maneuver by the individual. In order to configure it, a technician call needs to be scheduled and this could not be completed in the allotted time. Therefore, we were only able to record the best maneuver. We will configure it to save the best three maneuvers prior to the main study.

The participating child in pilot home #2 listened to and followed the directions but still had some difficulties as expected on the first few maneuvers. The child was able to do three that were likely acceptable, but unfortunately, only one was saved and so only one was reviewed.

The participating child in pilot home #3 had difficulty listening to directions. She attempted to do spirometry before receiving all the directions. We repeatedly asked her to stop and wait but she proceeded anyway. She also had a hard time following auditory directions during the coaching. The field staff was reluctant to be more forceful with stopping her as her parent is a colleague from UC Davis. We also were a bit taken aback by the preteen need for independence which may have also resulted in the lack of listening to directions. We feel we will be more prepared for preteen participants knowing in advance there is a good chance we will need to be a bit more forceful in our directions. Even so, the last attempt was a good attempt.

As only one test was saved from each child, we were unable to review the tests for repeatability. The one test that was saved was reviewed by Dr. Schenker and both were found to be acceptable.

The spirometry measurement took approximately 15 minutes, and it took approximately 4 minutes to measure weight and height.

4.2.8 eNO measurement

One eNO test was performed in each pilot home. The goal is to get 2 successful attempts in one test, but at maximum 6 attempts could be made. Table 9 shows the eNO measurement results in pilot.

Table 9. eNO measurement results in pilot

Home	Successful attempt 1	Successful attempt 2	Value used	Note
Home #1				No successful attempt
Home #2	67	64	65.5	
Home #3	31		31	Only 1 successful attempt

The child in the pilot home #1 appeared to have a developmental delay. The child tried three times to conduct an eNO measurement but did not blow into the machine long enough to get a valid result on any of the three attempts. Then the child got frustrated and did not want to do a fourth trial. We felt that in this situation, this happened partly due to the child's developmental delay. However, we expect this also could happen on a small percentage of typically developing children in the main study.

The child in home #2 was able to complete two successful measurements during the allotted six trials. During the first two attempts, the child did not have the correct exhalation rate, but by the third attempt had the correct speed, and just needed to maintain it for a longer period of time.

The child in home #3 had trouble following the directions when conducting an eNO measurement, just as with the spirometry measurement. Although study staff tried to stop the participant in order to provide more instructions, the participant did not stop and just made repeated attempts. Again, our staff did not want to appear to be too forceful in stopping the participant to provide additional instruction as the participant's parent was a colleague from UC Davis. In the actual study, we will be able to be more forceful with stopping children and providing more instruction between attempts. We think this will result in a higher success rate. The participant made six attempts and finally got one successful trial at the last attempt. If two successful attempts are conducted, they are averaged, but if only one is obtained, it is used directly. Therefore, we would have used this one value in the main study.

The current protocol specifies the participant can either hold the monitor or blow into it while it is sitting on the table. The second method is for children who find it too heavy to hold. However, all three children initially blew into it while it was sitting on the table and then switched to holding it. They all did better when holding it and so we are going to strongly recommend the child hold the monitor beginning with the first attempt. In all cases, we demonstrated the noises the machine makes for "too fast", "too slow", and "just right" and this eliminated any problems with the participant being surprised by the noise as in the pilot home.

The eNO measurement is ideally conducted by a child who has not eaten in the last hour. We thought that by conducting eNO at the end of the visit, the participant would be unlikely to have eaten as we did not think they would eat while we were there. However, one child got themselves a snack while we were there. The staff was not aware the child had served themselves a snack. We think this was an unusual occurrence and are not making any changes to the protocol. We further note that there is no evidence to show eating within one hour of measurements affects the measurement significantly.

The eNO measurement took 3-8 minutes.

4.2.9 Peak flow measurement

The mouthpiece of the peak flow meter comes in a sealed plastic bag. The mother in pilot home #2 had a hard time installing the mouthpiece on to the peak flow meter. This happened at pilot home #3 as well. Therefore, we have decided to cut open the bag, hold the mouthpiece through the bag, attach the mouthpiece to the peak flow meter, and then hand it to the child.

The results of peak flow measurements are presented in Table 10-12. Some measurements had an error code given by the peak flow meter. The error code indicates one or more of the following occurred during the test: a cough was detected; the blow effort was not long enough; the blow effort had a slow start; the result of the test was unnaturally low or high. Most likely, the effort was not long enough and thus they were included unless they were identified as outliers. We will train the participants further on using the peak flow monitor to ensure they will have successful test results.

Morning and night average PEF (forced expiratory flow) and FEV1 (forced expiratory volume at 1.0 second) were calculated for each participant respectively. If there was more than one measurement in each morning or evening, only the higher value was taken for calculating the average. The percent difference from average was further calculated for morning and night data separately, based on the morning and night average. The morning-evening variability was calculated based on the days with both morning and evening measures. Asthmatic children are anticipated to have variability in their PEF and FEV1 values from day to day based on the fact that their lungs are not completely healthy. As they are collecting measures at home, there is some concern that there may be cases where another family member used the peak flow monitor which would result in a value that was greatly different from the participants. Also, a child may have had a poor attempt at using the peak flow monitor due to either incorrect form or poor effort and the resulting value may differ significantly from the true value of that child at that point in time. As peak flow measurements are one of our secondary outcomes, we do not intend to individually review each record. We therefore need to develop a method to screen the data to determine which ones need to be reviewed by a person. As stated in our QA/QC document, our criteria for screening weeks of data that need to be individually reviewed was any of the values being greater than 15% from the average value. For the pilot, either Dr. Schenker or Dr. Kenyon reviewed the data based on the criteria and determined if any values need to be thrown out. Over the course of this study, we will develop more automated screening criteria to identify outliers, in consultation with the ARB. After reviewing data, a few outliers were identified, and

morning/night average and percent difference were recalculated with some of the outliers removed.

The participant in pilot house #1 appeared to have a developmental delay. As a result, the peak flow measurements were very inconsistent, with almost all PEF and FEV1 values being more than 15% from the mean. We note that on the first and last day, there is only one measurement on the day, since they do not have the meter for both morning and evening. The participant had the meter for 7 full days, and completed both measurements on 4 days, and only completed one measurement on three days. We further note that on one day where both morning and evening measurements were conducted, one evening two measurements two hours apart were completed.

Table 10. Peak flow data collected in pilot home #1

Date/Time	Day		PEF (L/min)	% diff from avg PEF	FEV1 (L)	% diff from avg FEV1	Error code
7/18/13 5:15 PM	1	Evening	108	26%	1.01	18%	X
7/19/13 5:15 AM	2	Morning	352	81%	2.22	50%	
7/19/13 9:30 PM	2	Evening	18	88%	0.28	77%	
7/20/13 7:00 AM	3	Morning	391	101%	2.58	75%	
7/20/13 11:45 AM	3	Morning	89		0.68		
7/21/13 9:30 PM	4	Evening	179	22%	1.14	7%	
7/22/13 10:45 PM	5	Evening	92	37%	0.79	36%	
7/23/13 4:45 AM	6	Morning	72	63%	0.54	63%	
7/23/13 9:00 PM	6	Evening	92	37%	1.38	13%	X
7/24/13 4:45 AM	7	Morning	124	36%	1.09	26%	
7/24/13 7:45 PM	7	Evening	108		0.77		
7/24/13 9:30 PM	7	Evening	391	167%	2.64	115%	
7/25/13 4:45 AM	8	Morning	111	43%	1.36	8%	
7/26/13 8:45 PM	9	Evening	147	0%	1.34	9%	
7/27/13 9:00 AM	10	Morning	118	39%	1.08	27%	
Average morning PEFR (N=6)			195	61%	1.48	42%	
Average evening PEFR (N=7)			147	54%	1.23	39%	
Morning-evening PEFR variability (N=3)			-5.89		-1.91		
Note: For days with more than one measurement, the higher value was taken for calculating the average.							

The participant in pilot house #2 had peak flow measurements for 10 full days, 5 days with both the morning and evening measurements and 5 days with only one measurement. There are two measurements about 30% from the average FEV1 value, and based on review by Dr. Schenker, they appear to be outliers and should be removed from the data set. After removing these two values, we re-calculated the percent different from average FEV1 value, and the rest of the data remain within 20% from the average FEV1 value, with one exceeding the 15% criteria.

Table 11. Peak flow data collected in pilot home #2

Date/Time	Day		PEF (L/min)	% diff from avg PEF	FEV1 (L)	% diff from avg FEV1	% diff from avg FEV1 (outliers removed)	Error code
7/18/13 8:00 PM	1	Evening	253	10%	1.89	3%	4%	
7/18/13 9:00 PM	1	Evening	240		1.81			
7/19/13 6:45 AM	2	Morning	240	4%	1.77	4%	4%	
7/19/13 10:00 PM	2	Evening	372	32%	2.50	28%	outlier	
7/20/13 8:45 AM	3	Morning	209	16%	1.72	7%	7%	
7/21/13 8:15 AM	4	Morning	242	3%	1.90	3%	3%	
7/21/13 9:30 PM	4	Evening	335	19%	2.17	11%	19%	
7/22/13 7:00 AM	5	Morning	265	6%	1.91	4%	4%	
7/22/13 9:15 PM	5	Evening	211	25%	1.61	17%	11%	
7/23/13 9:30 PM	6	Evening	217	23%	1.53	21%	16%	
7/24/13 9:30 PM	7	Evening	244	13%	1.71	12%	6%	
7/25/13 10:00 PM	8	Evening	240	15%	1.76	10%	3%	
7/26/13 12:15 PM	9	Morning	224	10%	1.59	14%	14%	
7/27/13 2:15 PM	10	Morning	289	16%	1.98	7%	7%	
7/27/13 7:15 PM	10	Evening	289	3%	1.81	7%	0%	
7/27/13 9:15 PM	10	Evening	260		1.88			
7/28/13 9:15 AM	11	Morning	278	11%	2.03	10%	10%	
7/28/13 10:00 PM	11	Evening	328	17%	2.00	3%	10%	
7/29/13 7:30 PM	12	Evening	326	16%	2.49	28%	outlier	
Average morning PEFR (N=7)			250	10%	1.84	7%		
Average evening PEFR (N=10)			282	17%	1.95	14%		
Morning-evening PEFR variability (N=5)			0.11		0.02			
Average evening PEFR (2 evening outliers removed) (N=8)			262	13%	1.82		7%	
Morning-evening PEFR variability (2 evening outliers removed) (N=4)			0.04		-0.04			
Note: For days with more than one measurement, the higher value was taken for calculating the average.								

The participant in pilot house #3 had peak flow measurements for 6 full days, 4 days with both the morning and evening measurements and 2 days with only evening measurements. On one of the days with only evening measurements, there were two evening measurements, but one was an outlier, most likely conducted by someone else. After removing this value, the remaining data points were within 20% from the average FEV1 value, with one exceeding the 15% criteria. This participant missed the morning on the day we picked up the sampler. We plan to add to the protocol to ask participants if they have done the test yet on the visit day.

Table 12. Peak flow data collected in pilot home #3

Date/Time	Day		PEF (L/min)	% diff from avg PEF	FEV1 (L)	% diff from avg FEV1	% diff from avg FEV1 (outliers removed)	Error code
7/20/13 12:15 PM	1	Morning	447	13%	1.51	8%	8%	X
7/20/13 10:00 PM	1	Evening	330	19%	1.75	10%	5%	X
7/21/13 11:00 AM	2	Morning	356	10%	1.79	9%	9%	X
7/21/13 10:45 PM	2	Evening	412	1%	1.77	9%	6%	
7/22/13 6:00 PM	3	Evening	564	38%	3.57	84%	outlier	
7/23/13 12:15 AM	3	Evening	384	6%	1.58	19%	5%	X
7/23/13 8:15 AM	4	Morning	405	2%	1.4	15%	15%	X
7/23/13 7:15 PM	4	Evening	364	11%	1.49	23%	11%	X
7/24/13 8:15 AM	5	Morning	381	4%	1.85	13%	13%	X
7/24/13 9:45 PM	5	Evening	398	2%	1.42	27%	15%	X
7/25/13 10:45 PM	6	Evening	405	1%	2.01	4%	20%	X
Average morning PEFR (N=4)			397	7%	1.64	11%		
Average evening PEFR (N=6)			408	11%	1.94	25%		
Morning-evening PEFR variability (N=4)			-0.07		-0.03			
Average evening PEFR (1 evening outlier removed) (N=5)			382	6%	1.67		10%	
Note: For days with more than one measurement, the higher value was taken for calculating the average. Removing of one outlier does not affect morning-evening PEFR variability.								

Based on review of the pilot data, we have thought more about how we will conduct the screening review of the peak flow data. We tested our QA/QC criteria, which is within 15% from the average PEF or FEV1 value. We feel that the original criterion is too stringent. We note that PEF is typically more variable than FEV1, and thus we may not want to use PEF variability as a criterion. Therefore, we are changing the criteria for review to be an FEV1 value within 20% from the average FEV1 value.

In cases where there is a data point more than 20% from the average, we will first look to see if evening FEV1 values tended to be lower than morning FEV1 values. If so, we will calculate the difference from the mean for morning and evening separately. Next, we will look to see if the participant consistently had great variability in their FEV1 value, or if the point with the value more than 20% from the mean was an outlier. In the former case, the data would likely be kept, while in the latter case, it would likely be dropped. Weeks not meeting the QA/QC criteria will be reviewed by Drs. Schenker or Kenyon to determine what to do with individual data sets. As we review data with Drs. Schenker and Kenyon, we will further refine our criteria for keeping or dropping individual attempts.

It took approximately 3 minutes to explain the peak flow measurement.

Table 13 Summary of the major problems encountered in pilot health measurements and proposed solutions

Problems encountered	Solution proposed
In some homes, it is hard to find a place to setup stadiometer, as the base is so big	Since completing the questionnaire and health measures takes longer than the air sampler set-up, it is more efficient to have the staff who sets up air samplers set up the stadiometer, specifically, the stadiometer will be set up while the air sampler pumps are warming up.
The spirometer broke on the way to pilot visit most likely due to the poor suspension of the cargo van. This was determined because the spirometer worked in the morning before going in the van and did not work after the bumpy van ride.	We now have a bag with a thick foam pad for the spirometer, so that it won't bounce in transit. In addition, we will use a mini cargo van in the main study, which is built based on car chassis providing a much gentler ride.
The spirometer was not configured to save all maneuvers before we used it, so it saved only the best maneuver by the individual. Therefore, it did not save all maneuvers but only record the best maneuver.	We will configure it to save the best three maneuvers prior to the main study.
For the eNO test, all three children initially blew into it while it was sitting on the table and then switched to holding it. They all did better when holding it.	In the future, we are going to strongly recommend the child hold the monitor beginning with the first attempt.

4.2.10 Air Sampling

There were several problems with the particulate matter samples. We had a problem with all the PM filter samples being contaminated by a residue that we did not successfully clean off the samplers, as discussed further below in the PM Results section. We also had problems related to collecting the samples. Unfortunately, we were not able to get the software to launch the timer with the launching program. The launching program turns the sampler back on in case of any loss of power. Instead, we turned them on manually, and when turned on manually, they will not restart if there is a loss of power. This resulted in the loss of several samples, listed in detail below. In addition, there were a few other problems.

We encountered a few issues during air sampler set-up. One participant was surprised by the noise when we turned on the pump. We have decided to mention the noise beforehand, and inform the participant that it will be quieter once it is set-up. Once the door of the pump box is closed, the noise is significantly reduced. Further, it appears that having duplicate pump boxes in the main living area may be overwhelming and cause extra burden to participants, considering the space they take, which would discourage participation prior to establishing a good working relationship between the participant and study staff. We have decided if a home is particularly small or the occupant is particularly sensitive to noise, we will not collect duplicate PM samples in such homes. We will make every effort to find homes that we think can accommodate duplicate indoor samplers. However, if we do not find enough candidate homes, a greater portion of our duplicates may be from outdoor samples in the pre-intervention period. More indoor duplicates will be collected in later visits as we build a good rapport with participants.

Another issue resulted from the wing nuts used to hold the PEMs and cascade impactors in place. Unfortunately, the university only had a cargo van to rent to us for the pilot. We have secured a long term lease on a mini cargo van for the main study. The suspension is very poor on the cargo van as opposed to the mini cargo van. As a result, the wing nuts all fell off the screws due to

vibration during transport. When the staff opened the pump boxes in the field, it took them extra time to retrieve the wing nuts as they had fallen off the screws and behind the pumps. They are also somewhat difficult to place on the screw and often several attempts were made. This resulted in a longer time to complete the air sampling set-up. We decided to install a nylon stop nut at the end of each screw. Nylon stop nuts are designed not to back-off under any conditions, and thus will hold the wing nuts if they turn, so that the wing nuts will not fall off screws during transportation, eliminating this problem.

In the visit to pilot home #3, Dr. Bennett wanted to try using the equipment herself so she would know if it was difficult or not. Dr. Bennett forgot to turn off the pump prior to attaching the sampler, in spite of it being listed as an important step on her field checklist. This increases the risk of resulting in a hole in the filter. Ms. Moran forgot to do this with one sampler at pilot home #2. As it is stressful to remember everything under the watchful eyes of the participants, we are going to use our label maker to make a yellow label to place on the timer reminding the field technician to turn off the pump before attaching the sampler. This is the only step that appears to be difficult to remember to conduct. Should this have happened in the main study, Dr. Bennett would receive additional training to ensure she did not deviate from the checklist in the future.

The flow meter worked well and it was easy to adjust the samples to the correct flow rate.

In week 1 at pilot home #1, we collected indoor duplicate samples but no outdoor duplicate samples were collected. A fuse blew on the 6th day of sampling. This home was older and both the indoor and outdoor samplers were on the same fuse, so all of the samplers turned off. At first, we were worried the power use from three pump boxes may have been part of the problem, but we calculated an approximate wattage of 45 watts per box, and thus three pump boxes would only be 135 watts, less than 1 ½ 100 watt light bulbs. There was a portable air conditioner and a large television set on the same fuse, which was likely the cause of the problem. Additionally, the home was constructed in the 1940s and thus did not have a modern electrical system. We will add to our protocol to be wary of rooms that appear to have too many electronics, but there may be little we can do. In week 2 at pilot home #1, the two indoor samplers were still running at the end of the week, but the outdoor sampler was off. The indoor samplers were moved by our staff between the first and second week to the other portion of the main living area to make way for a piece of exercise equipment being installed in the original location. We speculate that the outdoor pump being off was related to the installation of the exercise equipment which was on the same electrical circuit, an event unlikely to occur frequently.

In pilot home #2, indoor and outdoor duplicates were set up both weeks. Due to our IRB issue, the equipment ran for 10 days. Everything was running when we picked it up. In the second week, both outdoor samplers were running, but the indoor samplers were not. One of the parents was extremely noise sensitive and we suspect they unplugged them one night. We will need to be cautious about setting up indoor duplicates in quiet homes with noise sensitive individuals. In this case, if the pump box had been launched by the launching program, the samplers would have turned back on.

In pilot home #3, indoor duplicates and a single outdoor sample were set up the first week, with both indoor and outdoor samplers being set up the second week. The first week, one indoor

sampler was running and the other was not. The outdoor sampler was running. The second week, all sampling equipment was running. We do not know why the one indoor sampler was not running.

We found it difficult to find outdoor locations that met all of the requirements. At pilot home #1, much of the outdoor area was covered by a low awning that would have resulted in the sampler inlet being less than 1m from a surface. The uncovered area that was shaded by the house was a frequently used walkway and thus the samplers could not be placed there. The samplers ended up in the sun. Placement out of the sun is an important siting criterion because the internal temperatures in the sampling box can reach 130 d F and higher on the hottest mid-summer days in Fresno and Riverside. However, if only slight gains are made in terms of increasing shade, such as placing it directly next to a house under the eaves, which will only provide additional shade for a limited portion of the day, the desire to place the sampler 1m from a wall will take precedence over the desire for more shade. In pilot home #2, there was an out-of-the-way cement area with a plug. Although it was in the sun, it was clearly the most convenient for the participant as the children played frequently in the cement area near the home. Pilot home #3 was an apartment complex. The only private outdoor area was filled with a table and storage of sporting and other outdoor equipment. We therefore needed to pick a public area and the only feasible one was under a small tree. We will consider developing a portable shade structure next spring to use next summer. We note that we have sprayed the boxes with a hose and did not have any leaks when the water direction was in any direction rain could reasonably be expected to fall and thus we are not concerned about providing protection from the rain.

We need more multi-plug outlets capable of converting from a two prong to three prong plug. We will order some more. Our multi-plug outdoor extension cord was also too long. We will order a second, shorter one for outside duplicates.

In pilot home #1, it took 1 hour 50 minutes to set up two indoor pump boxes and one outdoor pump box in the enrollment visit, a little bit long due to the screw issue. In pilot home #2, it took 1 hour 30 minutes to set up two indoor pump boxes and two outdoor pump boxes in the enrollment visit. On average, it took 9 minutes to take down one indoor pump box.

Table 14. Summary of the major problems encountered in pilot environmental measurements and proposed solutions

Problems encountered	Solution proposed
Filter field blank contamination	A series of test has been designed to examine the problem.
We were not able to get the software to launch the timer with the launching program, which turns the sampler back on in case of any loss of power. Instead, we turned them on manually, and when turned on manually, they will not restart if there is a loss of power. This resulted in the loss of several samples.	A new version of software will be installed and the pump boxes will be launched on the timer.

Wing nuts used to hold the PEMs and cascade impactors in place all fell off the screws due to vibration during transport. When the staff opened the pump boxes in the field, it took them extra time to retrieve the wing nuts as they had fallen off the screws and behind the pumps. They are also somewhat difficult to place on the screw and often several attempts were made. This resulted in a longer time to complete the air sampling set-up.	We decided to install a nylon stop nut at the end of each screw. Nylon stop nuts are designed not to back-off under any conditions, and thus will hold the wing nuts if they turn, so that the wing nuts will not fall off screws during transportation, eliminating this problem.
Pump box turned off in several cases with various reasons. One is possibly related a fuse blow. One is likely related to new exercise equipment the participant installed. In one home, one of the parents was extremely noise sensitive and we suspect they unplugged them one night.	We will add to our protocol to be wary of rooms that appear to have too many electronics, but there may be little we can do. We will need to be cautious about setting up indoor duplicates in quiet homes with noise sensitive individuals.
It is difficult to find outdoor locations that met all of the requirements. Some outdoor samplers ended up in the sun.	We will consider using a portable shade structure next summer.

Table 15 presents the total number of air samples collected in the pilot.

Table 15. Number of air samples collected in the pilot

	Home #1		Home #2		Home #3		Total samples	Total duplicates	Total field blanks
	No filtration[a]	With filtration	No filtration	With filtration	No filtration	With filtration			
Indoor PEM PM2.5	2	2	2	0 (both primary and duplicate pumps stopped)	1 (duplicate pump stopped)	2	9	4	6
Indoor PM0.2, PM0.2-2.5, PM2.5-10	2	2	2	0 (both primary and duplicate pumps stopped)	1 (duplicate pump stopped)	2	9	4	6
Outdoor PEM PM2.5	1	0 (pump stopped)	2	2	1	2	8	3	0
Outdoor PM0.2, PM0.2-2.5, PM2.5-10	1	0 (pump stopped)	2	2	1	2	8	3	0
Indoor ozone	2	1	2	1	1	1	6	2	3
Outdoor ozone	1	1	2	1	1	1	6	1	0

Note: For those occasions with one sample without note, we had one sample setup without duplicate.

[a] In this sampling week, all pump boxes in this home stopped due to fuse blew on the 6th day of sampling. As we know the approximate sampling time, which is in the acceptable range, we consider these samples valid for this pilot, for the purposes of evaluating the precision of the duplicates, as we have so few duplicate pairs to compare. In the main study, we would not consider any samples that did not have exact sampling time valid samples.

4.2.10.1 Ozone Results

The ozone concentrations for all samples we collected in the pilot homes are shown in Table 16. Three field blanks were collected, and the average nitrate mass on blank filters is 0.25 ± 0.04 μg. The nitrate mass was converted to nominal ozone concentration based on the equation in Section 2.2.2, assuming the sampling time as the difference between the set-up and take-down time, with an average of 0.46 ± 0.04 ppb. The LOD was calculated as three times of the standard deviation of the nominal ozone concentrations of field blanks, with a value of 0.13 ppb. Our target LOD value as stated in the QAQC plan is 1.2 ppb. We report the blank corrected concentrations by deducting average field blank concentration of nitrate from each sample before calculating ozone concentrations. One home had both blank-corrected indoor ozone measurements below LOD, and all other samples had levels above LOD.

As shown in the table, indoor concentrations are significantly lower than outdoor concentrations. The average blank corrected indoor ozone concentration is 0.35 ± 0.33 ppb, and the median is 0.29 ppb. The average blank corrected outdoor ozone concentration is 33.5 ± 7.8 ppb, and the median is 32.4 ppb. The outdoor ozone concentrations obtained in our pilot were mostly within ±10% from the data reported by California state monitoring sites close to each pilot home, except one sample which was off by 19%. The indoor/outdoor ratio ranges from 0.0005 to 0.0230, with an average of 0.0109 ± 0.0090.

Two pairs of indoor duplicate samples and one pair of outdoor duplicate samples was collected. The precision between the two pairs of indoor ozone samples are 0.45 and 0.37 respectively, compared to the criteria of 0.20. The low precision of indoor ozone was likely due to the uncertainty of measuring low concentrations. The precision between the one pair of outdoor ozone samples is 0.004, compared to the criteria of 0.10.

In home #1 and #2, ozone concentrations were lower in the sampling weeks with filtration than the weeks without filtration, while the case is opposite in home #3. Given the very low concentrations of indoor ozone in all of these homes, there is some uncertainty with measuring these low levels. There may also have been differences in windows or doors being open between the two weeks which could have affected the true I/O ratio. With a larger sample, we will be able to determine the population wide trend.

Table 16. Ozone concentrations in pilot homes

HHID	Filter ID	Primary/ Duplicate	Indoor / outdoor	Fil-tra-tion	Set up Date	Set up - time	Take Down Date	Take Down - time	Within acceptable sampling time range (5-9 days)	Sampl-ing time (min)	Nitrate (µg)	Un-corre-cted O_3 conc (ppb)	blank corre-cted O_3 conc (ppb)	I/O ratio	State Ozone data (ppb)[a]	% diff from state ozone data
P0001	O3P0020		Blank		7/18/2013	18:06	7/26/2013	16:13	Yes	11407	0.240	0.47				
P0002	O3P0011		Blank		7/18/2013	20:29	7/29/2013	19:40	No	15791	0.292	0.41				
P0003	O3P0010		Blank		7/19/2013	19:18	7/26/2013	18:11	Yes	10013	0.223	0.49				
P0001	O3P0009	Primary	Indoor	No	7/18/2013	18:03	7/26/2013	16:23	Yes	11420	0.740	1.44	0.95	0.0230		
P0001	O3P0008	Duplicate	Indoor	No	7/18/2013	18:06	7/26/2013	16:08	Yes	11402	0.562	1.09	0.60			
P0001	O7P0007	Primary	Indoor	Yes	8/1/2013	16:15	8/8/2013	16:13	Yes	10078	0.397	0.87	0.32	0.0105		
P0002	O3P0014	Primary	Indoor	No	7/18/2013	20:29	7/29/2013	20:03	No	15814	0.333	0.47	0.11	0.0026		
P0002	O3P0016	Duplicate	Indoor	No	7/18/2013	20:28	7/29/2013	19:43	No	15795	0.369	0.52	0.16			
P0002	O5P0005	Primary	Indoor	Yes	7/29/2013	20:42	8/5/2013	10:10	Yes	9448	0.259	0.61	0.02	0.0005		
P0003	O3P0018	Primary	Indoor	No	7/19/2013	19:14	7/26/2013	18:11	Yes	10017	0.370	0.82	0.26	0.0090		
P0003	O3P0003	Primary	Indoor	Yes	8/3/2013	11:41	8/9/2013	18:41	Yes	9060	0.435	1.06	0.45	0.0197		
P0001	O3P0015	Primary	Outdoor		7/18/2013	18:06	7/26/2013	16:30	Yes	11424	27.418	41.5	41.1		34.6	19%
P0001	O4P0004	Primary	Outdoor		8/1/2013	16:20	8/8/2013	16:26	Yes	10086	18.022	30.9	30.5		27.6	10%
P0002	O3P0017	Primary	Outdoor		7/18/2013	20:33	7/29/2013	20:49	No	15856	40.078	43.7	43.5		43.4	0%
P0002	O3P0012	Duplicate	Outdoor		7/18/2013	20:33	7/29/2013	20:45	No	15852	39.893	43.5	43.3			
P0002	O3P0013	Primary	Outdoor		7/29/2013	20:55	8/5/2013	10:28	Yes	9453	19.006	34.8	34.3		38.0	-10%
P0003	O4P0022	Primary	Outdoor		7/19/2013	19:33	7/26/2013	18:21	Yes	10008	16.898	29.2	28.8		29.4	-2%
P0003	O6P0006	Primary	Outdoor		8/3/2013	12:04	8/9/2013	19:51	Yes	9107	12.206	23.2	22.7		23.7	-4%
[a] Data was downloaded for the nearest monitoring station from http://www.arb.ca.gov/aqmis2/aqdselect.php?tab=daily in Sept. 2013.																

4.1.10.2 Particulate Matter Results

A number of field blanks were collected in the pilot. Field blanks for PM measurements can indicate if there is any background contamination or gross error. Additionally, in cases where there are consistent and positive values on the field blanks, sample values can be blank corrected. We did not adjust for blanks in the pilot due to the severe and variable contamination levels. We will determine if we will blank correct the actual field samples based on the values of the blanks from the main study in consultation with ARB. The PM field blank data are presented in Table 17 and Figure 4.

Table 17. Field blanks of PM (mg/filter or PUF)

HHID	Set up Date	Filtration	PM2.5 filter (mg)	PM0.2 filter (mg)	PM (0.2-2.5) PUF (mg)	PM (2.5-10) PUF (mg)	Note
Wisconsin mass control (mean ± SD) (mg)			0.005 ± 0.002 for filters		0.020 ± 0.007 For PUFs		
P0001	7/18/2013	No	0.757	0.019	0.024	-0.015	
P0001	8/1/2013	Yes		1.057	-0.064	-0.011	CI only, not opened in field
P0002	7/18/2013	No	0.130	0.749	-0.008	-0.010	
P0003	7/19/2013	No	0.062	1.167	-0.015	-0.020	
P0003	7/19/2013	No		0.621	-0.011	-0.015	CI only
P0003	8/3/2013	Yes	0.073	0.360	-0.027	-0.020	
	8/12/2013		0.763				PEM only, Loaded into sampler, did not go to field
	8/12/2013		0.423				PEM only, Loaded into sampler, did not go to field
Average field blank (mg)			0.368	0.662	-0.017	-0.015	
Standard deviation (mg)			0.331	0.430	0.029	0.004	
Nominal LOD (µg/m^3)[a]			—	—	1.71	0.254	
Target LOD (µg/m^3)			0.450	0.162	0.425	0.425	
[a] Nominal LOD was not calculated for filters due to concern of background contamination.							

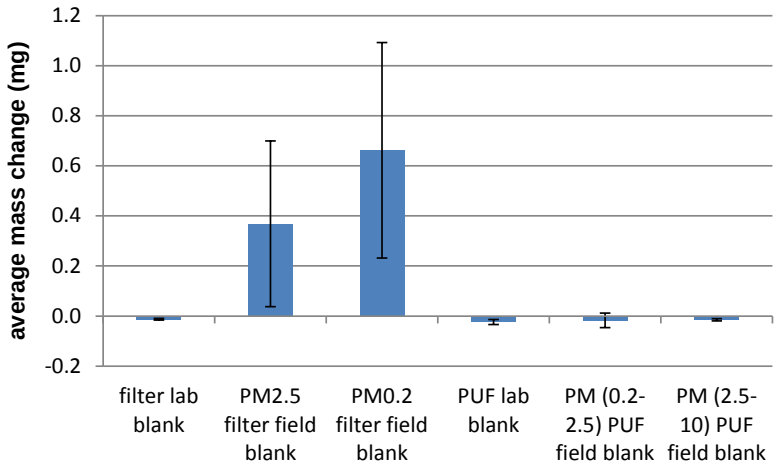

Figure 4. Lab blank and field blank levels (error bar is standard deviation)

The average mass change on the field blank filters is 0.37 ± 0.33 mg and 0.66 ± 0.43 mg for PM2.5 and PM0.2, respectively, while the 4 lab blank filters had an average mass change of -0.013 ± 0.003 mg with actual values being -0.014 mg, -0.011 mg, -0.010 mg, and -0.017 mg. The field blank values clearly exceed any acceptable target value, and indicate some sort of contamination or gross error. After the pilot was complete, we conducted extensive diagnosis activities to solve the problem. These are reported in Appendix C: Diagnosing and solving the problem with the PM filters.

The field blanks of PUF measurements were acceptable, with the average net mass change of -0.02 ± 0.03 mg for PM0.2-2.5 PUF and -0.02 ± 0.004 mg for PM2.5-10 PUF. Please recall that to account for small changes in mass in the PUF due to relative humidity variation during weighing, there is a mass control that is weighed at each session and sample mass changes are adjusted by the changes in these lab controls (Table 17). The PUF mass change was converted to nominal PM concentration assuming the sampling time was 7 days. The LOD was calculated as three times the standard deviation of the nominal PM concentrations of field blanks, with a value of 1.71 $\mu g/m^3$ for PM 0.2-2.5 and 0.25 $\mu g/m^3$ for PM 2.5-10. All PM2.5-10 PUF samples and 14 out of 17 available PM0.2-2.5 PUF samples had a concentration above the LOD. Ideally, the target set in the QA/QC for the LOD was 0.425 $\mu g/m^3$. Given the small number of blanks collected, we are not concerned about exceeding this value for PM 0.2-2.5, especially considering that blanks were under the target value for PM 2.5-10.

Nine pairs of duplicate samples were collected in the pilot, including 2 pairs of indoor duplicates without filtration, 2 pairs of indoor duplicates with filtration, and 3 pairs of outdoor duplicates; another 2 pairs of duplicate samples could not be used, as one or both pumps stopped in the middle of sampling and we do not know the exact sampling time. Note that one pair of indoor duplicates without filtration also had both pump boxes stopped due to fuse blew on the 6th day of sampling. As the approximate sampling time is in the acceptable range, we consider these samples valid for this pilot, for the purposes of evaluating the precision of the duplicates, as we have so few duplicate pairs to compare. The precision between duplicate samples was calculated based on method described in Section 2.5.1.1, and results are shown in Table 18.

Table 18. Precision between duplicate samples collected in pilot

HHID	Set up Date	Indoor/ outdoor	Filtra-tion	PM2.5	PM0.2	PM (0.2-2.5)	PM(2.5-10)	Calculated PM2.5	Calculated PM10
P0001	7/18/2013	Indoor	No	25%	4%	4%	13%	3%	1%
P0001	8/1/2013	Indoor	Yes	33%	36%	7%	23%	32%	32%
P0002	7/18/2013	Indoor	No	90%	133%	8%	21%	118%	108%
P0002	7/18/2013	Outdoor	No	12%	62%	9%	12%	48%	36%
P0002	7/29/2013	Outdoor	Yes	59%	51%	0.1%	0%	41%	35%
P0003	8/3/2013	Indoor	Yes	115%	50%	50%	6%	50%	43%
P0003	8/3/2013	Outdoor	Yes	7%	76%	10%	4%	65%	56%
Precision criteria defined in QA/QC plan		Indoor	Yes	20%	30%	30%	20%	20%	20%
		Indoor	No	10%	20%	20%	10%	10%	10%
		Outdoor		10%	20%	20%	10%	10%	10%

The precision for the filters as well as calculated PM2.5 and PM10 was unacceptable. This is most likely due to the fact that there is some sort of severe and random contamination or gross error occurring with the filters. This distortion of the background on the filters severely limited our ability to detect any signal from the actual air pollution.

The precision was within 10% for six duplicate pairs of PM0.2-2.5 PUF samples, except for one pair of indoor samples with a precision of 50%, above the target criteria in QA/QC plan at 30%. The mass on the pair of PUFs that exceeded the criteria was the lowest mass of any duplicate pairs, with the two resulting concentrations being 2.02 $\mu g/m^3$ and 1.21 $\mu g/m^3$. The precision between duplicate pairs of PM2.5-10 PUF samples ranged from 0% to 23% (N=7), four of which were above the criteria of 20% for indoor samples with filtration and 10% for outdoor/indoor samples without filtration. The mass on the two pairs of PUF where precision exceeded 20% was also the lowest of any duplicate pairs, with resulting concentrations of 1.93 $\mu g/m^3$ and 1.53 $\mu g/m^3$ from one pair of duplicates and 2.19 $\mu g/m^3$ and 2.72 $\mu g/m^3$ from the other pair of duplicates.

Table 19. Setup and take-down flow rates of cascade impactor and PEM in pilot

HHID	Set up Date	Filtration	Indoor or outdoor	Primary, Duplicate or Blank	CI Set Up Flow	CI Take Down flow	%diff	PEM Set Up Flow	PEM Take Down flow	%diff	Pump (on/off) at take down
P0001	7/18/2013	No	Indoor	Primary	5.115	5.096	-0.4%	1.830	1.836	0.4%	off
P0001	7/18/2013	No	Indoor	Duplicate	5.120	5.120	0.0%	1.811	1.828	0.9%	off
P0001	7/18/2013	No	Outdoor	Primary	5.115	4.989	-2.5%	1.806	1.781	-1.4%	off
P0001	8/1/2013	Yes	Indoor	Primary	5.222	5.030	-3.7%	1.883	1.833	-2.7%	
P0001	8/1/2013	Yes	Indoor	Duplicate	5.213	5.024	-3.7%	1.815			
P0001	8/1/2013	Yes	Outdoor	Primary	5.217	5.214	-0.1%	1.824	1.816	-0.4%	off
P0002	7/18/2013	No	Indoor	Primary	5.137	5.124	-0.2%	1.822	1.836	0.8%	
P0002	7/18/2013	No	Indoor	Duplicate	5.109	5.109	0.0%	1.824	1.816	-0.5%	
P0002	7/18/2013	No	Outdoor	Primary	5.117	5.130	0.3%	1.824	1.829	0.3%	
P0002	7/18/2013	No	Outdoor	Duplicate	5.101	5.079	-0.4%	1.819	1.799	-1.1%	
P0002	7/29/2013	Yes	Indoor	Primary	5.202	5.236	0.6%	1.826	1.813	-0.7%	off
P0002	7/29/2013	Yes	Indoor	Duplicate	5.087	5.123	0.7%	1.819	1.797	-1.2%	off
P0002	7/29/2013	Yes	Outdoor	Primary	5.221	5.087	-2.6%	1.830	1.808	-1.2%	
P0002	7/29/2013	Yes	Outdoor	Duplicate	5.170	5.123	-0.9%	1.806	1.803	-0.2%	
P0003	7/19/2013	No	Indoor	Primary	5.130	5.156	0.5%	1.820	1.857	2.0%	
P0003	7/19/2013	No	Indoor	Duplicate	5.160	5.324	3.1%	1.810	1.858	2.6%	off
P0003	7/19/2013	No	Outdoor	Primary	5.070	4.933	-2.7%	1.820	1.790	-1.7%	
P0003	8/3/2013	Yes	Indoor	Primary	5.120	5.150	0.6%	1.824	1.845	1.1%	
P0003	8/3/2013	Yes	Indoor	Duplicate	5.109	5.177	1.3%	1.823	1.846	1.3%	
P0003	8/3/2013	Yes	Outdoor	Primary	5.043	5.062	0.4%	1.822	1.855	1.8%	
P0003	8/3/2013	Yes	Outdoor	Duplicate	5.058	5.073	0.3%	1.819	1.842	1.3%	
				Mean	5.135	5.112	-0.4%	1.823	1.824	0.1%	
				STD	0.054	0.086	1.7%	0.015	0.023	1.4%	

All flow rates were easily adjusted to be within range at the start of the week. If the sampler did not shut off and was running when we came to pick up the sampler, the flow rate was within range at the end of the week.

The PM concentrations in each pilot home measured by both CI and PEM are shown in Table 20. As stated earlier, some pump boxes were off when we picked up the samplers. Due to the pump box timer issue, we do not know the exact pump running time and thus cannot calculate PM concentrations. One exception was made for the first sampling period at home #1 because the participant told us which day the fuse in her home blew and therefore we could approximate the time. As the approximate sampling time is in the acceptable range, we consider these samples valid for this pilot, as we have so little data. In the main study, we would not consider any samples that did not have exact sampling time. The summary statistics for indoor concentrations without filtration, indoor concentrations with filtration, and outdoor concentration are shown in Table 21.

Given the concern to the potential background contamination of filters, we are unable to make further interpretation of PM2.5 and PM0.2 filter data as well as calculated PM2.5 and PM10 data.

Table 20. PM concentrations in pilot homes

HHID	Set up Date	Filtration	Indoor/ outdoor	Primary/duplicate	Sampler (on/off) at collection	Sampling days	Sampling time (min)	PM2.5 ($\mu g/m^3$)	PM0.2 ($\mu g/m^3$)	PM (0.2-2.5) ($\mu g/m^3$)	PM (2.5-10) ($\mu g/m^3$)	Calculated PM2.5 ($\mu g/m^3$)	Calculated PM10 ($\mu g/m^3$)
P0001	7/18/2013	No	Indoor	Primary	off	6	8640	76.3	44.7	6.42	4.83	51.1	55.9
P0001	7/18/2013	No	Indoor	Duplicate	off	6	8640	59.4	43.1	6.70	5.50	49.8	55.3
P0001	7/18/2013	No	Outdoor	Primary	off	6	8640	23.0	11.4	5.73	7.00	17.1	24.1
P0001	8/1/2013	Yes	Indoor	Primary		7	10098	11.1	19.6	1.33	1.93	21.0	22.9
P0001	8/1/2013	Yes	Indoor	Duplicate		7	10089	7.96	13.7	1.43	1.53	15.1	16.7
P0001	8/1/2013	Yes	Outdoor	Primary	off	7							
P0002	7/18/2013	No	Indoor	Primary		11	15860	8.30	6.39	2.50	2.19	8.88	11.1
P0002	7/18/2013	No	Indoor	Duplicate		11	15834	21.8	31.6	2.70	2.72	34.3	37.0
P0002	7/18/2013	No	Outdoor	Primary		11	15887	39.6	12.3	5.83	6.63	18.1	24.7
P0002	7/18/2013	No	Outdoor	Duplicate		11	15876	44.5	23.3	6.36	5.86	29.7	35.6
P0002	7/29/2013	Yes	Indoor	Primary	off	7							
P0002	7/29/2013	Yes	Indoor	Duplicate	off	7							
P0002	7/29/2013	Yes	Outdoor	Primary		7	9460	30.9	20.7	7.01	5.90	27.7	33.6
P0002	7/29/2013	Yes	Outdoor	Duplicate		7	9462	16.9	35.0	7.02	5.90	42.0	47.9
P0003	7/19/2013	No	Indoor	Primary		7	10023	16.4	23.0	5.87	6.05	28.8	34.9
P0003	7/19/2013	No	Indoor	Duplicate	off	7							
P0003	7/19/2013	No	Outdoor	Primary		7	10003	31.9	4.66	5.86	8.29	10.5	18.8
P0003	8/3/2013	Yes	Indoor	Primary		6	9074	61.8	22.7	2.02	4.03	24.7	28.7
P0003	8/3/2013	Yes	Indoor	Duplicate		6	9082	16.6	13.6	1.21	3.79	14.8	18.6
P0003	8/3/2013	Yes	Outdoor	Primary		6	9109	39.4	41.7	4.15	6.30	45.9	52.2
P0003	8/3/2013	Yes	Outdoor	Duplicate		6	9101	42.2	18.8	4.59	6.07	23.4	29.5

Note: All pump boxes used in pilot home #1 on 7/18/2013 were off at collection. As participants reported the pump boxes stopped due to a fuse blew happened on the 6th day of the sampling, we decided to use 6-day as sampling time to calculate PM concentration.

Table 21. Summary statistics of PM concentrations in pilot

	PM2.5 ($\mu g/m^3$)	PM0.2 ($\mu g/m^3$)	PM (0.2-2.5) ($\mu g/m^3$)	PUF (2.5-10) ($\mu g/m^3$)	Calculated PM2.5 ($\mu g/m^3$)	Calculated PM10 ($\mu g/m^3$)
Indoor without filtration						
Arithmetic mean	36.4	29.8	4.84	4.26	34.6	38.9
Standard deviation	29.7	15.8	2.07	1.71	17.3	18.4
median	21.8	31.6	5.87	4.83	34.3	37.0
Indoor with filtration						
Arithmetic mean	24.4	17.4	1.50	2.82	18.9	21.7
Standard deviation	25.2	4.51	0.36	1.27	4.79	5.35
median	13.8	16.7	1.38	2.86	18.0	20.8
Outdoor						
Arithmetic mean	33.5	21.0	5.82	6.49	26.8	33.3
Standard deviation	9.76	12.4	1.03	0.83	12.3	11.7
median	35.7	19.8	5.84	6.18	25.6	31.6

The indoor/outdoor PM ratio was calculated when paired indoor and outdoor concentrations were available. Only four pairs are available (Table 22). In home #3, I/O ratios are available for both with and without filtration and lower in the week with filtration. However, due to the concern of background contamination, further data are needed to evaluate the trend.

Table 22. Indoor/outdoor ratios observed in pilot homes

HHID	Set up Date	Filtration	I/O Ratio PM2.5	I/O Ratio PM0.2	I/O Ratio PM (0.2-2.5)	I/O Ratio PM (2.5-10)	I/O Ratio Calculated PM2.5	I/O Ratio Calculated PM10
P0001	7/18/2013	No	3.0	3.9	1.1	0.7	2.9	2.3
P0002	7/18/2013	No	0.4	1.1	0.4	0.4	0.9	0.8
P0003	7/19/2013	No	0.5	4.9	1.0	0.7	2.7	1.9
P0003	8/3/2013	Yes	1.0	0.6	0.4	0.6	0.6	0.6

The paired indoor PM concentrations with filtration and without filtration are available for homes #1 and #3. A comparison of the indoor concentrations with and without filtration is illustrated in Figure 5. The ratio between the indoor PM concentrations with filtration and without filtration was also calculated (Table 23). Except for PM2.5 measured with the PEM in home #3, the ratios between PM concentrations with filtration and without filtration were less than 1 for all size fractions in the two homes. We note that we are only truly confident about the values obtained for the size fractions PM 0.2-2.5 and PM 2.5-10, and these values all showed significant reductions due to filtration.

Table 23. Ratios between indoor PM concentrations with filtration and without filtration

HHID	PM2.5	PM0.2	PM (0.2-2.5)	PM (2.5-10)	Calculated PM2.5	Calculated PM10
P0001	0.1	0.4	0.2	0.3	0.4	0.4
P0003	2.4	0.8	0.3	0.6	0.7	0.7

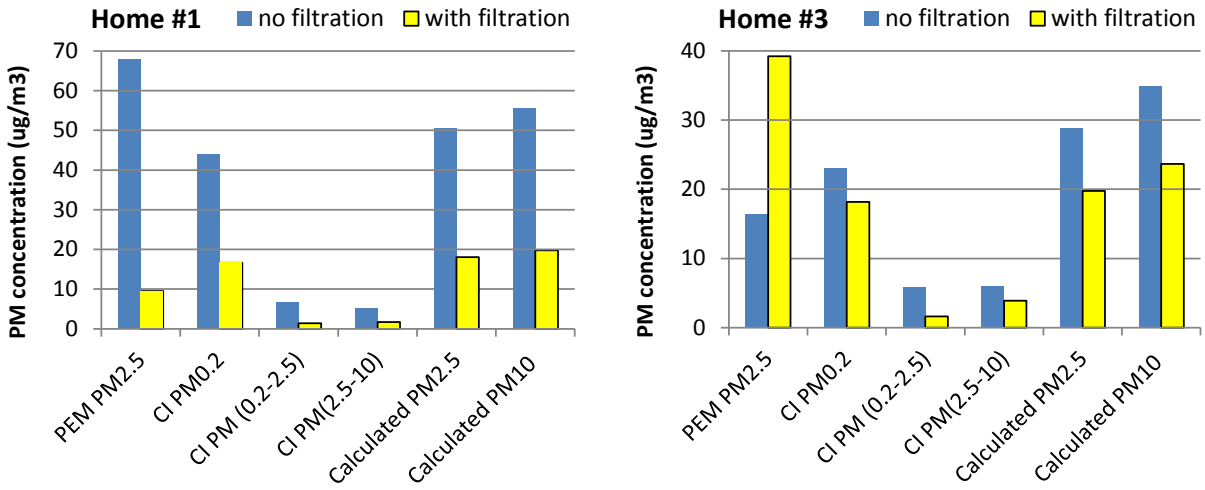

Figure 5. Comparison of the indoor concentrations with and without filtration

4.2.11 Installation of Air Cleaner

We encountered some issues when selecting a proper location for air cleaners. In pilot home #1, the outlet that worked best in terms of the location for the participant turned out to be operated by a switch. Rather than moving the air cleaner or pulling an extension cord across the room, we continued using that outlet so that the air cleaner would be in a convenient location. We plan to add a note in the SOP for Stand-alone Air Cleaner regarding this issue. We will try to use an outlet that is not on a switch. Specifically, we will ask the participant when we discuss possible locations with them if the outlet is always on or if it is operated by a switch. In the case we have to use an outlet that is on a switch, we will ask the participants' permission to put a piece of tape on the switch to remind people to keep it on. Apart from this issue, there were no problems locating the air cleaner.

In the pilot home #2, the child's bedroom was small. We had to move some toys to fit the air cleaner in the room. It took some time for the child to decide which toys would be moved. This may occur in the future but we were able to ultimately find a good location in the child's room. There was no problem finding a location in the main living area.

In pilot home #3, we were able to find good locations in both rooms. Installing an air cleaner self only took 3 minutes. We tested our revised protocol and asked if the outlets were operated by a switch when selecting a location and this went smoothly.

The stand-alone air cleaners that we are using in this study have a central processing unit (CPU) which records the total number of hours that the air cleaner has operated. In addition, when set at a specified flow speed, the CPU reports the total number of hours left on the filter. As the number of hours left on the filter is based on how much air has passed through the filter, which is a function of both the number of hours operated and the air flow rate, by recording both of these pieces of information at the beginning of the week and the end of the week, one can determine

both the number of hours operated and the average flow rate during the week. We can therefore determine if the participant turned off the air cleaners or adjusted the speed.

In pilot home #1, we set the flow rate at 2 for the air cleaner in the living room and at 1 for the air cleaner in the child's bedroom. We used an older model of the air cleaner than planned for the main study and we matched levels to the protocol for the new air cleaner based on noise level. Both air cleaners ran for the full 7 days between the set-up and take-down visit at the flow rate we set. For home #2, we forgot to check the filter hours left before the sampling, so we cannot determine if the participants had modified the air cleaner setting or if they had unplugged air cleaners. They were still running at the speed they were initially set to at the take down visit. The participant reported no problems with the air cleaner. In pilot home #3, we set the flow rate at 3 for the air cleaner in the living room and at 1 for the air cleaner in the child's bedroom. Both air cleaners ran for the full 6.3 days between the set-up and take-down visit at the flow rate we set. We note that in the main study, some participants will have stand-alone air cleaners and some will have filters installed in their central system, as determined by the randomization plan in Appendix A.

4.2.12 Installation of Mattress Cover

It requires two people to put on the mattress cover. We had assumed it would, and our pilot confirmed this. In pilot home #1, there were no issues with installing the mattress cover. In the pilot home #2, the parent offered to help us. The participants' bed was a top bunk so it was particularly difficult to install. In pilot home #3, the participant slept on a King size bed. We had not anticipated that a child would sleep on a King size bed and so had not ordered any King size mattress covers. We will order a few King size mattress covers. We note that we have ordered a variety of sizes and are planning to track the sizes participating children have and future orders will reflect what we are seeing in the field. It took 8-10 minutes to install a mattress cover.

4.2.13 Dust Collection

In the first two homes, there were no problems with the dust collection and it took 18 – 20 minutes. Ms. Moran collected the dust in these two homes. She has been conducting dust collection for a number of years in various studies. In the third pilot home, Ms. Roudneva conducted the dust sampling. She has less experience with this protocol and so the time was longer, 30 minutes. We anticipate with future practice, the time in the field will be 18 to 20 minutes. Additionally, in this home, she set the vacuum cleaner vertically. As a result, the exhaust outlet was blocked and the vacuum cleaner was over heated at the very end of sample collection and smelled a bit. We will note in the protocol that vacuum cleaner should be set horizontally when vacuuming. We will also affix a yellow label tape to the vacuum to remind field staff to set it horizontally.

4.2.14 Personal Exposure Measurement

All three participating children were in the age range (9-12 years) to wear the personal sampler. All three children were asked if they would be willing to wear it. The participating children in pilot homes 2 and 3 agreed to wear the personal sampler.

The batteries for personal pumps are supposed to run for 48 hours each; however, one personal pump ran for 23 min, and the other ran for four days. We have consulted the pump manufacturer to find a solution to the problem. In regard to the pump that ran for 23 minutes, the manufacturer said that unless the battery is fully charged, sometimes there is a problem and it will not run for more than a few minutes. Unfortunately, the time listed to fully charge a battery in the directions is less than the actual time to fully charge a battery given to us when we asked about the problem. The revised time will be used from now on. In regard to the pump that ran for four days, the manufacture said the 48-hour stated time is for the maximum load at extremely cold temperatures. We will ask participants to turn off the pump after 48 hours and provide them with clear directions on how to turn it off.

The child in pilot home #2 was not able to wear the personal sampler while skateboarding and during some other sports. He thought it was “cool” to wear the personal sampler. It ran for 4 days and the participant wore it for the full 4 days.

The participant in pilot home #3 wore the backpack for the full 48 hours as requested. Her backpack was red and black. She noted she would have preferred a solid black backpack. As we do have backpacks in a variety of colors, for the main study, we will bring two color choices in and ask which the child prefers. This should help with compliance as children like to be given choices.

It took about 10 minutes to set up personal sampler.

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Appendix A. Randomization Plan

The primary objectives of our randomized cross-over study design is to estimate true versus sham filter effects separately and pooled for two types of filtration systems, central system and stand-alone. Our randomization plan is designed to achieve, within each filtration system type, equivalent groups with respect to initial filter status (true fist versus sham first).

During the recruitment telephone call, for subjects that agree to schedule an enrollment visit, we will ask the participant whether or not they have a central air system. Participants reporting that they do not have a central air system will be assigned a stand-alone filtration system, and will be randomly assigned to "true first" versus "sham first" in a 1:1 allocation, using random permuted blocks with a block size determined by the study statistician (Dr. Daniel Tancredi) and stratified by study site (Fresno versus Riverside).

- "SX-T" – could only be in the stand alone group, true filtration first
- "SX-S" – could only be in the stand alone group, sham filtration first

Participants reporting that they do have a central air system will be randomly assigned to one of four groups in a 1:1:5:5 allocation, also using a stratified (Fresno vs. Riverside) random permuted block design with a block size determined by the study statisticians:

- "RS-T" (Randomized to stand-alone filtration, true first initially)
- "RS-S" (Randomized to stand-alone filtration, sham filter initially)
- "RH-T" (Randomized to central system filtration if possible, true filter initially"),
- "RH-S" (Randomized to central system filtration if possible, sham filter initially),

At the study enrollment visit to homes in the "RH-T" and "RH-S" groups, a determination will be made as to whether or not the participants have a central air system that is able to take the upgraded central system filtration. Exclusions could be based on any of the following reasons: 1) they rent and their landlord does not agree to the upgrade, 2) they are in a multiunit building that does not have an individual system for each unit, 3) there is not a physical way to install the upgraded filter, 4) the location of their air intake is not compatible with the upgraded intake as it is on the floor or low on a wall in a walkway, 5) there is no way to run the central system in fan only mode and it cannot be easily upgraded to do so, or 6) the participant does not want to have the filter installed or does not want to run the fan for 15 minutes per hour for any reason, for example, concern about the noise of the fan turning on and off during the night. The households assigned to the central system filtration but excluded from receiving them will instead be assigned a stand-alone filtration system. Among those groups randomized to receive the central system filtration, we will add suffixes to specify whether or not they actually receive the central system filtration.

- "RH-T" (Randomized to central system filtration if possible, true filter initially"),
    - RH-T-S – ended up with stand alone
    - RH-T-H - ended up with central system filtration
- "RH-S" (Randomized to central system filtration if possible, sham filter initially),
    - RH-S-S – ended up with stand alone
    - RH-S-H - ended up with central system filtration

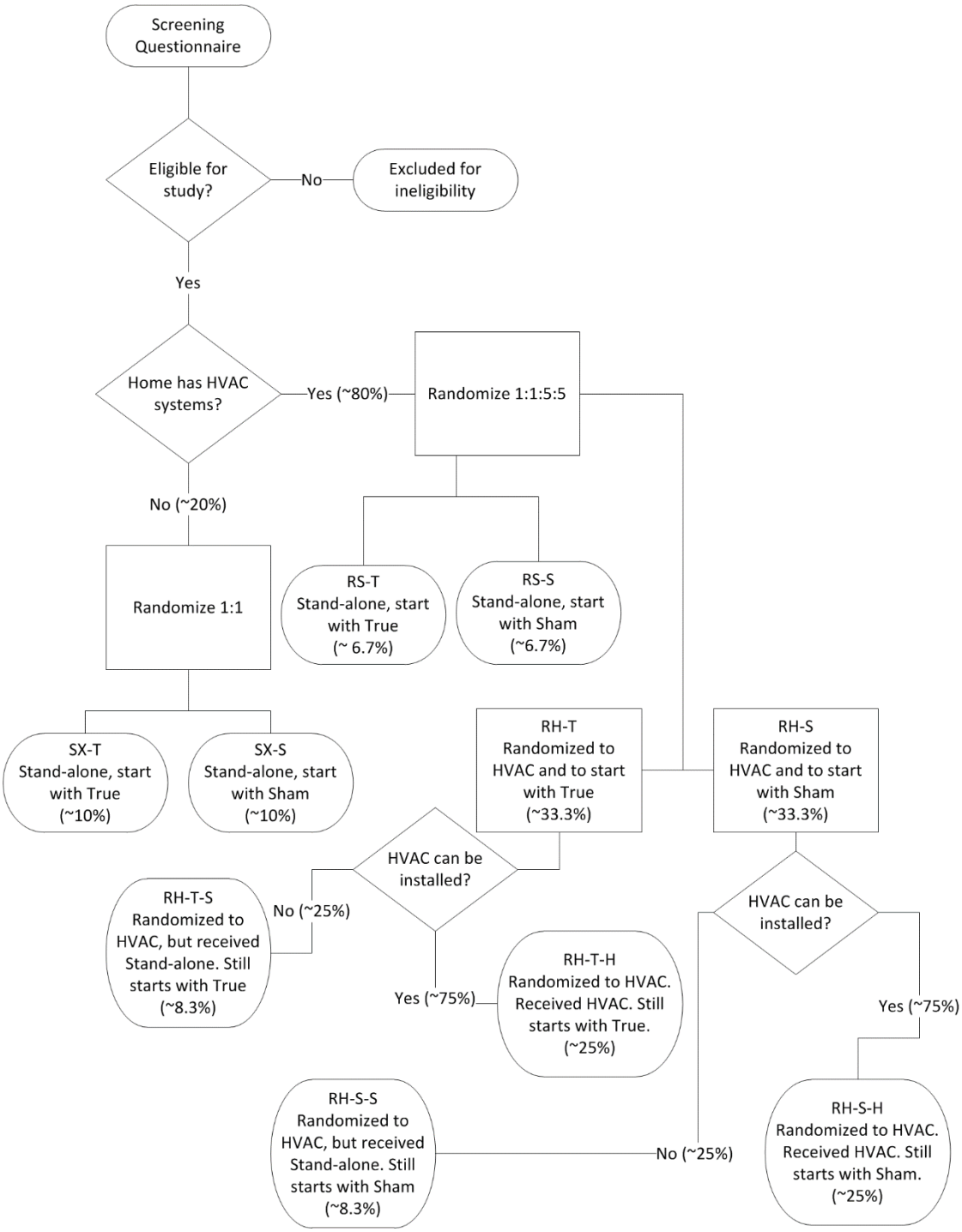

Figure A-1. Randomization flow chart. Percentages in boxes refer to total of eligible study participants, while percentages on lines refer to immediately preceding decision. The two right-most terminal nodes comprise the ~50% of study participants who will receive the central system filtration intervention. The other six terminal nodes comprise the participants receiving the Stand-alone intervention.

We anticipate that 80% of the homes will have a central air system. Of those with a central air system, we anticipate that approximately three of four (75%) will actually be able to have an

upgraded central system filtration installed. Therefore, of those participants with an central system, 83% [(33.3+33.3)/80] will be randomized into the group to receive the central system filtration intervention, and 17% [(6.7+6.7)/80] will be randomized into the group to receive the stand-alone air cleaner. Once we are in the home, 25% will not be able to be upgraded to an central system and will be moved into the stand-alone air cleaner group. The groups are demonstrated in the flowchart in Figure A1.
As can be seen from the list below, the randomization allocation ratios were chosen such to target a total sample size with 100 participants in the central system filtration group and 100 participants in the stand-alone air cleaner group. Ideally, these participants will roughly be divided according to the total sample size between Fresno and Riverside.

- "SX-T" – N=20 - could only be in the stand alone group, true filtration first
- "SX-S" – N=20 – could only be in the stand alone group, sham filtration first
- "RS-T" - N=14 -(Randomized to stand-alone filtration, true first initially)
- "RS-S" - N=13 -(Randomized to stand-alone filtration, sham filter initially)
- "RH-T" (Randomized to central system filtration if possible, true filter initially"),
    - RH-T-S – N=16 - ended up with stand alone
    - RH-T-H – N=50 - ended up with central system filtration
- "RH-S" (Randomized to central system filtration if possible, sham filter initially),
    - RH-S-S – N=17 - ended up with stand alone
    - RH-S-H - N=50 - ended up with central system filtration

We note that the randomization percentage for households with central air to receive standalone or central system filtration (17%/83%) is based on our assumptions regarding the percent of homes with central air and of those homes, the percent that are actually able to receive central system filtration. This value will need to be readjusted as we determine the actual fraction of homes with central air systems that are able to be upgraded. The needed randomization percentage may also vary between Riverside and Fresno as the housing stock in Riverside is newer than the housing stock in Fresno. The randomization percentage will be confirmed after 30 homes have been enrolled in Fresno for the Fresno region. Once 30 homes have been enrolled we will know both the fraction with central air and the fraction of those with central air that can be upgraded to a central system. The new percentages will go into effect beginning at the 35th home. Likewise, in the Riverside region the randomization percent will be confirmed after 15 homes have been enrolled, and the new randomization percent will go into effect for the 20th home. Similar adjustments will be made after enrollment of the 62nd and 95th home in Fresno, and after enrollment of the 31st and 47th home in Riverside.

As we will be scheduling enrollment visits prior to enrollment, we will also check the percent of homes with central air after the same numbers of homes had been scheduled in each region. If less than 70% of the homes have central air, as opposed our estimated 80%, the randomization percentage will be readjusted at that point to ensure that enough homes are screened for eligibility of an upgraded central system.

Analysis can be done on various comparison groups. Please see the statistical analytical plan for details.

Appendix B. Wisconsin Filter/PUF Mass Control data

Filter	TECL ID	CHANGE in MASS (mg)
MASS CONTROL	T1230001	0.006
MASS CONTROL	T1230003	0.003
MASS CONTROL	T1230004	0.002
MASS CONTROL	T1230005	0.005
MASS CONTROL	T10930080	0.004
MASS CONTROL	T1230001	0.007
Average change in mass		0.005
Standard Deviation of change		0.002
Applied control correction		-0.005

PUF	TECL ID	CHANGE in MASS (mg)
MASS CONTROL	SP120001	0.013
MASS CONTROL	SP120023	0.027
MASS CONTROL	SP120012	0.018
MASS CONTROL	SP120001	0.018
MASS CONTROL	SP120023	0.009
MASS CONTROL	SP120012	0.019
MASS CONTROL	SP120034	0.029
MASS CONTROL	SP120012	0.025
Average change in mass		0.020
Standard deviation of control changes		0.007

Appendix C: Diagnosing and solving the problem with the PM filters

A number of blanks were collected in the pilot. We have three types of blanks:

- True field blanks which were loaded into the samplers, taken into the field, taken out in the field and allowed to sit out while the actual samplers were being attached to the pumps, and returned to the laboratory and put in the refrigerator.
- Quasi-field blanks which were loaded into the samplers, taken into the field but never opened in the field, and returned to the laboratory and put in the refrigerator.
- Laboratory blanks which were never removed from their sealed case and never put in the refrigerator.

The field blanks for PM clearly indicate there is background contamination or gross error. The PM blank data are presented in Table 1.

Table C-1. Field blanks of PM (mg/filter or PUF)

HHID	Set up Date	Filtra-tion	PM2.5 filter (mg)	PM0.2 filter (mg)	PM (0.2-2.5) PUF (mg)	PM (2.5-10) PUF (mg)	Note
Wisconsin mass control (mean ± SD) (mg)			0.005 ± 0.002 for filters		0.020 ± 0.007 For PUFs		
Lab blank (mean ± SD) (mg)			-0.013 ± 0.003		-0.024 ± 0.010		
Field blank							
P0001	7/18/2013	No	0.757	0.019	0.024	-0.015	
P0001	8/1/2013	Yes		1.057	-0.064	-0.011	CI only, not opened in field
P0002	7/18/2013	No	0.130	0.749	-0.008	-0.010	
P0003	7/19/2013	No	0.062	1.167	-0.015	-0.020	
P0003	7/19/2013	No		0.621	-0.011	-0.015	CI only
P0003	8/3/2013	Yes	0.073	0.360	-0.027	-0.020	
	8/12/2013		0.763				PEM only, Loaded into sampler, did not go to field
	8/12/2013		0.423				
Average field blank (mg)			0.368	0.662	-0.017	-0.015	
Standard deviation (mg)			0.331	0.430	0.029	0.004	
Nominal LOD ($\mu g/m^3$)[a]			—	—	1.71	0.254	
Target LOD ($\mu g/m^3$)			0.450	0.162	0.425	0.425	
Personal sampler blank (mg)			-0.057	—	—	—	PEM only (used sampler)

[a] Nominal LOD was not calculated for filters due to concern of background contamination.

The average mass change on the field blank filters is 0.37 ± 0.33 mg and 0.66 ± 0.43 mg for PM2.5 and PM0.2, respectively, while the 4 lab blank filters had an average mass change of -0.013 ± 0.003 mg with actual values being -0.014 mg, -0.011 mg, -0.010 mg, and -0.017 mg. The field blank values clearly exceed any acceptable target value, and indicate some sort of contamination or gross error.

To identify the potential contamination on the filter blanks, we have considered the following facts to try to determine the source of the contamination:

- The laboratory blanks do not appear to have any contamination, while both the true field blanks and the quasi-field blanks appear to have contamination. This would indicate that the filters were either contaminated while loaded into the samplers or contaminated in the refrigerator.
- There appears to be less contamination on the PEM filters than on the CI filters. If the contamination were coming from the laboratory, we would anticipate the opposite. The PEM filters are exposed to laboratory air for a longer period of time because we conduct the reflectance pre-measurement on them while the CI filters are only loaded into the samplers.
- There does not appear to be any contamination on the PUF substrates. This would indicate that whatever process is impacting the filters is not impacting the PUF substrates.
- We reviewed the filter blanks from the Dairy Study conducted at UC Davis, for which PM concentrations were determined through our laboratory using both SKC "button" samplers and PM 2.5 cyclone samplers. The filters were loaded into the samplers and were true field blanks in this study. However, the samplers were never placed in the refrigerator. The average blank concentration was 3 μg.
- We reviewed the filter blanks from the SMBC study conducted by my laboratory. These samples were collected in a larger cascade impactor. The filters were loaded into the samplers and were true field blanks in this study. However, the samplers were never placed in the refrigerator. The average blank concentration was 7 μg.
- We reviewed the filter blanks from the prepilot, which were weighed at Wisconsin. These filters were never refrigerated. There were no problems with these blanks and the average blank concentration was 0.2 μg.
- Upon examining the samplers used in the pilot, we found a bit of white film in some places on some of them, and some samplers had a slightly sticky film. We think that the formulation of the detergent we used for cleaning the samplers initially may have changed from what we had used previously or that we used too much of the detergent in the initial cleaning of the samplers and it was not all removed in the water rinse and alcohol rinse.

Based on the above facts, we have two hypotheses on the source of contamination.

- Water condensation hypothesis: ARB requested we immediately place the filter in the refrigerator and also requested we do not remove the filter from the sampler in the hotel in the field, but wait until we were back at the lab. We took these two requests to mean that we were to place the whole sampler in the refrigerator immediately after sampling while the filter is still loaded in the sampler. The cascade impactor has 160 mL of air inside of it and the PEM sampler has 13 mL of air inside of it. In both of these samplers, when they are placed upright, the filter is at the bottom of the air compartment. Perhaps moisture from the air is condensing onto the metal of the sampler and somehow dripping onto the filter. Either this water is not being removed when the filter is equilibrated, or the water is causing the drain disc that is placed under the filter to break down and somehow result in contamination of the filter.
- Incomplete cleaning hypothesis: All the CI and PEM samplers come in new from the machine shop. We cleaned the new samplers with Liquinox, but it appears that the cutting

oil was not thoroughly cleaned and the residual, which was either the cutting fluid, or the residual Liquinox, or a combination of both, may contact the filter while the filter was in the sampler. We suspect Liquinox changed their formulation and thus did not remove the grease effectively. This same detergent had been effective in previous studies.

It is conceivable that the filters were somehow switched either in the field or laboratory and thus the pre- and post-weights were not matched up properly. We ruled out that possibility because had that been the case, there would necessarily need to be some filters coming back with large negative values. Also there could be some uncertainty in the scale, which also seems unlikely as all of the laboratory blanks were fine. We did, however, do some additional testing to confirm the reported values from the Wisconsin lab.

Evaluating Results Reported by the Wisconsin Laboratory

We sent ten filter samples from pilot (mostly duplicate samples) that had been weighed by Wisconsin to Lawrence Berkeley National Laboratory (LBNL) where they were equilibrated and weighed. Additional testing took place at LBNL as this was the most reliable scale we had easy access to.

Table C-2. Comparison of weight (mg) of pilot samples provided by Wisconsin Lab and LBNL.

	Wisconsin Lab				LBNL average	Diff between Wisconsin and LBNL
FILTER #	weight 1	weight 2	Difference between weight 1 and 2	average		
T1330012	120.467	120.469	0.002	120.468	120.456	-0.012
T1330014	113.581	113.586	0.005	113.584	113.580	-0.004
T1330016	115.908	115.904	-0.004	115.906	115.905	-0.001
T1330021	111.318	111.323	0.005	111.321	111.313	-0.008
T1330025	109.095	109.100	0.005	109.098	109.095	-0.003
T1330034	118.790	118.787	-0.003	118.789	118.778	-0.011
T1330040	107.615	107.615	0.000	107.615	107.608	-0.007
T1330042	110.310	110.305	-0.005	110.308	110.302	-0.006
T1330050	98.417	98.421	0.004	98.419	98.409	-0.010
T1330052	102.967	102.964	-0.003	102.966	102.957	-0.009
T1330057	100.671	100.670	-0.001	100.671	100.661	-0.010
T1330060	94.958	94.946	-0.012	94.952	94.936	-0.016
T1330061	92.103	92.098	-0.005	92.101	92.094	-0.007
T1330067	105.628	105.626	-0.002	105.627	105.626	-0.001
T1330069	111.918	111.917	-0.001	111.918	111.910	-0.008
Mean			-0.001			-0.008
STD			0.005			0.004

Table 2 presents the post-weight of pilot samples provided by the Wisconsin Lab and the weight at LBNL respectively. The LBNL weight was consistently lower, on average -0.008 ± 0.004 mg,

than the weight reported by the Wisconsin lab, probably due to slight differences in the scale, or the environment (such as temperature and relative humidity in the weighing room), or the weighing technique of different people. The variability of the difference between the weight reported by the two labs, as indicated by the standard deviation (0.004 mg), is comparable with the standard deviation of the difference between the repeat weight reported by the Wisconsin lab. These results suggest that Wisconsin weights are reliable.

Reliability of LBNL Scale

We also tested the LBNL scale by weighing four filters repeatedly, and obtained a mass change ranging from 0.0002 to 0.0016 mg between repeated weighing (Table 3).

Table C-3. Results of repeated weighing of filters in LBNL

Filter #	Weight 1 (mg)	Weight 2 (mg)	Mass change (mg)
T1330067	105.6401	105.6413	0.0012
T1330068	99.8711	99.8713	0.0002
T1330070	106.6975	106.6991	0.0016
T1230006	100.7593	100.7597	0.0004

Testing the Incomplete Cleaning and Water Condensation Hypotheses

A new cleaning procedure was developed using Dawn detergent. Dawn detergent is powerful at breaking up grease and was thought to be potentially better than Liquinox at removing the residual cutting oil. Also, we added a more thorough rinse process to ensure there was no residual detergent. We hope that this new cleaning protocol would reduce the contamination.

To test the incomplete cleaning and water condensation hypotheses, we sent ten filters that were pre-weighed by Wisconsin but had not been used to LBNL where they were equilibrated and weighed. They were sent back to UC Davis. Five were processed as we did in the pilot and five were processed using our new cleaning protocol with no refrigeration. If the five blanks processed with the new method came back without contamination, the test would not allow us to differentiate if the new cleaning protocol or not refrigerating the samplers solved the problem, but it could tell us if the combination of the two changes solved the problem. After unloading, they were sent back to LBNL where they were weighed after a 24-hour equilibration, and again after a 48 hour equilibration. However, all of the ten blanks showed some degree of contamination, suggesting that the new cleaning procedure did not work (Table 4). Not refrigerating samplers did not reduce blank contamination, however, we decided to no longer refrigerate the samplers anyway, as it is not a standard practice and the ARB had not intended us to refrigerate the samplers and we had misinterpreted their suggestions about refrigeration.

Table C-4. Comparison of filter blank level between old and new filter processing procedures (new detergent, no refrigeration)

Filter ID	Procedure	pre-weight (mg)	post-weight (mg)			Mass change (mg)
			24-hr equilibration	48-hr equilibration	Diff	
T1330001	old	122.848	123.025	123.021	-0.004	0.178
T1330002	old	118.690	119.129	119.127	-0.002	0.440
T1330006	old	118.759	119.084	119.082	-0.002	0.325
T1330007	old	92.416	92.471	92.468	-0.003	0.055
T1330008	old	109.839	110.175	110.173	-0.002	0.336
T1330003	new	114.929	115.284	115.280	-0.004	0.355
T1330004	new	119.779	119.923	119.920	-0.003	0.144
T1330005	new	113.966	114.409	114.408	-0.002	0.444
T1330009	new	113.719	113.806	113.803	-0.003	0.087
T1330010	new	118.522	119.302	119.301	-0.001	0.780
				Mean	-0.003	0.314
				STD	0.001	0.216
				CV	0.34	0.69

Developing New Hypotheses

As we did not have problems with the blanks in our pre-pilot which used older CIs owned by Harvard School of Public Health (HSPH), and others have not reported problems with blanks using the PEM samplers, we thought that we should test "used" samplers.

Alternatively, we thought that perhaps there was significant deposition on the filters while they were loaded at Bennett laboratory. Although this seemed very unlikely as it did not seem possible for that much contamination to occur in the short period of time the filters were exposed to the air, we tested that hypothesis as well.

Testing Used Samplers

We took two approaches to test used samplers. First, we borrowed a used CI sampler from HSPH to test if there is anything wrong with our loading/unloading procedure. Second, we repeatedly wiped, assembled, disassembled, and wiped three new CIs to make them "like used" samplers.

A filter was loaded into the used Harvard sampler and unloaded immediately, resulting in a mass change of 4.9 µg (Table 5). We also loaded a filter into a "like used" CI sampler treated with extra cleaning procedure and unloaded immediately, and the weight difference was 17.8 µg. These tests suggest that we did not have a problem with our loading/unloading procedure using the true used sampler, and that things look promising for the "like used" samplers which had been repeatedly loaded and cleaned by wiping with a piece of Kimwipe moistened with ethanol.

We then tested more of the "like used" samplers along with a retest of the Harvard used CI. Filters were loaded into these CIs, immediately unloaded, and weighed at LBNL. This resulted in better results, on the order of 9-15 µg of mass. The blank in the actual used sampler sent in from HSPH had a mass change of 7.3 µg. Compared to earlier tests with less cleaning, repeated

cleaning does reduce the contamination of the filter blank. While we were pleased that things were improving, we still desired to have lower blanks. We also learned that the used sampler from Harvard had not been cleaned or wiped at all after the last use, and thus the blank from that was likely higher than if it had been wiped.

Table C-5. Comparison of filter blank level between using used and "like used" CI samplers.

Filter #	Action	Pre-weight (mg)	Post-weight (mg)	Mass change (μg)
Test 1				
T1230006	loaded in Harvard CI	100.7552	100.7601	4.9
T1330067	loaded in CI #11	105.6247	105.6425	17.8
Test 2				
T1330067	loaded in Harvard CI	105.6413	105.6486	7.3
T1330068	loaded in CI #11	99.8713	99.8806	9.3
T1330070	loaded in CI #13	106.6991	106.7138	14.7
T1230006	loaded in CI #4	100.7597	100.7735	13.8

Testing for Contamination in Bennett Laboratory

In addition, to test the possibility of contamination by the air of the Bennett laboratory, we opened pilot filters and waved them around for a few seconds in the Bennett laboratory, replicating the time period the filter was exposed to laboratory air while being loaded into the sampler. The filters were then weighed in LBNL and little mass increase was observed (Table 6), which confirms that there is no contamination in the air of the Bennett laboratory.

Table C-6. Evaluation of filter weight change after waving in the Bennett laboratory

Filter ID	Pre-weight (mg)	Post-weight (mg)	Mass change (μg)
T1330012	120.456	120.449	-7.5
T1330014	113.580	113.579	-1.7
T1330016	115.905	115.905	0.4
T1330021	111.313	111.311	-1.6
T1330025	109.095	109.093	-1.4
T1330034	118.778	118.772	-6.4
T1330040	107.608	107.604	-4.0
T1330042	110.302	110.303	1.1
T1330050	98.409	98.406	-2.6
T1330052	102.957	102.954	-2.1
T1330057	100.661	100.657	-4.4
T1330060	94.935	94.934	-1.5
T1330061	92.094	92.095	0.4
T1330069	111.910	111.910	0.0

Testing the Need for a Strong Solvent Wash

Although the contamination was reduced significantly with the continued wiping with an alcohol wetted Kimwipe, we thought there was probably still some residue as the blanks at LBNL are

routinely lower than we were achieving. We wanted to test if washing the samplers in a strong solvent solved the problem.

We therefore cleaned two samplers more thoroughly with pesticide grade dichloromethane (DCM) in LBNL. While washing in the solvent, one can clearly see the oil residue coming off the samplers. After cleaning, filters were loaded, unloaded and weighed, and the weight change of the blanks were reduced to 0.5 μg and 1.5 μg (Table 7). DCM appears to be an effective cleaner in removing cutting oil residue on the sampler.

Table C-7. Blank level after filters being loaded in samplers cleaned by DCM in LBNL

Filter ID	CI #	Pre-weight (mg)	Post-weight (mg)	Mass change (μg)
Same filter	7	105.9626	105.9631	0.5
	15	105.9631	105.9646	1.5

Then we proceeded with tests using samplers cleaned with DCM in combination with being loaded in the Bennett laboratory. The filters were loaded into CIs and immediately unloaded in Davis. The filters were then weighed in LBNL. One blank was pretty clean while the other one had slightly higher level (Table 8).

Table C-8. Blank level after filters being loaded in samplers cleaned by DCM in Bennett laboratory

Filter ID	CI #	Pre-weight (mg)	Post-weight (mg)	Mass change (μg)
RLM04	7	105.9626	105.9735	10.9
RLM03	15	105.4451	105.4479	2.8

We then wanted to confirm that once the samplers were clean, the blanks would remain uncontaminated following sampler used and routine cleaning, consisting of wiping the sampler with a Kimwipe moistened with ethanol. The samplers (cleaned with DCM at LBNL) were loaded with dummy filters and PUFs. The CI's with dummy filters and PUFs were put into two pump boxes and run for 24 hours outside. After sampling, the pump boxes were taken down and the dummy filters were taken out. The CI's were wiped with a Kimwipe moistened with ethanol. A new set of filters were then loaded and unloaded. The mass change on these blanks were minor (±2 μg) (Table 9), indicating that the samplers were still clean after the first use once the original cutting oil was thoroughly removed by DCM. Problems could arise with further use.

Table C-9. Filter blank level after loaded in samplers that were initially cleaned by DCM and routinely cleaned after being used

Filter ID	CI #	Pre-weight (mg)	Post-weight (mg)	Mass change (μg)
RLM01	7	112.5352	112.5341	-1.1
RLM02	15	116.0035	116.0055	2.0

Conclusion

Based on the above test results, cutting oil was probably the source of field blank contamination for filters and including a final wash with DCM appears to be an effective way for cleaning the samplers. After thorough cleaning with DCM, samplers will keep clean. Therefore, we decide to

clean all samplers with DCM before using them in the main study. Hope that will keep the field blank clean. We will keep monitoring field blank levels in the main study.

Therefore, all samplers will be thoroughly washed prior to use. This will consist of first washing any dust off the samplers with liquid detergent and water. Then all metal parts of the samplers will be placed in a clean glass beaker and sonicated for 5 minutes in deionized water. The water will then be drained out of the beaker. Methanol will be added to the beaker and the parts will be sonicated for 5 minutes. The methanol will be trained out of the beaker and pesticide grade dichloromethane will be added to the beaker and the parts will be sonicated for five minutes. The dichloromethane will be drained out of the beaker and pesticide grade hexane will be placed in the beaker and all parts will be sonicated for 5 minutes. The parts will be allowed to air dry on a Kimwipe.

In between each use, the sampler will be wiped with an ethanol moistened Kimwipe, with extra focus placed on cleaning the slots through which the air passes in the impactor and the surfaces that contact the filter.

We will continue to monitor blanks, especially at the beginning of the study, to ensure that they are continuing to come back with little contamination.

Appendix D: Diagnosing and solving the problem with the PM filters – Post pilot

The decision was made to consider the first few homes pilot homes. Unfortunately, the filter field blanks from these homes came back contaminated (Table D1).

Table D1 Field blanks collected in December Homes

Filter ID	Sampler type	Sampler #	Sample mass (mg)		PUF ID	Stage	Sampler #	Sample mass (mg)
t1130192	CI	15	0.721		SP130050	0.2-2.5µm	15	-0.005
t1130196	CI	16	1.017		SP130039	2.5-10µm	15	-0.010
t1130197	CI	65	0.675		SP130054	0.2-2.5µm	16	-0.004
t1130200	CI	67	0.543		SP130043	2.5-10µm	16	-0.011
t1330235	CI	38	1.245		SP130091	0.2-2.5µm	38	-0.009
t1130205	CI	21	0.943		SP130081	2.5-10µm	38	-0.013
t1130195	CI	18	0.760		SP130055	0.2-2.5µm	65	-0.002
t1330234	CI	42	0.560		SP130044	2.5-10µm	65	-0.009
t1130193	CI	4	0.464		SP130058	0.2-2.5µm	67	0.005
					SP130047	2.5-10µm	67	-0.004
t1330138	PEM	30	0.622		SP130063	2.5-10µm	21	-0.010
t1330149	PEM	39	0.444		SP130073	0.2-2.5µm	21	-0.011
t1130182	PEM	12	0.285		SP130053	0.2-2.5µm	18	-0.003
t1130189	PEM	19	0.396		SP130042	2.5-10µm	18	-0.012
t1330155	PEM	9	0.134		SP130090	0.2-2.5µm	42	-0.005
t1330150	PEM	53	0.495		SP130080	2.5-10µm	42	-0.014
t1330148	PEM	40	0.559		SP130051	0.2-2.5µm	4	-0.006
t1330141	PEM	15	0.362		SP130040	2.5-10µm	4	-0.012

The first thought was that the samplers had not actually come clean. Fresh filters were weighted, loaded into the samplers with red O-rings, unloaded immediately, and weighted again. There was virtually no change in mass. We concluded that there was no longer contamination from contacting the surface.

One sampler was left loaded overnight. Over the course of approximately 12 hours, the filter gained approximately 100 ug. We recalled that in an effort to meet ARB's desire for absolutely no leaks, we were using a red silicone O-ring rather than the standard black Buna rubber one. The black one resulted in slight leak and we were concerned ARB would find that unacceptable. The red silicone O-ring reduced the leak rate to <0.8%. The original black O-rings in both the CI stage 4 (the filter stage) and PEMs were replaced by the red O-ring, while other stages of CIs still have the original black O-rings. O-rings are cleaned prior to installation by wiping with a kimwipe damped with Milli-Q water.

To test our hypothesis, 12 fresh Teflon filters were conditioned, weighted and then

- 3 were kept as controls in petri dish
- 3 were loaded into cascade impactors that had never been used that had black O-rings
- 6 were loaded into cascade impactors that had never been used with red O-rings

CIs (in ziplocs) and blanks (in petri dishes) were left on the counter in the lab overnight. Filters were removed and re-weighed in the morning the next day. The filters stayed in CIs for 12 hours. Results show that the CIs with red O-rings gained 130 ug on average overnight, while the CIs with black O-rings gained less than 2 ug (average), and the weight of blanks remains same (Table D2). The results point to the red O-ring as the source of contamination.

Table D2. Filter weight change in cascade impactors with different types of O-rings.

time in CI			12 hours		84 hours	
Filter #	Group	pre (mg)	post (mg)	diff (ug)	post (mg)	diff (ug)
5	blank	102.950	102.950	-0.2	102.949	-0.8
9	blank	100.283	100.283	-0.4	100.282	-0.8
13	blank	108.640	108.640	0.2	108.639	-0.6
average diff (ug)				-0.1		-0.7
standard deviation (ug)				0.3		0.1
10	black	97.511	97.512	1.1	97.514	3.2
11	black	100.781	100.785	4.0	100.785	4.7
12	black	101.168	101.168	0.0	101.168	0.3
average diff (ug)				1.7		2.7
standard deviation (ug)				2.1		2.2
2	red	120.167	120.251	84.2	120.301	133.7
3	red	114.599	114.812	213.1	114.912	312.3
4	red	103.107	103.254	147.1	103.309	202.5
6	red	108.996	109.110	113.9	109.149	152.4
7	red	110.502	110.619	116.9	110.679	177.3
8	red	100.565	100.670	105.7	100.730	165.0
average diff (ug)				130.2		190.5
standard deviation (ug)				45.4		64.0

The filters were loaded back to the original CIs (the blanks were kept in petri dishes), and unloaded again after 84 hours (3.5 days). Results were consistent with those from 12 hours, still very little change in CIs with black O-rings, continuing increase for the red O-rings, and blanks pretty much unchanged.

The true problem being the O-rings is consistent with our original findings. In the original pilot samplers, the samplers were originally assembled without filters or drain disks prior to the installation of drain disks and filters for the first usage. Also, it is possible that some of the screens may have been flipped over at some point in the samplers. This likely resulted in a film being present on the portion of the sampler which contacted the filter. Although we ran the samplers and the reloaded them to ensure there was no new contamination, we never left filters in the samplers, assuming it was a contact contamination. Although we though the problem was originating from residue from the manufacturing process, we had begun to be careful with ensuring that the screens were never flipped over and always having a drain disk present in assembling the samplers for use in December as we thought there was a slight possibility that a contact residue could be coming from the O-ring. This is why no new residue likely developed during the use of the sampler in December.

We have ordered the standard black O-rings for all the samplers. This will result in a few percent of the flow rate leaking through the metal components holding the filter. We do not consider this a problem because the leak rate is basically consistent between the samplers. Also, given the turns the air needs to make, we do not anticipate that many particles will reach the filter. Finally, a slight leak is far superior to contamination.

Other summary of the December PM results

Table D3 presented the PM data currently available from December sampling. We only had filters from the first week weighed. Once we identified the filter contamination problem, we did not have the rest weighed. We will have the PUFs weighed at some point but not the filters, because they are contaminated and we will not yield much information from them.

Table D3. PM concentrations in pilot homes

HHID	Set up Date	Indoor/outdoor	Primary/ duplicate	Sampler (on/off) at collection	Sampling days	PM2.5 ($\mu g/m^3$)	PM0.2 ($\mu g/m^3$)	PM (0.2-2.5) ($\mu g/m^3$)	PM (2.5-10) ($\mu g/m^3$)
80004	12/4/2013	indoor	primary	on	7	19.7	36.2	13.2	10.3
80004	12/4/2013	outdoor	duplicate	off (right before visit)	7	30.8	27.2	17.0	6.6
80004	12/4/2013	outdoor	primary	off (right before visit)	7	27.4	29.6	15.2	6.8
80009	12/5/2013	indoor	primary	off (unknown)	7	23.5	26.7	7.3	4.1
80009	12/5/2013	outdoor	primary	on	7	39.2	25.3	19.4	6.2
80012	12/6/2013	indoor	primary	on	7	48.9	43.6	16.2	7.4
80016	12/5/2013	indoor	duplicate	on	7	49.0	27.1	15.1	12.0
80016	12/5/2013	indoor	primary	on	7	49.8	22.4	14.8	11.9

We note that the children at home 80004 unplugged the sampler right before we arrived at the home. This was confirmed by the field staff because the pumps still felt warm when touched. Home 80009 had a problem with surging power to all their plugs which caused the power to turn off.

Table D4. Summary statistics of PM concentrations determined by PUF in December homes

	PM (0.2-2.5) ($\mu g/m^3$)	PUF (2.5-10) ($\mu g/m^3$)
Indoor (pre-intervention)		
Arithmetic mean	13.3	9.1
Standard deviation	3.5	3.4
median	14.8	10.3
Outdoor		
Arithmetic mean	17.2	6.5
Standard deviation	2.1	1.9
median	16.1	6.7

Two pairs of duplicate samples were available. The precision between PUF duplicate samples was calculated based on method described in Section 2.5.1.1, and results are within the range defined in QA/QC plan (Table D5).

Table D5. Precision between duplicate samples collected in pilot

HHID	Set up Date	Indoor/ outdoor	PM (0.2-2.5)	PM(2.5-10)
80004	12/4/2013	Outdoor	11%	4%
80016	12/5/2013	Indoor	2%	1%
Precision criteria defined in QA/QC plan		Indoor	30%	20%
		Indoor	20%	10%
		Outdoor	20%	10%

The indoor/outdoor PM ratio for the PUF size fractions was calculated when paired indoor and outdoor concentrations were available. Only 2 pairs are available (Table D6).

Table D6. Indoor/outdoor ratios observed in pilot homes

HHID	Set up Date	I/O Ratio for PM (0.2-2.5)	I/O Ratio for PM (2.5-10)
80004	12/4/2013	0.8	1.5
80009	12/5/2013	0.4	0.7

January Field Blanks

Once we received the blank O-rings, we proceeded with field sampling. Five of each types of sampler were taken into the field as blank samplers. The filter field blanks collected in January are acceptable, showing that we have solved the filter blank contamination problem by replacing the red O-rings with black O-rings (Table D7).

Table D7 Filter field blanks collected in January

Filter ID	**Sampler type**	**Sampler #**	**Sample mass (mg)**		**PUF ID**	**Stage**	**Sampler #**	**Sample mass (mg)**
t1130232	CI	2	0.000		SP130178	0.2-2.5µm	2	-0.008
t1130224	CI	14	0.010		SP130163	2.5-10µm	2	0.020
t1130229	CI	17	0.012		SP130171	0.2-2.5µm	14	-0.005
t1330293	CI	34	0.008		SP130156	2.5-10µm	14	-0.020
t1130226	CI	49	0.000		SP130176	0.2-2.5µm	17	-0.015
t1330295	PEM	22	-0.002		SP130161	2.5-10µm	17	-0.007
t1330270	PEM	28	-0.006		SP130180	0.2-2.5µm	34	-0.011
t1330134	PEM	57	0.001		SP130165	2.5-10µm	34	0.009
t1330296	PEM	72	0.000		SP130173	0.2-2.5µm	49	-0.012
t1330137	PEM	73	-0.002		SP130158	2.5-10µm	49	-0.004

APPENDIX E: QA/QC

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Quality Assurance Project Plan
BENEFITS OF HIGH EFFICIENCY FILTRATION TO CHILDREN WITH ASTHMA

University of California, Davis
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Old Davis Road
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Prepared by: _____ Date: 1/14/2014
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Approved by: _____ Date: 1/13/14
Tim Tyner, Co-Investigator

Approved by: _____ Date: 1/23/17
Jeff Williams, Project Manager at ARB

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Distribution List

Deborah H. Bennett (Principal Investigator, UC Davis)
Marc Schenker (Co-Investigator, UC Davis)
Nicholas Kenyon (Co-Investigator, UC Davis)
Dan Tancredi (Co-Investigator, UC Davis)
William Fisk (Co-Investigator, Lawrence Berkeley National Laboratory)
Paul Mills (Co-Investigator, UCSF Fresno)
Tim Tyner (Co-Investigator, UCSF Fresno)
Rebecca Moran (UC Davis Project Manager)
Xiangmei (May) Wu (UC Davis QA Manger)
All Field Staff Personnel
Peggy Jenkins (ARB)
Jeffery Williams (ARB)
Qunfang (Zoe) Zhang (ARB)

A. Project Management

A.1 PROJECT/TASK ORGANIZATION

This study will be conducted by an experienced research team from the University of California at Davis, in collaboration with the Indoor Environment Department (IED) at LBNL and UCSF Fresno. The Principle Investigator, Dr. Deborah Bennett, has the experience and skills in exposure assessment studies and analytical techniques to ensure that projected aims and goals are achieved. All Co-Investigators of this study are faculty members or senior researchers in the exposure, epidemiology, biostatistics, and medical fields. All other staff will be trained professionals, students, or recent graduates who will be trained to conduct the tasks. The organizational structure, personnel responsibilities, and management and coordination for the proposed study are described below.

A.1.1 Organizational Structure

The organizational plan for this study is shown in Figure 1. This study is staffed with a team of individuals with extensive experience in exposure and epidemiology studies and data analysis, along with lab analysis. All of the staff for the program will be working together and will report directly to the Principal Investigator and will come together in meetings to discuss progress. Together, the research team has considerable experience in the design, performance, and analysis of exposure assessment studies.

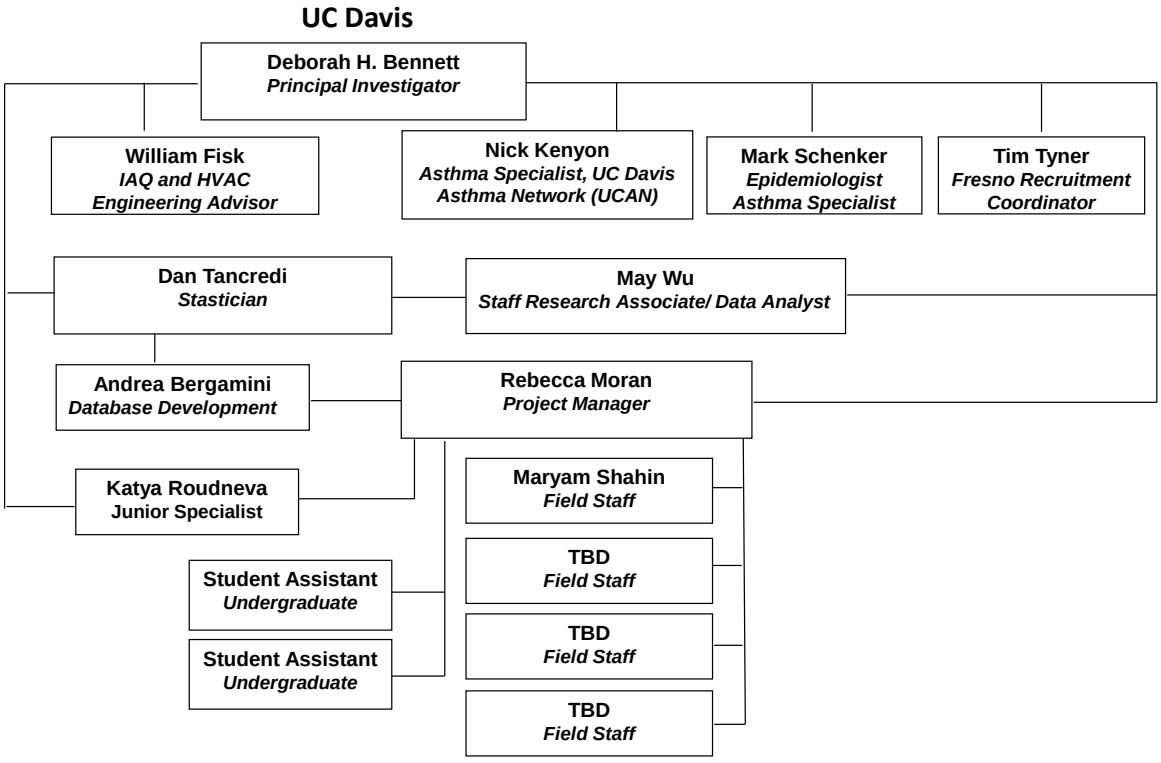

Figure 1: Organization structure for conducting the study

Dr. Bennett and Ms. Roudneva would be the backup for Ms. Moran if she is not available. Ms. Moran, Dr. Wu and Ms. Roudneva are backup for the field staff.

A.1.2 Personnel Responsibilities

Each member of the research team will have pre-defined responsibilities and will also assist in other areas of the study. The title and responsibilities of key personnel who will be responsible for principal functions in the study and who will coordinate project tasks are listed below in Table 1.

Table 1: Project Personnel and Responsibilities

Function	Title and Project Responsibilities
Principal Investigator:	Deborah Bennett, Associate Professor, Environmental and Occupational Health, UC Davis Department of Public Health *Provide guidance on all aspects of project, from sampling scheme through data analysis. Responsible for final approval of work product.*
Co-Investigators:	Marc Schenker, Professor, Environmental and Occupational Health, UC Davis Department of Public Health Nicholas Kenyon, Associate Professor, Department of Internal Medicine, UC Davis School of Medicine *Responsible for the development of the health measure protocols. Review spirometry tracings.*
Co-Investigator:	Tim Tyner, Associate Director of the Center for Clinical and Translational Research at UCSF Fresno *Responsible for coordinating with the Fresno Unified School District Asthma Management program and local health care providers, to recruit 130 families of children (6 -12 yrs old) with asthma.*
Co-Investigator and Biostatistician:	Dan Tancredi, Assistant Professor, Department of Pediatrics, UC Davis School of Medicine *Develop and oversee the implementation of data management plan and the statistical analysis plan*
Co-Investigator:	William Fisk, Lawrence Berkeley National Laboratory *Assist in the selection of filtration devices used and help communicate with providers*

Contact for the Riverside recruitment	To be determined
UC Davis Project Manager:	Rebecca Moran, M.S. UC Davis Department of Public Health Sciences, Center for Health and the Environment *Responsible for day-to-day operations. Oversees implementation of project goals and all components of the study, including ordering and managing equipment and supplies, training and supervising lab technicians, field staff, and student assistants, designing and maintaining the Subject Tracking System and study Database, maintain IRB records; coordinating compensation and reimbursement, coordinating participant contacting, vehicle lease and use, staff travel, sample shipments, sample analysis with outside labs, oversee home visit logistics, field office set-up, and study document storage and organization*
UC Davis Quality Assurance Manager and Data Manager:	Xiangmei (May) Wu , PhD, UC Davis Department of Public Health Sciences *Oversees all aspects of project quality assurance and quality control. Responsible for overall project quality assurance and maintaining the official approved QA project plan. Audits methods and approves QA report and associated documents. Conducts periodic audits of the data collection systems every three months for the first year and every 6 months after that. Monitor situations that require corrective action. Coordinate structure of database. Analyze data. Prepare progress reports*
Contractor for filtration	Frank Hammes, IQ Air Will provide stand-alone air cleaners and in-line filtration. Oversee his staff who will inspect homes and install HVAC modifications.
Database Manager and Programmer	Andrea Bergamini, UC Davis Department of Public Health Sciences Keith Jose, UC Davis Department of Public Health Sciences *Coordinate with Dr. Xiangmei Wu and Rebecca Moran to implement and maintain database, questionnaire, and codebooks.*
Field Staff	Maryam Shahin, Carina Segoviano Perez, Alex Gutierrez, Jorge Gamboa *Conduct field visits to collect environmental sample, questionnaire data, and health measurements, and transport samples from field to Dr. Bennett's lab in UC Davis. They will upload field logs, questionnaires and other documentation to the secure server.*
Junior Specialist	Katya Roudneva, UC Davis Department of Public Health Sciences

	Oversee lab work, including sampler cleaning, sampler loading and unloading, sample logging and shipment, reflectance measurements, and data entry, at UC Davis under Rebecca Moran's guidance. She will eventually help with statistical analysis and will report to Drs. Bennett and Tancredi in that capacity.
Recruiter, scheduler and interviewer	To be staffed as needed *Answer recruitment calls, schedule sampling, and conduct telephone interview*
Data entry staff	To be staffed as needed *Enter questionnaires and field logs into the data entry system and conduct necessary quality control such as double entry.*
Lab technician	To be staffed as needed *Responsible for loading and unloading sampler, cleaning the samplers, logging samples, packing and unpacking the delivery*
Reflectometer technician	To be staffed as needed *Conduct reflectance measurements and maintain the reflectometer*

A.2 PROBLEM DEFINITION AND BACKGROUND

Particulate matter (PM) and other air pollutants have long been known to cause adverse respiratory health effects. Elevated PM levels have been found to be related to increased asthma symptoms in numerous studies as well as being related to reduce lung function in studies of healthy children. Ozone and VOCs have also been found to be related to asthma symptoms. As people spend approximately two-thirds of their time indoors at home (Jenkins et al. 1992; Klepeis et al. 2001; Phillips TJ 1991; Phillips TJ 1990), indoor levels of air pollution have an impact on health.

Approximately 8.5 % of children in the United States suffer from asthma (American Lung Association 2010). In California, 8.6% have asthma currently and 13.3% have been diagnosed with asthma at some point in their lives (American Lung Association 2010). Asthma puts considerable burden on the health care system and treatment costs $3.2 billion per year in the United States (Weiss et al. 2000). Should air filtration improve symptoms, there could be tremendous cost savings from implementing air filtration as an asthma intervention tool on a larger population, particularly in a region with high air pollution levels, such as California.

This study aims to determine if filtering indoor air reduces air pollution concentrations and subsequently reduces asthma symptoms. This study will provide superior air filtration, either installing high efficiency filters in HVAC systems or installing stand-alone air cleaners, in regions with high outdoor air pollution levels. The number of

participants will be larger than in many of the previous studies that evaluated filtration. Filtration utilization will be monitored and improvements in indoor air will be quantified. Should this project find that both HVAC filtration and stand-alone air filtration units result in lower indoor air pollution and lower prevalence of asthma symptoms, these interventions could reduce health costs associated with asthma care.

A.3 PROJECT/TASK DESCRIPTION AND SCHEDULE

A.3.1 Project Purpose and Overview

The objectives of this study are: 1) in homes of children with asthma, determine the extent to which the use of high efficiency HVAC filtration and high efficiency portable air cleaners reduces indoor concentrations of PM0.2, PM2.5, and PM10, the resulting personal exposures, and indoor concentrations of ozone; 2) to determine the extent to which the use of high efficiency filtration reduces their asthma symptoms, emergency room (ER) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction, specifically exhaled nitric oxide and spirometry, in children with moderate to severe asthma; 3) in homes of children with asthma, to measure indoor and outdoor concentrations of, PM0.2, PM2.5, and PM10 and ozone, and resulting indoor and personal exposures. The first two objectives will be met by comparing the respective measures between the sham and true filtration periods. These outcomes will also be compared to the pre-intervention period. The third objective will be met through the pre-intervention measurements, personal monitoring later in the project, and modeling. The specific tasks to meet the objectives to collect the necessary data for this study include, but not limited to, the following:

- Develop and administer a home walkthrough procedure assessing the home ventilation condition of participating households.
- Develop and administer 2-week recall questionnaire to collect health information every 3 months for a total of 9 collection periods.
- Develop and administer a symptom diary continuously for two-week periods, every 3 months for a total of 9 collection periods.
- Collect exhaled nitric oxide (eNO) samples every 6 months for a total of 5 times, conduct spirometry measurements annually for a total of 3 times, and measure peak flow twice daily for one-week periods every 3 months for a total of 9 times from 200 children with asthma.
- Collect indoor temperature and relative humidity continuously for one-week periods every 6 months, for a total of 5 times.
- Collect indoor and outdoor particle (PM2.5, PM0.2, PM0.2-2.5, and PM2.5-10) samples from 200 households for one-week periods every 6 months, for a total of 5 one-week integrated samples per home.
- Measure reflectance using indoor and outdoor PM2.5 filter samples before and after sample collection. Samples are collected every 6 months for a total of 5 times.
- Collect indoor and outdoor one-week integrated ozone samples from 200 households annually in high ozone season (May – October), for a total of 2 measurement periods.

- Collect indoor one-week integrated NO_2 samples from 200 households annually in the cold season (November – April), for a total of 2 measurement periods.
- Collect personal exposure 48-hour integrated samples to PM2.5 from 25-30 children with asthma every 6 months, for a total of 4 measurement periods.

We have selected Fresno and Riverside, CA because these two cities ranked in the top 5 cities nationwide for ozone pollution and in the top 10 for short term particulate matter exposure in the United States (American Lung Association 2011). Approximately two-thirds (120-144) of the participants will be recruited from the Fresno area, and one-third (60-72) of the participants from the Riverside area. Ideally, participants will be between 6 and 12 years of age with doctor-diagnosed persistent moderate to severe asthma. If it is difficult to meet the recruitment goals, the age criteria will be altered to 6-17 years upon mutual agreement of the investigators and the ARB.

Integrated one-week air pollution samples will be collected every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true periods. Ozone measurements will be made in the high ozone season May - October using a passive badge. One-week integrated indoor and outdoor measurements will be made during the high ozone season in both the true and sham periods. One-week integrated NO_2 will be measured indoors only in the cold season, from November - April.

Health outcomes, including symptoms, unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, respiratory infections, etc, will be collected by questionnaire. Health measurements, such as peak exhaled flow, spirometry, and exhaled nitric oxide (eNO) will be obtained as described above.

A.3.2 Description of Work to be Performed

Two hundred asthmatic children between 6-12 years living in non-smoking homes in regions with high outdoor air pollution, specifically Fresno and Riverside counties, will be enrolled in a randomized placebo cross-over trial to evaluate the effectiveness of high efficiency filtration of indoor air in reducing their exposure to PM and ozone and their asthma symptoms. One intervention group will have modifications of their HVAC system to enable the installation of a high efficiency filter. The second intervention group will have high efficiency portable air cleaners placed in the child's bedroom and in the main living area that reduce particles, ozone, and VOCs. Improvements in asthma symptoms will be evaluated in a cross-over design, with each participant receiving true air filtration for a year and a placebo for a year, allowing us to isolate the improvements related to the air filtration.

Two outcome domains will be considered: the reduction of indoor air pollution levels and the improvement of asthma. Air pollution will be recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true filter periods. Air quality will be measured as one-week integrated indoor and outdoor samples of PM2.5, PM0.2 (representing ultrafine particulate matter), PM0.2-2.5, and PM2.5-10, ozone during high ozone seasons, NO_2 during cold seasons, and reflectance as a measure

of BC. PM0.2 and PM0.2-2.5 will be summed as an alternative measure to quantify PM2.5. PM0.2, PM0.2-2.5, and PM2.5-10 will also be summed to quantify PM10.

The primary measure of asthma health effects will be symptom days per 14 day period. Secondary measures include unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, respiratory infections, peak exhaled flow, spirometry, and exhaled nitric oxide (eNO). Symptoms, unplanned utilization of the healthcare system, short-term rescue drug medication use, and peak exhaled flow will be recorded prior to intervention and quarterly both during the true and the sham periods. Exhaled nitric oxide will be recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true periods. Spirometry will only be recorded pre-intervention and once during each of the true and sham periods.

Table 2 shows the air pollution data that will be collected through the different aspects of this study. Table 3 shows the health outcome data to be collected in this study. This study will last 4 years with Field Collection occurring over approximately 2.5 years. The work will be both field based and laboratory based, with field work conducted in Fresno and Riverside by investigators at the University of California, Davis with support from the University of San Francisco, Fresno.

Table 2: Air Pollution Measures to be Collected in the Study

Analyte	Sampling Method	Analytical Method	Analytical Laboratory	Number of Samples Collected per Home/Person			Number of Samples Collected in Total				
				Indoor	Outdoor	Personal	Indoor	Outdoor	Personal	Blank	Duplicate
PM 0.2 mass	Harvard 5L PM cascading impactor integrated over 1 week	Gravemetric on Teflon filter	Wisconsin	5 [a]	5 [a]	--	1000	1000	--	200	200
PM 0.2-2.5 mass	Harvard 5L PM cascading impactor integrated over 1 week	Gravemetric on PUF	Wisconsin	5 [a]	5 [a]	--	1000	1000	--	200	200
PM 2.5-10 mass	Harvard 5L PM cascading impactor integrated over 1 week	Gravemetric on PUF	Wisconsin	5 [a]	5 [a]	--	1000	1000	--	200	200
PM 2.5 and PM10 mass	Harvard 5L PM cascading impactor integrated over 1 week	Summed from above measures	--	5 [a]	5 [a]	--	1000	1000	--	200	200
PM 2.5	1.8 LPM PM2.5 PEM integrated over 1 week	Gravemetric on Teflon filter	Wisconsin	5 [a]	5 [a]	--	1000	1000	--	200	200
reflectance on PM 2.5	EEL 43D smokestack reflectometer	Based on ISO 9835	UCD	5 [a]	5 [a]	--	1000	1000	--	200	200
PM 2.5 mass (30 people)	Harvard 4.0L PM2.5 PEM integrated over 48 hours	Gravemetric on Teflon filter	Wisconsin	--	--	4	--	--	120	12	0
Ozone	Ogawa passive badge		RTI	2	2	--	400	400	--	80	80
NO2	Ogawa passive badge		RTI	2	--[b]	--	400	--		40	40

[a] The 5 samples include 1 pre-intervention and 2 each for true and sham filtration periods.
[b] Outdoor NO2 will be from nearest ambient monitoring station.

Table 3: Health Measures to be Collected in the Study

Health Measure	Sampling Method	Number of Samples Collected per Person			Number of Samples Collected in Total
		Pre	Sham	True	
eNO	NIOX Mino, 2 samples averaged	1	2	2	1000
Peak Flow	Piko Electric Peak Flowmeter, 3x per session, 2x per day for 1 week	1	4	4	1800
Spirometry	Astra Touch, 3 attempts per collection	1	1	1	600
Symptoms, medicine use, quality of life	2-week recall	1	4	4	1800
Symptoms, medicine use, quality of life	1or 2-week diary	1	4	4	1800
Health Care utilization	3-month recall	--	4	4	1600
Health Care utilization	1-year recall	1	--	--	200

A.3.2.1 Approximate Expected Measurements

See Table 2 and 3.

A.3.2.2 Special Personnel and Equipment Requirements

Field staff will have relevant degrees in scientific fields.

Major equipment and devices that will be used in this study include

- impaction-based PEM (Demokritou et al. 2001)
- cascade impactor (Demokritou et al. 2001; Lee et al. 2006)
- personal sampling pumps (BGI 400, Waltham, MA)
- passive Ogawa badge (OGAWA & Co., Pompano Beach, FL)
- electronic piston volumetric gas flow meter Bios 520/510 (Bios international, New Jersey)
- pump boxes manufactured by Harvard University that include the following components:
  - Medo pumps VPO125- 7 LPM (MEDO, Roselle, IL)
  - Medo pump VPO140 -3 LPM (MEDO, Roselle, IL)
  - flow control valve Milli-Mite 1300 Series 1315G4B (Hoke, Spartanburg, SC)
  - two-channel timer Talento 992+ (RS, Northamptonshire, UK)
- EEL43M Smoke Stain Reflectometer (Diffusion Systems Ltd., London, UK)
- Eureka Boss Vacuum (Eureka, Charlotte, NC)
- DUSTREAM™ sampler (Indoor Biotechnologies, Charlottesville, NC)

- HOBO U10-003 and HOBO U23-001 temperature and relative humidity data logger (Onset Corp., Cape Cod, MA)
- Actical accelerometer (Phillips Electronics, NV) to determine if personal sampling bagpacks are worn
- NIOX MINO (Aerocrine AB, Solna, Sweden) to measure eNO2
- AstraTouch™ Spirometer (SDI Diagnostics, Easton, MA)
- Piko electronic Peak Flow meter (nSpire Health Inc., Longmont, CO)
- laboratory refrigerator (-5°C)
- laboratory freezer (-80°C).

Additional equipment used in the study can be found in the protocols.

A.3.2.3 Schedule for the Work Performed

The timeline is extremely ambitious, to allow for a two year intervention period within a 4 year study.

Project Months 1-12:	Initial project planning involves developing partnerships with pediatric pulmonologists, obtaining IRB clearance with all partner institutions, selecting a company to provide air cleaners, developing protocols and selecting products and contractors to use for in-duct interventions, and developing sampling plans Define the study population, determine recruitment plans, define planned sampling approach and protocols, develop QA/QC plan, and prepare for pilot study.
Project Months 13:	Conduct pilot testing and prepare pilot memo
Project Months 14-17:	Begin participant recruitment, hire and train field staff, and finalize statistical analysis plan.
Project Months 18-24:	Participants will be enrolled on a rolling basis, while continuing to recruit. For each participant, it will take approximately 2 weeks to evaluate the participants HVAC system, make any necessary modifications, and collect baseline data. Participants will join the study over the course of 6 months, a somewhat aggressive estimate that allows us to ensure the timeline.
Project Months 25-48:	We will conduct follow-up visits during the 24 month intervention period. Therefore, the entire recruitment/participation cycle will take 30 months.

Project Months 44-48:	Analyze field data and write draft report on available data. Data analysis will actually begin prior to completion of field work. All introductory sections will also be written prior to completion of field work.
Project Months 49:	Turn in final report.
Project Months 50-55:	ARB to provide comments on final report, present seminars.

The proposed enrollment and filtration schedule for this study is illustrated below in Figure A-2.

The project was delayed in the first year. A no cost time extension will be needed, as the final report must be turned in 6 months before the end of the contract. Due to delays early in the projects, the staff time for analysis was greatly decreased.

A.3.2.4 Project and Quality Records

Samples of necessary project and quality record keeping forms are included in the attached appendices. These records include those for the participant's Baseline Questionnaires, Home Walk-through, Recall Questionnaires, Symptom Dairies, and Mini PAQLQ, as well as other important records to be kept during data collection such as field logs for the monitoring equipment, lab logs, calibration logs, and sample chain-of-custody forms. Following data collection, data entry and data analysis personnel will maintain detailed data analysis logs. All subject records will be kept locked and secured by the field study coordinator, as described later in section A.6.4.

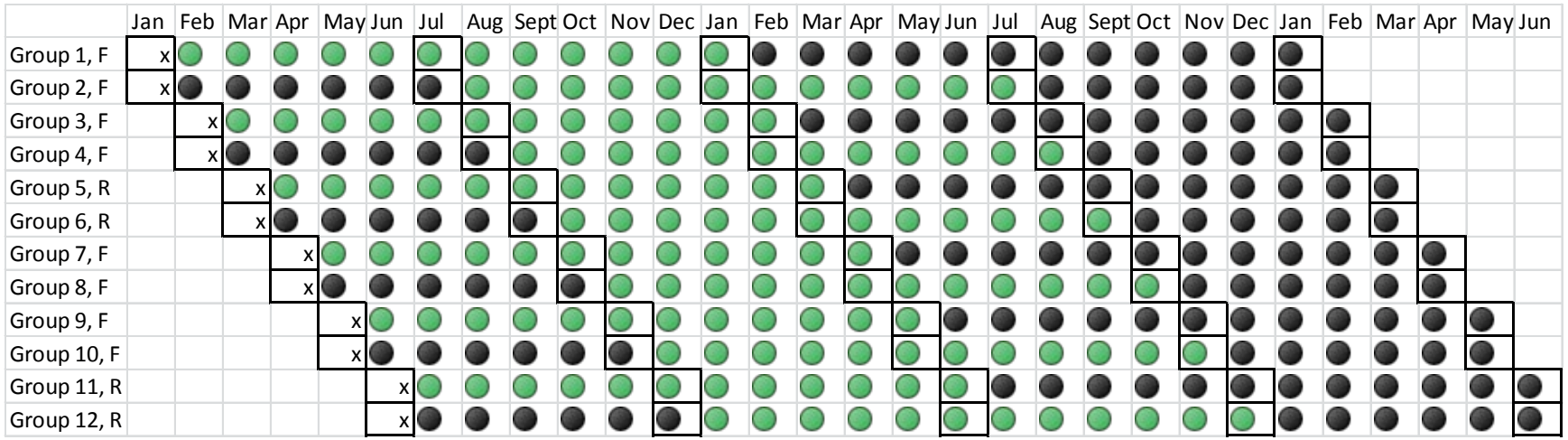

Figure 2: Enrollment and filtration schedule
Green circles indicate true filtration and black circles indicate sham filtration. "F" indicates the group is in Fresno while "R" indicates the group is in Riverside. Black boxes indicate 1-week integrated indoor/outdoor PM monitoring at each participant home.

A.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

A.4.1 Data Quality Objectives

Our primary assessment of intervention effects will use generalized linear mixed-effects regression models in order to provide the most efficient analysis of the available data from our randomized placebo self-controlled crossover study. This regression strategy allows us to account for important features of our longitudinal data, including the need to account for time-varying confounders, including seasonal effects, and partial follow-up from subjects not completing all scheduled assessments. Our primary analysis will use an intention-to-treat approach that considers participants as belonging to the experimental conditions in which they were randomized. This statistical model will allow us to isolate the intervention-specific effects of filtration by comparing periods with real versus sham filtration.

To maximize the efficiency of the analysis, measures collected at the time of enrollment may be included as independent variables, to statistically adjust for characteristics that may be associated with between-person differences in outcomes. Random effects will be used to account for within-person correlation in the vector of repeatedly measured outcomes. The effects of each intervention will be assessed by the intervention-specific adjusted mean difference in outcomes in real vs. sham filtration periods. In addition, between-intervention comparisons of real vs. sham filtration contrasts will be estimated, to compare the interventions on effectiveness. We will also make statistical comparisons between the measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally adjusted measurements from the true and sham filtration periods. Additional covariates specified prior to model fitting will be included. As data from multiple time periods are being compared, the precision of the data is the most relevant, with the data being more precise than the anticipated changes in levels due to the intervention. More details on the methods for determining the reduction in indoor levels can be found in the statistical analytical plan.

A.4.1.1 Objective 1: Determine if indoor air levels of particulate matter, ozone, and reflectance in the households of children with asthma, and the resulting personal exposures, are reduced with the high efficiency filtration.

The primary analysis will compare the values of the primary outcomes, i.e. indoor/outdoor ratios and indoor concentrations, between the periods having true filtration and not having filtration. In cases where we have values for the primary outcome at multiple time points with and without true filtration, all measured values are included in the model. For the t^{th} measurement on the i^{th} individual, $Y_{i,t}$ is the outcome,

$$E(Y_{i,t}) = \mu_{i,t}$$

and $z_{i,t}$ is the matrix of covariates, where $Riverside_i$ is the reference level for the city variable and $Spring_{i,t}$ is the reference level for the season variable.

$$z_{i,t} = \begin{bmatrix} outdoor\ level_{i,t} \\ Fresno_i \\ summer_{i,t} \\ fall_{i,t} \\ winter_{i,t} \end{bmatrix}$$

$g(\mu)$ is a link function that depends on the outcome:
$g(\mu) = \mu$ for normally-distributed variables;
$g(\mu) = \log \mu$ for count or log-normal distributed variables;
$g(\mu) = \log ODDS = \frac{\mu}{1-\mu}$ for binary or proportion data in [0.1] range

The **core model** is

$$g(\mu_{i,t}|\gamma_i) = \beta_0 + z'_{i,t}\bar{\beta}_{covariates} + \beta_{true,SA} \times True_{i,t} + \beta_{HVAC} \times HVAC_i + \beta_{true,HVAC} \times True_{i,t} \times HVAC_i + \gamma_i \qquad \gamma_i \sim N(0, \sigma_N^2)$$

$True_{i,t}$ is a time-varying binary indicator for with (1) vs. without (0) true filtration,
$HVAC_i$ is a time-nonvarying binary indicator for whether the individual has been assigned to the HVAC (1) or the Stand-alone (0) filtration system study arm,
$\beta_{true,SA}$ explains the effect of filtration for stand-alone air cleaner;
$\beta_{true,SA} + \beta_{true,HVAC}$ explains effect of filtration for HVAC;
$\beta_{true,HVAC}$ explains the difference between HVAC and Stand-alone filtration.

If incorporating the actual use time of the filtration into the model, the $True_{i,t}$ term needs to be replaced by $True_{i,t} \times ActUse_{i,t}$.

Separate regression models will be specified for each outcome (indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone). We will statistically adjust for the three listed independent variables (season, city, and household ID), and potentially outdoor concentration.

A suite of exposure-related covariates were collected, such as outdoor levels of PM2.5, PM10, PM0.2, and ozone, NO_2 concentrations, air cleaner / central filtration system utilization, window/door opening, mold and water damage in child's home, indoor smoking, secondhand smoking, cooking sources, frequency of using fan over stove when cooking, frequency of using gas stove/oven, wood/candle burning, cleaning product usage, having furry pets, time spent indoors/outdoors, distance to roadways, wood burning in the neighborhood, removing shoes when entering home, having door mat, pest problem, new paint and furniture, etc. The correlation between both the I/O ratio and indoor concentration of $PM_{2.5}$ and these covariates that may potentially be related to these values will be calculated, either using Spearman correlation analysis (for continuous or interval variables) or ANOVA (for categorical variables). The correlation matrix will be used to identify potential modifiers. Only those variables with statistical significant association with the I/O ratio of PM2.5 (unless otherwise specified) will be considered

potential modifiers and will be included in the further analysis. If significant association is observed for PM2.5, we will try for other relevant size fractions or ozone.

We will also construct a basic personal model, which is a function of the concentration in each microenvironment and the time spent in that microenvironment. This can be expressed by the following equation:

$$Personal\ Exposure = C_1t_1 + C_2t_2 + C_3t_3 + ...C_nt_n$$

where C_i is the concentration in a given microenvironment and t_i is the time spent in that microenvironment. The subscript *i* refers to the specific microenvironment, with *n* being the number of microenvironments the individual was in over the course of the day. Based on this equation, we will calculate personal exposure to PM for all participants for all weeks with air sampling, using the measured indoor and outdoor concentrations, the reported indoor time at home, the reported time spent outdoors, as well as the distribution of time spent in other indoor locations along with representative concentrations found in the literature. We will also use the reported hours that are spent indoors at home and multiply this by the measured reduction in indoor PM2.5 concentrations to determine the anticipated decrease in PM2.5 personal concentrations due to high-efficiency filtration.

Personal exposure samples will be collected on 25-30 participants. We will compare the distribution of the limited personal exposure measurements obtained with and without true filtration to determine if there is a statistically significant difference between the distributions. We will use generalized linear mixed-effects regression models. More details can be found in the statistical analytical plan.

A.4.1.2 Objective 2: Determine if there are improvements on asthma symptoms, emergency room (ER) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma condition in children with moderate to severe asthma, between the true and sham filtration period.

Measures of health effects will include number of days of symptoms, unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, peak exhaled flow, spirometry, and exhaled nitric oxide (eNO).

The recall questionnaire administered to the parent determines the number of days of symptoms, use of control medication, unplanned health care utilization, and a limited number of questions related to environmental exposures. It is developed based on questions used in the inner-city asthma study (ICAS) and additional studies conducted by those researchers (Busse et al. 2011; Mitchell 2012; Morgan et al. 2004), or by the UC Davis team, or modified from a questionnaire developed by the American Academy of Pediatrics. Spanish translations are also available. We will confirm the translations are specific for Mexican Spanish.

Questions on the symptom diary are mostly taken from the inner-city asthma study. The symptom areas recorded are the same as in the recall questionnaire. The MiniPAQLQ

will be administered to the child as part of the recall questionnaire. This survey covers a one-week period. The Pediatric Asthma Quality of Life Questionnaire (PAQLQ) is a validated tool developed to assess the impact of symptoms on quality of life. It is part of the suite of questionnaires often referred to as the Juniper questionnaires. The MiniPAQLQ was recently validated against the PAQLQ in a group of 42 asthmatic children (Wing et al. 2012). Correlation coefficients for each of the corresponding domains of the PAQLQ with the MiniPAQLQ were moderate to strong ($r=0.50$-0.94). Reliability was strong for the MiniPAQLQ ($ICC>0.91$). The responsiveness index value for the MiniPAQLQ (1.05) was higher than that of the original PAQLQ (0.90). These results provide confidence that the MiniPAQLQ is valid, reliable and responsive to change and suitable for use for long-term monitoring in clinical trials. This instrument will be used in its entirety. It has been noted that the last question does not specify activity limitation due to asthma. Also, it is noted that it does not specifically ask if the activity was limited, but rather were the children bothered. We feel that because this instrument is validated, it is still the best one to use despite these limitations.

Exhaled nitric oxide (eNO) provides a measure of airway inflammation. Measures of pulmonary function will be used to classify asthma severity at baseline. Health outcomes must meet the criteria of acceptability and reliability defined in A.7.2.

Measures of pulmonary function will be used to classify asthma severity at baseline. We will also look at changes in pulmonary function over time, with each subject serving as his/her own control in this cross-over design. For spirometry, we will record actual volume-time tracings. From the volume-time tracing, we can calculate the best FEV1, FVC, FEV1/FVC and FEF25-75. Because the results of the spirometry test are used to determine respiratory health status, the measurement must be performed according to strict standards by staff that have been properly trained and certified in how to conduct the maneuver. As the children will grow throughout the study, we do not intend to use the absolute values from the spirometry, but rather percent predicted values.

In addition to spirometry testing, we will record height and weight annually. To measure height and weight, a scale and stadiometer is used. The measurements obtained are used to calculate Body Mass Index (BMI).

Similar to Objective 1, the intervention effect will be characterized using the generalized linear mixed-effects regression models described above. The primary analysis will estimate the adjusted mean difference on study outcomes arising from real versus sham filtration. We will also perform a series of "effect modification analyses" to assess whether and by how much the impacts of filtration are modified by measured household and user characteristics. We will statistically adjust for patient, household (including % of time filtration was utilized), seasonal, and regional characteristics that may impact outcome measures.

There are a number of other factors collected in the lifetime history, such as BMI, asthma severity, controller medicine use, allergy, asthma trigger, taking Acetaminophen, having an asthma action plan, having cold, etc. They may potentially explain why participants do

not respond to decreases air pollution. Exploratory analysis considering potential modifiers (aim to understand the factors associated with heterogeneity of the treatment effect) and mediators (used to understand mechanism of action) will be conducted. Many of the variables are not anticipated to be distributed evenly across the population and therefore do not make sense to be included in the models, however, we may find that some of the variables are distributed evenly throughout the population and we may want to include them. Ideally, health measurements should be sensitive to changes in health status over time. More details can be found in the statistical analytical plan.

A.4.1.3 Objective 3: Measure indoor and outdoor concentrations of PM0.2, PM2.5, PM10, and ozone, and resulting indoor and estimated personal exposures in homes of children with asthma.

One-week integrated PM samples will be collected before the intervention is installed, which represent typical concentrations inside and outside the home. We will calculate summary statistics for these values as they represent typical indoor PM levels the children prior to any influence from the study.

Ozone measurements will be collected while the sham filtration is in place and will represent typical ozone concentrations inside and outside the homes for children with asthma.

We will construct a basic personal model, including reported number of hours indoors at home and outdoors and typical number of hours spent in other microenvironments for each age group. We will determine representative values of PM2.5 levels in schools and in transit from the literature. We will use measured indoor and outdoor PM2.5 levels for each participant to determine the range of anticipated personal exposure.

A.4.2 Performance Criteria for Measurement Data

In order to ensure that the data collected will be of proper quantity and quality to meet the scientific objectives of this study, measurement performance criteria have been established for this study. These measurement performance criteria will be used to evaluate the quality of the analytical data. A formal evaluation of all measurement performance criteria will be evaluated quarterly throughout the study.

The remainder of this section discusses each of the measurement performance criteria used in this study. Criteria for environmental measurement data for this study are defined in terms of the completeness, precision, limit of detection, and recovery. However, there is no official guideline for quality control of health measures available, therefore, we define the criteria for health measurements in this section. Since these criteria may be defined in a variety of ways, it is important that the method by which each criterion will be evaluated is clearly defined beforehand.

A.4.2.1 Completeness

Completeness in this study is defined as the percent of valid samples of a given parameter from all samples scheduled. There are three factors influencing the completeness: 1) whether or not a particular visit is able to be conducted, 2) if all aspects of the visit are successfully completed in the field, and 3) if all samples collected yield valid results. Our plan for maximizing completeness as well as how we measure completeness is listed below for each component.

1) Whether or not a particular visit is able to be conducted. The visit scheduling procedure described in Appendix A is followed for every visit. Every effort will be made to contact the participant and schedule a visit. If a participant cannot be reached while we are sampling in the participant's location for that season, the scheduled visit is considered not complete. All measurements to be collected at the visit will be considered "not complete". This will be tracked in the Subject Tracking Database.

2) Completing all aspects of the visit in the field. We will try to complete all aspects of the visits in the field. The staff will be well trained and we will have checklists and protocols to ensure nothing will be forgotten. However, events out of our control may occur. For example, while the child was originally scheduled to be at the visit and our staff was told the child would be there, they may not be there. They may have become ill during the day and not be able to do things such as spirometry or eNO. Every effort will be made to schedule an additional visit to collect these measures. The parent may refuse to have the air sampling conducted at this particular visit for an unexpected reason (e.g. an unexpected house guest may have arrived and may be sleeping in the main living area). For each visit type, the subject tracking system lists each activity, which will be marked "completed", "partially completed", or "not completed" depending on the situation.

3) Samples yield valid results. We anticipate that the vast majority of collected samples will yield valid results. We are using pre-printed ID labels to avoid loss of samples due to transcription errors. We are using respected laboratories to maintain a high percent of valid samples. There will be some samples that are not valid due to damaged filters or analytical errors. We will determine the fraction of samples collected that are valid. The validness of samples is determined after we receive data from lab (i.e. RTI and Wisconsin lab), and then the percent completeness is determined.

The overall completeness can be calculated using the following formula:

% Completeness = (Number of valid samples ÷ Number of scheduled samples) × 100%

Scheduled samples include both samples that have been collected and samples that are not collected but are supposed to be collected by the due day of the quarterly progress report. Those participants still within their seasonal time window but have not yet had their visit will not be included in the number of scheduled samples.

The percent completeness is composed of two parts. Before receiving data from lab, percent of collected samples over the total number of scheduled samples generated by the subject tracking database report. After receiving data from lab, percent of valid samples over the number of collected samples is calculated.

Though the target to complete 100% of the sampling, we may encounter unexpected events that will affect completion rate. We have established criteria for completion rate for environmental measurements and each of health measurements.

For all environmental measurements, we have established a completeness criterion of 90%. The number is a standard goal of many projects based on values obtained in other similar studies. Possible reasons that will affect completion rate include: 1) the participant could not be visited in the specified season, 2) some samples are not able to be collected in some visit, 3) samples may be invalid because participants unplug the pump boxes, and 4) samples may be damaged or contaminated during transportation or analysis.

Completion criteria are also set for health measurements. Possible reasons that will affect completion rate include: 1) the participant could not be visited in the specified season, and 2) there may be a change in the children's schedule and they may not be home. To reach the maximum completion, our staff will be trained to make participants comfortable and make sure to remind parents that the child needs to be present at the visit when confirming the appointment. For all health-related data, we will use best practices to collect high quality data as outlined in the protocols.

For eNO, the criterion of completion rate is set as 90%. The number is selected as it is a reasonable goal based on rates obtained in other studies. Besides the reasons listed above, children may be unwilling or unable to blow at the specified speed.

For spirometry, the criterion of completion rate is set as 80%. The number selected is lower than for eNO because spirometry is difficult for some children and thus a lower percent of children will be able to complete this measure than eNO. This number was based on Dr. Kenyon's experience with collecting this type of data. Please also note that some children will not be able to complete this measure due to safety concerns, as outlined in the decision tree in Appendix B. Besides the reasons listed above, spirometry is difficult for some children with asthma to complete and requires great effort on the part of the participant if they are not having successful attempts.

For peak flow, the criterion of completion rate is set as 80%. This number is selected as some children will forget during the week. This value was set high and may not be met based on the data from other studies, but we are hopeful that our participants will be cooperative. Participants may forget to do the test twice daily, which would be the major reason affecting completion rate of this measurement.

If data capture appears to fall below these criteria, field staff and Co-Principal Investigators will work to address the data losses during field operations.

A.4.2.2 Precision

Precision will be measured using co-located samples. Co-located samples will be collected in at least 10 percent of all samples at a rate of 6 samples per month. Precision calculations between each pair of co-located samples will be conducted by finding the difference between the sample pairs and dividing by their average, as shown by the equation below. Table 4 lists the target precision criteria for this study. Precision criteria are determined based on results of the pilot study and precision reported in the literature (Brown et al. 2009; Sarnat et al. 2006; Schafer 2012). Precision for indoor samples are set at different values from outdoor samples because concentrations are expected to be lower indoors. It is more difficult to measure small masses precisely.

Table 4: Batch Relative Precision Criteria per parameter

Sample Type	Indoor True filtration Sample	Outdoor/unfiltered Indoor/Personal
PM0.2	0.30	0.20
PM2.5 and PM10	0.20	0.10
NO_2	0.10	0.10
Ozone	0.20	0.10

For a co-located pair, x_i, y_i, sample $x_i >$ LOD and sample $y_i >$ LOD, the precision for a single sample is expressed as coefficient of variation, CV_i,

$$CV_i = \left| \frac{x_i - y_i}{(x_i + y_i)/2} \right|$$

The overall precision will be determined by taking the average of all individual CV values. Precision between duplicates will be checked every quarter, to make sure it does not change over time. If precision estimates are not acceptable, sampling may be interrupted as sampling analytical protocols and procedures are re-examined.

A.4.2.3 Overall Limit of Detection (LOD)

The LOD for PM mass is attributed to the following factors. First, it is primarily determined by the sensitivity of the scale. Second, there is a change in mass of filter/PUF due to temperature/relative humidity that the filter/PUF was conditioned at. PUFs are more sensitive to changes in relative humidity than filters, which may cause greater deviation from the true mass. Third, contamination introduced during the handling of the filter, i.e. loading and unloading process, may affect LOD. Fourth, there may be a minor component of the LOD influenced by the length of time the filter is in the sampler.

PM mass will be quantified by automated (Bohdan Automation) gravimetric analysis using a high-precision (± 0.001 mg) balance (Mettler Toledo MX-5). The precision of the scale defines the physical limits of the LOD. Filters and PUF will be equilibrated in a

temperature (21 ± 2 °C) and humidity (35 ± 3% RH) controlled dedicated weighing room for a minimum of 24 h before weighing. These actions will reduce the final LOD. The scale does not differentiate by the size of the particles to be collected on the filter/PUF and thus the scale precision is the same regardless of what is being weighted.

The actual LOD is presented in two ways. The overall Limit of Detection (LOD) is calculated as three times the standard deviation of the field blanks for each set of samples. The value represents the degree to which the scale can detect a change in mass of a filter or PUF considering precision of the scale, changes in mass related to changes in temperature and relativity humidity, and contamination. We also calculate a nominal LOD by dividing by the nominal volume of air expected to flow through the sampler. This is convenient because it allows us to compare the LOD to air concentrations we expect in the field. Nominal LOD values differ by the volume of air that goes through sampler. The nominal LODs of 24-hour samples using the 4-LPM PEM for PM2.5 range from 2.9 to 4 $\mu g/m^3$ in the literature (Brown et al. 2009; Sarnat et al. 2006). Likewise for ozone and NO_2, the LOD is determined by the sensitivity of analytical equipment, possible contamination introduced during loading /unloading, and length of time and temperature in sampler. The LOD reported in the literature is 3.2 ppb (Koutrakis et al. 1993).

Preliminary criteria for the LOD of PM are established during the cascade impactor pilot testing. Four field blanks were collected in the cascade impactor pilot testing. The field blanks collected in the cascade impactor pilot were transported and handled the same as regular samples, were opened and resealed in the field, then brought to the lab. Conversion of LODs listed in Table 5 from total mass to mass per volume of air used the following nominal flow rates: 5 L/min for Cascading impactor and 1.8 L/min for PEM. The sampling time used for this conversion is one week.

The average change in mass for the five Teflon filter lab blank was 0.002 mg, with a standard deviation of 0.002 mg. The average change in mass for the four Teflon filter field blanks was 0.0002 mg, with a standard deviation of 0.0027 mg. Calculating the limit of detection (LOD) as three times the standard deviation of the Teflon filter blanks yields and LOD of 0.008 mg, resulting in a nominal concentration of 0.162 $\mu g/m^3$, assuming a 7 day sampling period. The average change in mass for the corrected values of the four PUF field blanks was -0.0008 mg, with a standard deviation of 0.007 mg. Calculating the LOD as three times the standard deviation of the PUF blanks yields and LOD of 0.021 mg, resulting in a nominal concentration of 0.425 $\mu g/m^3$, assuming a five LPM flow rate and a 7 day sampling period as planned for the main study. The PM2.5 PEM criteria were based on the blank level for PM0.2 in the pre-pilot study. Ozone and NO_2 LOD values come from Harvard University.

Table 5: LOD of Pollutants to be measured

Parameter	LOD Criteria	Nominal LOD value
Filter for PEM PM2.5	0.008 mg	0.44 $\mu g/m^3$
Filter for PM0.2	0.008 mg	0.16 $\mu g/m^3$

PUF for PM0.2-2.5	0.021 mg	0.42 μg/m^3
PUF for PM2.5-10	0.021 mg	0.42 μg/m^3
Ozone	196 ppb-hr or 2.60 μg	1.2 ppb or 22.6 μg/m^3
NO_2	50.4 ppb-hr	0.3 ppb

Note that for the pre-pilot study, the pre- and post-weight of PUF and filters were measured in different rooms with different temperature and relative humidity, resulting in greater system errors, as PUFs are especially sensitive to temperature and relative humidity. The LODs are likely to be less in the real study than the pre-pilot study, when pre- and post-weight and filters are measured in the same room.

A.4.2.4 Percent of Samples over LOD

The percent of samples over the LOD criteria for each compound is important to study to ensure that appropriate sampling monitors were selected to meet the goals of the study. We always compare actual sample mass to the LOD criteria. However, readers may prefer converting field blank levels into air concentration units as a straightforward reference. Therefore we also provide nominal LOD values for reference but do not actually use them. Initial values are based on previous studies where available. Specifically, the LODs for outdoor samples were determined by going over the measurement data taken in Fresno and Riverside available in the ADAM database (http://www.arb.ca.gov/adam/weekly/weekly1.php). However, there is no information available on pollutant levels with filtration, so the LOD for indoor samples are to be determined. Table 6 below will be revised after the pilot study and the first quarter of sampling. The methods were selected to be sensitive enough to have the majority of samples over the LOD.

Table 6: Target Percent Detected and Expected Values

Parameter	Indoor Sample		Outdoor Sample	
	Target % Above LOD criteria	Expected Range of Values	Target % Above LOD criteria	Expected Range of Values
PEM PM2.5	90	TBD	90	5-80 μg/m^3
PM0.2	TBD	TBD	TBD	1-60 μg/m^3
PM0.2-2.5	TBD	TBD	TBD	1-60 μg/m^3
PM2.5-10	90	TBD	90	5-100 μg/m^3
Ozone	90	TBD	90	4-100 ppb
NO_2	90	TBD	—	—
TBD = To be determined				

A.4.2.5 Quality Control for Health Measures

Health measures collected in this study include Recall Questionnaire and Symptom Diary data and direct measurements of peak expiratory flow rate (PEFR), spirometry, and exhaled nitric oxide (eNO).

Completeness –

Questionnaire data

For the recall diary, in some cases we anticipate that the participant may not answer all questions. As outlined in the statistical analytical plan, outcome variables involve the response to multiple questions, and the outcome variable will only be created if all involved questions are answered. All outcome variables that can be derived from the answered questions in a particular recall diary will be utilized in the analysis, regardless of whether or not all outcome variables from a particular diary are available.

For Symptom Diary collected over fourteen consecutive days, if results are available for 10 of the 14 days, we will preliminarily determine that the data will be utilized. We will track the percentage of diaries meeting this criterion. Once we begin to analyze the data, we will consider alternate numbers of days recorded for defining a complete diary. We will consider the size of the change in available data for analysis, specifically considering less stringent criteria if we can increase the number of diaries available by more than 10%, or consider more stringent criteria if it decreases the number of diaries available by less than 10%. We will compare the number of symptom days between diaries of varying length to see if there is a statistically significant difference.

Health measurement data

For peak flow collected over seven consecutive days, if results are available for five of the seven days, we will preliminarily determine that the data will be utilized. Morning measurements must be collected between 5 AM and noon and evening measurements must be collected between 2 PM and midnight. While the participant is asked to complete three attempts, we will accept data that only includes two attempts. We will track the percentage of peak flow data meeting this criterion. Once we begin to analyze the data, we will consider alternate numbers of days recorded for defining a complete diary. We will consider the size of the change in available data for analysis, specifically considering less stringent criteria if we can increase the number of peak flow values available by more than 10%, or consider more stringent criteria if it decreases the number of peak flow values available by less than 10%. We will compare the peak flow values between peak flow records of varying length to see if there is a statistically significant difference.

The goal for eNO is to collect two values in one test and average them. However, we will consider one measure adequate. Completeness will be determined as the percent of measure we attempted to collect that were collected.

The spirometry data will be evaluated in the validity section below. The completeness will be determined as the percent of measures we attempted to collect that were collected and were valid.

Validity

Peak exhaled flow

The measured PEFRs will be compared across a week as an internal validity check. If a participant is having no symptoms, the FEV1 value should be within 20% from the average FEV1 value each day. If PEFRs vary day to day but there are no symptoms reported, it may indicate there is a problem with the data. We will flag files with a FEV1 value of greater than 20% from the mean value for review by Drs. Kenyon and Schenker. We will confirm if there are symptoms reported for the week. If not, we will further investigate the data. Subjects will be observed using their own PEFR meter at the time of enrollment to ensure technique and subject interpretation.

In cases where there is a data point more than 20% from the average, we will first look to see if evening FEV1 values tended to be lower than morning FEV1 values. If so, we will calculate the difference from the mean for morning and evening separately. Next, we will look to see if the participant consistently had great variability in their FEV1 value, or if the point with the value more than 20% from the mean was an outlier. In the former case, the data would likely be kept, while in the latter case, it would likely be dropped. Weeks not meeting the QA/QC criteria will be reviewed by Drs. Schenker or Kenyon to determine what to do with individual data sets. As we review data with Drs. Schenker and Kenyon, we will further refine our criteria for keeping or dropping individual attempts.

eNO

The reliability of the NIOX MINO has been demonstrated for field studies. This device is FDA approved for the measurement of eNO in both the research and clinical settings and it has proven quality control measures. It has been previously used in studies with kids (Baraldi et al. 2002; Cardinale et al. 2005; Covar et al. 2003; Strunk et al. 2003). The American Thoracic Society/European Respiratory Society 2005 statement recommends collection of two eNO measurements and averaging of the two values at each study visit, and we will follow this protocol. If only one valid attempt is obtained at a visit, this will be used in data collection. The participant will be given six attempts to obtain valid results. The validity of an attempt is automatically determined by the instrument based on the time of exhalation and the exhaled flow rate. Collections in children will be measured at 50 ml/sec as recommended. All exhalations are to be performed at an exhalation pressure of 10-20 cm H2O, to maintain a fixed flow rate of 50 +/-5 ml/sec. A visual display provides direct feedback on both time and flow rate to the subject during the test. Also, the participant is asked a series of questions relating to items that may impact the eNO measurement, specifically questions on foods consumed, medicine taken, symptoms, smoking, and vigorous exercise within specified time periods prior to the

attempt. We will track the percent of participants that answer yes to each question, noting if more than 5% of attempts had a yes answer to any of the questions. Presently, we plan to utilize data regardless of the answers to these questions, but may alter our plans if research becomes available indicating clear evidence that data should be excluded. Device specifications for calibrating will be followed.

Spirometry

The AstraTouch™ Spirometer developed by SDI Diagnostics, will be used in this study. This spirometer is compliant with the American Thoracic Society spirometry standards. In addition to be being portable and relatively inexpensive, it will print a hard copy of the spirometry results that can be given to the study subject. This instrument is integrated with a screen that will display results that can be seen by the participant as they are performing spirometry. There are "games" for children to encourage them to completely exhale, for example, one option is a screen with a hot air balloon that the child tries to "lift".

Device specifications for calibrating the AstraTouch™ Spirometer for exhaled flows and volumes will be followed. There are some problems for quality control in measuring spirometry in children. Asthma itself has the potential to increase the variability of lung function measures at a given test session (e.g., post-inhalation bronchoconstriction). It is also well know that young children cannot maintain a forced vital capacity maneuver for 6 seconds, the minimum duration criterion for adult testing.

Usually, three acceptable maneuvers are needed to determine repeatability. Repeatable tests give the validity to the test. We slightly relaxed the repeatability goal to be to have two repeatable maneuvers rather than three. In the field, we determine if the largest and second largest FVC and FEV_1 values are within 150 ml. It is not necessary that the values come from the same maneuver. If the two acceptable maneuvers do not meet the criteria for repeatability, continue with additional spirometry maneuvers until the repeatability criteria is met or the participant has conducted the maximum six maneuvers.

Acceptability and reproducibility criteria for children have been previously established and we utilize those criteria (Mortimer et al. 2003). The acceptability criteria are as follows:

- Back-extrapolated volume must be < 150 mL or 5% of the FVC
- Time to peak flow must be < 120 ms
- No abrupt ending (abrupt ending occurs when < 100 mL of volume is accumulated in the
  0.5-s interval preceding end of test)

As not all children will be able to meet these goals in the field, we have the following criteria for using the data. We stress that these are not the goals in the field, as the more stringent goals are used in the field. These criteria are only to try to maximize the data used in data analysis. The reproducibility criteria for data use for children are as follows:

- Two PEF values from acceptable efforts must be within 10%
- Two FEV_1 values from acceptable efforts must be within 10%
- Two FVC values from acceptable efforts must be within 10%

In addition, the curve must pass visual quality control. Dr. Kenyon will review the tracings for acceptability.

We will determine the proportion of spirometry attempts meeting both the 5% criteria and the 10% criteria.

Some common errors that lead to a maneuver being deemed technically unsatisfactory include:

- Slow start (which will inflate the FEV1 by moving the extrapolated start time to the right)
- Coughing during the first second
- Premature termination of effort (1 second plateau absent)
- Extra inhalations/hesitations/variable effort/Valsalva maneuver (glottis closure)
- Leaks around the mouthpiece
- Obstructed mouthpiece

An acceptable test is free from all six listed errors. As a minimum, a useable test has to be free from errors 1 and 2 above (no slow start and no coughing during the first second). A test may be usable but not acceptable. Ideally we want acceptable tests, but if after **six** attempts only useable tests (that are not acceptable) are recorded, then we will use results based on the three best useable trials, noting that data is less reliable.

A.5 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION LISTED

The Principal Investigator, Co-Principal Investigators, and staff have appropriate degrees and/or sufficient experience to coordinate a large-scale field study. Field Staff will have earned at least a bachelor's degree in a scientific, technical or medical/social field. Undergraduate assistants are in the process of earning a bachelor's degree in an appropriate field listed above.

Ms. Moran has been trained to operate PM and Ogawa sampling systems and conduct reflectance measurements by Mr. Mike Wolfson at Harvard University (Boston, MA) and Dr. Bennett. Ms. Moran will train field staff to carry out field monitoring duties, which will include setting up, calibrating, maintaining, and taking down sampling equipment. Field staff will also be responsible for the movement of samplers to the appropriate collection locations and obtaining information regarding the surrounding environment during sampling and will be trained to do so. Ms. Moran will also train lab technician to load and unload filters to prepare for sampling and train reflectance technician to conduct reflectance measurement. Trained staff will demonstrate their competency to Ms. Moran at the completion of training. If they are unable to confidently and independently conduct

the given activity, they will continue to practice (if they do everything correctly but lack confidence) and receive additional training (if they are not conducting the activity correctly). They will then be re-evaluated.

Field staff will take spirometry class approved by Dr. Nicholas Kenyon, and Dr. Kenyon will give staff training on peak flow and eNO measurements. Dr. Kenyon will re-evaluate staff prior to beginning study and then quarterly.

Once trained, they will also demonstrate their proficiency in the environmental and health methods to the project manager. Training will be re-evaluated every two weeks in the first month and every month in the first quarter by the project manager. They will be evaluated after that as part of the field and lab audit. Field and lab audits will occur every 3 months for the first year and every 6 months after that, and will be conducted by the QA/QC officer. QA/QC manager will maintain a log to record the evaluation of all staff.

In addition, all research personnel having direct contact with the study participants or participant's data will have completed a Department of Human Health Services on-line Human Subjects Training Program or an approved equivalent. The project coordinator will track IRB training renewal.

A.6 DOCUMENTATION AND RECORDS

Documentation, including field logs, lab logs, calibration logs, and maintenance logs are included in Appendix D2.

A.6.1 Field Operation Records

All relevant information for each sample will be recorded on a field data log, including any special notes needed to determine if a given sample must be voided or flagged for any reason. Sample collection records used in the field include the following: date and time of activity; names of field staff collecting data; participant ID number, type of sample; comment area for any unusual observations or changes in procedure; and general climatic conditions. All field logs will be scanned right after the field visit and stored at the field supervisor's office. Scanned copies will be saved on a secure server, which is backed up daily.

The temperature and relative humidity, the spirometry, and the peak flow data are recorded electronically on the sampling equipment. The data from these samplers will be uploaded onto the secure study database on the secure server along with the household ID, and the date of collection.

Chain-of-custody forms will accompany all samples that will be transferred between two separate parties. These forms include the project name, the sample identification number, the date and time of collection, the nature of the sample, signatures of anyone involved in the transfer of the samples, and a comments area to note any observations or problems

noted during the packing or unpacking of shipments. Chain of custody forms will be scanned and copied prior to shipment. The photocopies of the chain of custody will be included with each shipment; with original copies kept on-site until sample collection is completed.

A.6.2 Laboratory Records

Laboratory records document which samples have been prepared to go into the field. When uploading filters and PUFs into the samplers, i.e., PEM, cascading impactor, or Ogawa samplers, the filter ID, sampler ID, and date loaded is recorded in lab log. All samples will be labeled based on a defined numbering system as is discussed in detail in Section B.3.

Upon receipt of field samples, laboratory personnel will record all field samples received in the lab log, and check if they are in the original samplers. The unload date and household ID from the resealable sample bag is recorded in the lab log. Any observations or problems with the samples when the shipments are unpacked and the samples prepared for analysis will be noted directly into the lab log.

In this study, only reflectance will be measured in the UC Davis lab. The results will be typed into the Reflectance Data Entry Log, which is a Microsoft Excel file, and uploaded to the secure server after each data input session. All calibration data will also be recorded in the Reflectance Data Entry Log.

A.6.3 Data Handling Records

All data collected will be stored in a relational SQL (structured query language) database created for this project by UC Davis staff. All UC Davis staff regularly undergo training and certification on protection and confidentiality of human subject data. The database allows us to store all the data, and the common elements can be cross-referenced. The database does not permit manipulation or alternation of data, so data will be output to SAS or other data analysis software for analysis. All data handling procedures will be documented in SAS program records, which can be exported to a Microsoft Word document for review. We will provide ARB access to the SQL database. We will also provide them with datasets used for analysis, either as SAS datasets or excel files, to be determined at a later date by ARB. Occurrence of Data changes will be recorded in the database. Actual changes will be marked in red pen of the field log. See section B10 for more information on data management.

A.6.4 Data Documentation Control and Archiving

All paper documentation (chain of custody forms, field logs, lab logs, consent forms, questionnaires) will be maintained in files by the project coordinator. All records and data will be stored in locked file cabinets in field offices. In the event that changes are required to any documentation, a single line should be drawn through the entry and the field personnel should initial the change. All documentation will be in ink.

Electronic data will be downloaded from the monitoring instruments using a field computer, and will be saved on a secure server, which is backed up daily. A more detailed data management plan is included in section B10.

A.6.5 Hazardous Waste Disposal

Dichloromethane (DCM) is used to clean the oil residue on the new cascading impactors and PEMs. The cleaning will be conducted in a fume hood in Dr. Alan Buckpitt's laboratory in UC Davis campus, following the laboratory safety policy (available at http://safetyservices.ucdavis.edu/ps/cls/clsm/handlingChemicals). The disposal of used DCM will be stored in a clear labeled waste container and disposed through the UC Davis Office of Environmental Health and Safety. The procedure is available at http://safetyservices.ucdavis.edu/ps/cls/clsm/chemWasteDisposal.

A.6.6 QA/QC Plan

Dr. Wu will distribute it to all personnel identified in section A3. She will be responsible for maintaining the current approved QA/QC plan and for conducting evaluations and audits periodically, as described in Section B.5.4.

B. Data Generation and Acquisition

B.1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

B.1.1 Pre-Pilot and Pilot Testing

Everything needed to conduct the study will be developed and obtained prior to the pre-pilot. All instruments, including data entry systems, will be tested in both a pre-pilot test and a pilot test. All air quality measure protocols and field logs, health endpoint questionnaires and field logs will be developed. All questionnaires and diaries will need to be translated into Spanish. Once translated, they will be read by two native Spanish speakers from Mexico to see how they are interpreting the questions and if they found any of the questions confusing to ensure proper use of language. Additionally, once we in the main study, field staff will take special note of any questions asked by Spanish-speaking participants to determine if there may be any sources of confusion.

The pre-pilot will be conducted in a convenience home to confirm the logistics of following all protocols. Multiple trips will be made to the home to conduct each different visit type (both pre-intervention visits, and the visits before and after an air-pollution event without personal sampling). Questionnaires will be read to participants to test for the clarity of questions. Two staff will conduct the protocols while the third evaluates the process. Dr. Bennett will also observe a portion of the visits. Adjustments will be made to make things go more smoothly if necessary. If significant changes are made, a second pre-pilot test will be conducted. No actual samples will be collected in the pre-pilot.

Once the protocols have been demonstrated to work well in the pre-pilot, a pilot study will be conducted in three convenience homes in Northern California. The homes will have children within the specified age range with asthma. In the pilot, two visits involved in the pre-intervention period, collecting all PM and ozone samples, will be completed. Staff will go back to the homes a second time and conduct air pollution measures while the filtration is being conducted. Two stand-alone air cleaners will be set up, one in the main living area and one in the child's bedroom. Personal sampling will also be conducted if the child is within the appropriate age range. The pilot study will be conducted by the same personnel as the pre-pilot, with the staff alternating between the various roles and evaluator so all protocols will be conducted by three different people. All visits will be timed.

Table 7: Samples Collected and Analyzed as Part of the Pilot Study.

Pilot Samples	Number of Samples	Number of Duplicates	Number of Blanks
Indoor PM2.5, no filtration	3	3	3
Indoor PM0.2, no filtration	3	3	3
Indoor PM10, no filtration	3	3	3
Indoor PM2.5, with filtration	3	3	3
Indoor PM0.2, with filtration	3	3	3
indoor PM10, with filtration	3	3	3
Outdoor PM2.5	6	3	0
Outdoor PM0.2	6	3	0
Outdoor PM10	6	3	0
Personal PM2.5	2	0	0
Indoor ozone, no filtration	3	0	0
Indoor ozone, with filtration	3	0	0
Outdoor ozone	6	2	2

The samples to be collected in the pilot study include 3 sets of indoor PM samples without filtration and 3 sets of indoor PM samples with filtration using stand-alone air cleaners, with all indoor samples collected in duplicate; 6 sets of outdoor PM, with 3 sets collected in duplicate; 2 personal PM2.5 samples; and 6 sets of indoor and outdoor ozone samples, with 2 sets of ozone samples collected in duplicate (Table 7). All of the samples will be analyzed. We will determine the fraction of samples over the LOD.

B.1.2 Main Study Sampling

Two hundred asthmatic children between 6-12 years living in non-smoking homes in regions with high outdoor air pollution, specifically Fresno and Riverside counties, will be enrolled in a randomized placebo cross-over trial. Approximately two-thirds (120-144

participants) will be recruited from the Fresno area, and one-third (60-72 participants) from the Riverside area.

This study will collect both environmental measurements and health measurements. Environmental measurements to be collected include indoor and outdoor particle (PM2.5, PM0.2, PM0.2-2.5, and PM2.5-10) samples, indoor and outdoor ozone samples, indoor NO_2 samples, and indoor temperature and relative humidity. These measurements will be collected from 200 households at multiple time points. Reflectance will be measured using indoor and outdoor $PM_{2.5}$ filter samples. Personal exposure to $PM_{2.5}$ will be measured from 25-30 children with asthma at multiple time points. Health measurements to be collected include exhaled nitric oxide samples, spirometry and peak flow measurements from 200 children with asthma at multiple time points. The samples to be collected are listed in Table 2 and 3.We also developed a recall questionnaire and a symptom diary to collect health information at multiple time points, as well as a home walkthrough procedure.

Integrated one-week air pollution samples will be collected every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true periods. Ozone measurements will be made in the high ozone season May - October using a passive badge. One-week integrated indoor and outdoor measurements will be made both during the high ozone season in the true and sham periods. One-week integrated NO_2 will be measured indoors only in cold season November - April.

Health outcomes will be obtained through the use of three questionnaires: a two-week recall administered to the parents, a questionnaire designed to determine the quality-of-life based on asthma symptoms administered to the child, and two one-week symptom diary with the child answering questions on the symptoms and medicine use and the parent answering questions relevant for environmental exposures during the week before and the week of air monitoring. If the participant failed to complete the diary the week before air monitoring, they will be asked to complete it the week after if their filtration status did not change. Health recall, symptom diaries, and peak exhaled flow will be recorded prior to intervention and quarterly both during the true and the sham periods. Exhaled nitric oxide will be recorded every 6 months, with one measurement pre-enrollment and two measures in each of the sham and true periods.

Table 2 shows the air pollution data that will be collected through the different aspects of this study. Table 3 shows the health outcome data to be collected in this study. This study will last 4 years with Field Collection occurring over approximately 2.5 years.

At each house visit, an environmental samplers or a sampling suite will be placed in the main living area and outdoors. The outdoor sampler will preferably be placed in the backyard or otherwise blocked from the view of the street. The outdoor sampler boxes will be placed as far away as possible from trees, sprinklers, or other water sources, garage or driveway, trucks, busses, cars, or other internal combustion engines, walls or other surfaces. In some cases, the outdoor samplers may be set up on a balcony if that is

the only outdoor location available. If it is on the balcony, it will be located as far away from the wall of the house as possible.

The indoor sampler will be placed in the main room where the participant spends the majority of their awake time. The sampler will be placed as far away as possible from any combustion sources (i.e. fireplaces), devices that blow air or directly affect particle levels (radiators, vents, baseball heaters, air conditioners, windows, ceiling fans, TVs), directly under a light, gas stoves, door to the garage, sources of water, behind furniture and walls. The sampler box will be placed at least 1 foot away from the wall, if possible. This may not be possible in all homes (especially small homes), so samplers should be placed as far from the wall as possible, without causing a problem for the occupants of the home or causing a tripping or safety hazard.

A detailed sample location description will be entered into the subject tracking database so the sampler can be placed in the same location on each visit. The subject tracking information will be printed out prior to each visit. If the location of the home becomes inaccessible, we will attempt to locate the sampler as close to the original site as possible.

Sampling will begin in December 2013. During the first 6 months of enrollment, staff will enroll participants for 2 weeks out of every month, with interventions installed in the other two weeks each month. Each week, the target enrollment is 16.6 participants, and thus we will schedule 19 participants for enrollment visits, assuming some will cancel and we will end up with either 16 or 17 participants each week. Based on the number of cancelations, this number may be adjusted. As we will have two teams, this will be 2-3 visits per day per team, most likely in the late afternoon or early evening hours on Monday - Thursday. The same schedule will be followed two weeks later. If there are any problems adhering to the protocol in the field, modifications may be made.

Field staff will spend two months in Fresno followed by a month in Riverside throughout the project. Participants will be seen any time in the appropriate month, in other words, visits 6 months apart within a six-week window. Home visits will be scheduled three months in advance at the previous symptom recall, and participants will be received a confirmation call two weeks before the visit. When a visit is approaching, participants will be contacted two days before the scheduled visit to remind them again, and field staff will keep calling the participants until reaching them on the phone. As we are in Fresno for two months, staff will attempt to schedule them in the correct six-week period, but will allow for them to be in either the month prior or after their scheduled month if need be. Details on the efforts made to schedule appointments can be found in Appendix A.

Samples will be sent to the laboratories conducting analysis on a monthly basis.

B.2 SAMPLING METHODS

All sampling methods are detailed in specific sampling protocols, which are located in Appendix D1.

PM0.2, PM0.2-2.5 and PM2.5-10 will be collected using a cascade impactor, with the PM0.2 mass collected on a Teflon filter and the PM0.2-2.5 and PM2.5-10 mass collected on PUF. PM2.5 and PM10 will be determined by summing the mass across the stages. The sampler handling will follow the SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly; the sampling procedure will follow the SOP for Indoor/Outdoor Air Quality Field Sampling; the pump box maintenance will follow the SOP for Pump Box Cleaning and Maintenance. All of the protocols mentioned above and below can be found in Appendix D1.

PM2.5 will be collected using a Harvard PEM with flow rate of 1.8 LPM. The sampler handling will follow the SOP for Personal Environmental Monitors (PEMS) Cleaning, Assembly, and Disassembly; and the sampling procedure will follow the SOP for Indoor/Outdoor Air Quality Field Sampling.

The samplers were placed in the pump boxes to prevent access by children that may take an interest in the samplers. The pump boxes were designed to hold one 5 LPM Cascade Sampler with two Medo pumps VPO125- 7 LPM, one 1.8 LPM PEM with one Medo pump VPO140 -3 LPM, and connect them to the sampling inlet. The detailed description of the pump box and the maintenance procedure can be found in the SOP for Pump Box

PM filters (from both the cascade impactor and PEM) and PUFs were weighed before and after sampling at the University of Wisconsin, State Laboratory of Hygiene (WSLH). Filter and PUF weighing requires strict control of temperature and relative humidity, that is, weighing should be ideally conducted at RH of 40±3% for filters and at RH of 35±3% for PUFs. Usually, filters were equilibrated at least 12 hours before weighing, and PUF were equilibrated 48 hours before weighing.

Integrated 48-hour PM2.5 personal samples will be collected twice from 25-30 children with asthma during the true and sham period using a Harvard PM2.5 4.0 LPM PEM. The sampler handling will follow the SOP for Personal Environmental Monitors (PEMS) Cleaning, Assembly, and Disassembly; and the sampling procedure will follow the SOP for PEM Personal Sampling.

Ozone and NO_2 will be collected using Ogawa passive badge samplers. The sampler handling will follow the SOP for Ogawa Sampler (Ozone/NO2) Cleaning, Assembly, and Disassembly; and the sampling procedure will follow the SOP for Indoor/Outdoor Air Quality Field Sampling.

Indoor samplers were placed on a wooden base in the main living area of the home and the participating child's bedroom. For outdoor samplers, pump boxes were supported by a tripod.

For the above samples, while the target sample collection period is 1 week, samples collected between 5 and 9 days will be considered acceptable to allow for logistic considerations, in the event that participants are not available exactly 7 days later or participants need to reschedule or cancel.

The procedures for ensuring proper labeling and tracking of PM filters, PUFs and NO_2/Ozone filters are available in Appendix C.

Dust samples will be collected on a Nylon DUSTSTREAM™ filter fitted in a polypropylene tube installed on a Eureka Boss vacuum cleaner. The sampling procedure will follow the SOP for Vacuum Dust Sample Collection.

Temperature and relative humidity will be continuously measured using HOBO temperature and relative humidity data loggers, following the SOP for HOBO U23/U10 Deployment and Maintenance. They will be placed in the field following the SOP for Indoor/Outdoor Air Quality Field Sampling.

Exhaled NO will be collected using the NIOX MINO, a handheld unit appropriate for field applications, collected according to the ATS and ERS guidelines. The handling details are described in the SOP for Exhaled Nitric Oxide Measurement. This measure will be collected at the participant's home. Collections in children will be measured at 50 ml/sec as recommended. eNO collection is flow rate dependent and the NIOX MINO has visual clues to ensure the eNO levels are measured at this flow rate in children. eNO will be collected every 6 months directly following each air-monitoring period.

Spirometry will be measured using AstraTouch™ Spirometer, developed by SDI Diagnostics. Height and weight will be collected at the same time. The sampling procedure will follow the SOP for Spirometry and Anthropometry.

Peak flow will be measured using Piko Electric Peak Flowmeter, following the SOP for PIKO Peak Flow Meter. Participants will be given a Piko electronic Peak Flow meter, we will demonstrate how to use it, and asked to use it two times a day (morning and evening) for one week, with three attempts per time period. Peak flow is automatically saved on the instrument, eliminating either transcription errors or reporting false data if there is poor compliance.

The PM filters/PUFs will be stored in a refrigerator at 1-8.5°C after they have been unloaded from the samplers prior to the post-sampling gravimetric measurement. After weighing, filters/PUFs will be stored in a temperature and relative humidity controlled dark location (10-24°C). Ozone/NO_2 filters will be stored in a refrigerator until analyzed. Dust samples will be stored in a -20°C freezer until analyzed.

The maintenance and cleaning of sampling equipment are documented in the corresponding protocol for each piece of equipment, as described in Section B.6.

If any problem occurs during sampling, the project coordinator will be notified to solve the problem. If the problem cannot be solved, the QA/QC manager and PI will be notified. The PI will be responsible for determining corrective action.

B.3 SAMPLE HANDLING AND CUSTODY

This section applies to environmental samples collected in this study.

B.3.1 Labels

Filters and PUFs come with five identical, printed, adhesive bar-coded labels. The first label is stuck to the filter/PUF holder that comes with the filter/PUF, the second label will be placed on the lab log sheet, the third label will be placed on the field log sheet, the fourth label will be placed on the sampler, and an extra label will remain with the sample holder as a backup.

For ozone/NO_2 samples, three identical, printed, adhesive labels will be prepared. The first label will be placed on the lab log sheet, the second label will be placed on the field log sheet, and the third label will be placed on the sampler.

Two labels will be generated for dust samples, one affixed to the field log and the other affixed to the sample container.

B.3.2 Sample Transport

All samplers will be assembled in Dr. Bennett's lab in UC Davis, including filter/PUF loading and unloading, and transported fully assembled from Dr. Bennett's lab in UC Davis, to the field office/hotel room, and to participants' homes. Samplers will be installed into pump boxes in the home. Filters will be transported in the samplers, which will be placed in large resealable plastic bags. After sampling, the impactors will be wrapped in aluminum foil, placed in resealable plastic bags and will be transported fully assembled in coolers with frozen blue ice to the field office/hotel room where they will be stored at the room temperature. They will then be transported in a cooler with blue ice back to Dr. Bennett's lab at UC Davis. They will be stored at the room temperature until they are disassembled in Dr. Bennett's lab. Filters will be placed in their filter holders and placed in the laboratory refrigerator. Ogawa samplers will be placed in a resealable bag along with a silica gel packet, then in the storage bottle, securing the screw-on cap. The storage bottle will be refrigerated in the field office/hotel room or UC Davis lab before and after sample collection. Post-sampling transport of the Ogawa samplers will be the same as the filters. The Ogawa samplers will also be transported to the field in coolers with blue ice. More details about sampler transport can be found in Appendix C.

Samples to be analyzed in outside labs, including Teflon filters, PUFs, and Ogawa filters, will be shipped with frozen blue ice via FedEx overnight, with designated Chain of custody forms included with the samples. Shipping will only occur on Mondays, Tuesdays, and Wednesdays in order to assure weekday arrival. Filter, PUF and ozone samples will be shipped within four weeks of collection.

Dust samples will be refrigerated in the field. Upon return to UC Davis, dust samples will be placed in storage (-20°C) at UC Davis until funds can be obtained for analysis.

B.3.3 Chain of Custody Forms

The field personnel will complete UC Davis Chain of custody forms for all samples and signatures will be obtained at time of delivery. Copies will be made of all forms and filed in a locked file case or file cabinet by the laboratory and project coordinator. The outside labs may require particular chain of custody forms, e.g., Wisconsin Chain of Custody Form, which will also be completed.

B.4 ANALYTICAL METHODS

Sample analyses refer to PM filter/PUF weighing, ozone and NO_2 filter analysis, and measurement of reflectance.

Filters and PUFs will be weighed at the Wisconsin state laboratory. The SOP and QA/QC procedures from the laboratory, SOP for Filter/PUF Weighing, is included in Appendix D1. The laboratory has been asked to notify the PI if there are any problems.

Ozone and NO_2 samples will be analyzed at RTI, North Carolina. The laboratory has been asked to notify the PI if there are any problems.

Reflectance will be measured in Dr. Bennett's lab at UC Davis using the Smokestain Reflectometer (EEL Model 42M). The SOP for Reflectance Analysis is attached in Appendix D1, which is modified from a reflectance analysis SOP used previously by the Harvard School of Public Health. If problems occur, the project manager will be notified. If the project manager cannot solve the problem, the PI will be notified.

Filter and PUF samples will be returned to UC Davis and saved in a cool dark room (10-24°C) for additional future analysis. These will be stored for five years.

B.5 QUALITY CONTROL

B.5.1 Field Duplicates

Ten percent of all indoor and outdoor samples will be collected in duplicate. In principle, the homes will be selected randomly. However, given that homes may be small, we also need to consider if a home has sufficient room to accommodate duplicate sampling. On the first visit to the home, we will note if there is sufficient room both indoors and outdoors for collection of duplicate samples. Houses will be selected at random from those having sufficient room for duplicate samplers. Duplicate sampling will be balanced between homes receiving HVAC filtration and those receiving stand-alone air cleaners. We will bring two pump boxes for each set of duplicate sample and place them side by side or as close to each other as possible given the allocated space. The precision will be calculated from such co-located samples. The results from these duplicates will be used in the precision estimate calculations as outlined in section A.7.2.2.

No duplicates will be collected for personal samples because it is too burdensome for participants to wear two sets of personal sampling equipment.

B.5.2 Field Blanks

Ten percent of all samples will be field blanks. Field blanks will undergo the same storage, assembly and delivery procedures as the actual field samples with the exception of having any air drawn through them.

For PM, samplers loaded with field blank PM PUF and filter samples will be brought to the field. They will be taken out of their bags and the caps will be removed. The sampler will sit on the bag it was in while the actual sampler is being placed in the pump box. They will then have the caps placed back on them and be placed back into their bag. They will then be brought back to the field office and stored in the resealable plastic bags at the room temperature after the sampling set-up visit. The samplers will be transported fully assembled unloaded following the same procedures as the field samples. The unloaded filters and PUFs will be stored in the refrigerator in UC Davis lab.

For ozone/NO_2 filters, which come in package of 40 filters per batch, four filters from each batch will be used for field blanks. Different from PM field blanks, we do not take the blank Ogawa samplers out of the brown storage vials. The bottle containing the blank sampler must be kept closed and the whole bottle, containing the sampler, should be taped on top of the pump box, so that the field blank is kept at the same temperature and field conditions as the field sampler. Ozone/NO_2 blanks will be left in the field, placed in a closed amber jar attached on the pump boxes close to the sampling inlet tube, during the whole measurement period, as the ozone/NO_2 mass on the blank filters may be subject to chemical change due to temperature.

LOD will be calculated as specified in A.7.2.3.

B.5.3 Health Data Criteria

Health measures collected in this study include Recall Questionnaire and Symptom Diary data and direct measurements of peak expiratory flow rate (PEFR), spirometry, and exhaled nitric oxide (eNO).

PEFRs are automatically saved on the instrument, eliminating either transcription errors or reporting false data if there is poor compliance.

Participants will be given 6 attempts to complete the successful eNO measurements.

For spirometry, we will look at changes in pulmonary function over time, with each subject serving as his/her own control in this cross-over design. For spirometry, we will record actual volume-time tracings. From the volume-time tracing, we can calculate the best FEV1, FVC, FEV1/FVC and FEF25-75.

Acceptability and reproducibility criteria and the reproducibility criteria for children are presented in section A.7.2.5. In addition, the curve must pass visual quality control. Dr. Kenyon will review the tracings for acceptability.

When errors occur while participants attempt spirometry, technicians will review common errors with the participant before proceeding with additional maneuvers. They will ask the participant to watch the technician perform the FVC maneuver again. The technician should once again demonstrate the correct placement of the mouthpiece, emphasize the maximum depth of inhalation and then blast out the air. If the participant tries again and the reproducibility criteria are not met, the technician should continue administering the test as needed (up to a maximum of 6 maneuvers) assuming that the subject is able to continue.

The two highest values for FVC and FEV_1 taken from acceptable forced expiratory maneuvers must show minimal variability (within 150 milliliters of the second highest FVC and FEV_1). It is also important to inspect the volume-time curves to determine if the size and shapes of the curves are reproducible.

The American Thoracic Society defines FEV_1 and FVC as the best measurements from acceptable and reproducible maneuvers. It is not necessary that they all come from the same maneuver. The FEV_1/FVC and FEV_1/FEV_6 ratios are computed as the ratio of the individual measurements.

B.5.4 Evaluations and Audits

Data received from the Dr. Bennett's lab in UC Davis, the RTI lab, and the Wisconsin State Laboratory will be analyzed monthly for any discrepancies, such as, whether results of all the samples we send are received, whether the lab blanks and field blanks are below the expected background level, and whether there are any errors in matching sample ID in the received data and sampling records in our database. If any discrepancies are found, we will work to solve the problem.

The QA/QC officer will formally evaluate all of the field and lab operations. Field and lab audits will occur every 3 months for the first year and every 6 months after that, and will be conducted by the QA/QC officer.

During the QA field audit, the QA/QC officer will go to the home visits with each sampling team. A checklist will be used to evaluate all critical aspects. If any deviations from the approved protocol are found or if the goals of the study are not being met, the QA/QC officer will record the issues and notify the PI who will review, assess and, if necessary, develop a plan to address the problem(s).

A QA lab audit will also occur. The QA/QC officer will go to the lab and observe all laboratory procedures, using a checklist to evaluate all critical aspects. The data entry will also be evaluated.

Finally, a QA quarterly review will be conducted. Lab documents will be checked, including I/O PEM Lab Log, Personal PEM Lab Log, Cascade Impactor Lab Log, NO_2 Passive Sampler Loading/Unloading Log, and Ozone Passive Sampler Loading/Unloading Log. It will be checked whether all logs are completed and legible, and whether initials required in all logs are complete. The comments will also be reviewed for patterns of recurring issues and it will be determined if this problem has already been resolved. If it has not been addressed, a plan will be developed and it will be addressed. We anticipate the problems will have already been addressed as staff will be trained to inform the project manager when there are problems such that they can be solved promptly. Additionally, all logs documenting calibration procedures will be reviewed and it will be confirmed that all calibration activities are up to date. If any problems are found, they will be reported to the PI and addressed immediately.

If any significant changes are proposed to the protocols, the ARB contract manager will be notified of the change. The change will take place immediately. If the ARB does not approve the change, we will seek approval of an alternative solution. Minor logistical changes in the protocol will not be reported to ARB. For example, if we find a certain pair of tongs made out of the same material as the original tongs works better for washing a particular part of the Ogawa sampler, this would be considered a logistical change that in no way impacts the outcome of the measures of the study and would not be reported to the ARB.

B.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Major equipment and devices that will be used in this study are listed in Section A.6.2.2.

Table 8 lists all equipment and devices and the corresponding protocols with the testing and maintenance information. This table also includes all cleaning and calibration procedures. All protocols are included in Appendix D1.

A number of spare parts will be kept at UC Davis, including all components of the Ogawa badges, O-rings and metal screens for both the PEM and cascade samplers.

We will check flow rate when setting up and taking down the samplers and compare the pre- and post-sampling flow rate. If the change in flow rate of a pump is greater than 10% from the target flow at take-down (as instructed in indoor/outdoor protocol), it will be flagged on the take-down log sheet. Pump flow may be reduced due to overloading of the filter or problems with the pump. If the problem is due to the pump, the flow will consistently be low. If a given pump is flagged for having low flow two times in a two-month period, it will be labeled “do not use” and brought back to UC Davis for evaluation. Flags will be monitored by the QA/QC officer.

All of the samplers and all of the boxes will be leak tested every three months. If a leak is found in any of the samplers, the schedule for leak testing will be updated to become more frequent. The leak testing will be done as part of the QA/QC quarterly inspection

process. The boxes go out for a week every two weeks, and thus would be inspected approximately every sixth time they were used. The samplers themselves are used every other sampling period and thus leak testing would be completed approximately every third usage.

The PI will be notified if there are maintenance problems and a solution will be developed.

Table 8: Equipment and devices used in this study and the corresponding protocols

Equipment and devices	Category	Action	Frequency	Protocol	QA check
Impaction-based PEM	Inspection/ maintenance	Check O-ring for nicks or other damage, inspect the impaction plate to make sure grease is smooth, check if screens are bent	Every time before assembling the sampler	SOP for Personal Environmental Monitors (PEMs) Cleaning, Assembly, and Disassembly, Section B	QA lab audit
		Leak test	Upon receipt, quarterly	SOP for PEM and CI Leak Testing and QA/QC plan Section B.6.	QA quarterly review
	Cleaning	Routine cleaning	Between each use	SOP for Personal Environmental Monitors (PEMs) Cleaning, Assembly, and Disassembly, Section A1-A2	QA lab audit
		Deep cleaning	When new sampler arrives or if sampler appears visibly soiled		
Cascade impactor	Inspection/ maintenance	Check O-ring for nicks or other damage before assembly, check if screens are bent	Every time before assemble the sampler	SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly, Section B	QA lab audit
		Leak test	Upon receipt, quarterly	SOP for PEM and CI Leak Testing and QA/QC plan Section B.6.	QA quarterly review
	Cleaning	Routine cleaning	Between each use	SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly, Section A	QA lab audit
		Deep cleaning	When new sampler arrives or if sampler appears visibly soiled		

Table 8 (continued): Equipment and devices used in this study and the corresponding protocols

Pump Box –Medo pumps, flow control valve Milli-Mite 1300 Series 1315G4B , two-channel timer Talento 992+	Inspection/ maintenance	Check components listed in protocol	Every time it goes into field	SOP for Pump Box Cleaning and Maintenance	QA field audit
		Check pump if off for unknown reason or if flow comes back low multiple times	Every time after sampling visit	SOP for Indoor/Outdoor Air Quality Field Sampling and QA/QC Plan Section B.6.	QA field audit
	Cleaning	Clean components listed in protocol	Every time it goes into field	SOP for Pump Box Cleaning and Maintenance	QA field audit
Personal sampling pumps	Inspection/ maintenance	Check if flow comes back low	Every time after sampling	SOP – PEM Personal Sampling Procedures, Pg 2	QA field audit
Actical accelerometer	Inspection/ maintenance	To confirm the actical records activity, battery	Every time we download data	SOP for Actical Deployment and Maintenance	QA lab audit
Passive Ogawa badge	Cleaning	All sampler components (end caps, screens, and bodies) must be carefully rinsed with Milli-Q water and dried	Before each use	SOP for Ogawa Sampler (Ozone/NO2) Cleaning, Assembly, and Disassembly Section A1	QA lab audit
	Inspection/ maintenance	Make sure screens are not bent	Before each use	SOP for Ogawa Sampler (Ozone/NO2) Cleaning, Assembly, and Disassembly, Pg 3	QA lab audit
Electronic piston volumetric gas flow meter Bios 520/510	Calibration	Flow meter co-location	Every 3 months	SOP for Flow Meter Calibration	QA quarterly review
		Calibrated by the product's manufacturer	Annually		
Eureka Boss vacuum	Inspection/ maintenance	Confirm not overheating. If equipment begins to smell, remove from service	Every time sample is collected	SOP for Vacuum Dust Sample Collection	QA field audit

Table 8 (continued): Equipment and devices used in this study and the corresponding protocols

HOBO U10-003 and HOBO U23-001 temperature and relative humidity data loggers	Calibration	Co-locate the HOBO data loggers in a group of 4 to make sure their reading is consistent.	Every 6 months	SOP for HOBO Co-location Comparison	QA quarterly review
	Inspection/ maintenance	Check battery	Before connecting the device to the computer for U10 HOBO and after connecting the device to the computer for U23 HOBO.	SOP for HOBO U23/U10 Deployment and Maintenance	QA lab audit
Temperature / Relative humidity meters	Calibration	Calibrate the T/RH meter	Quarterly	SOP for Calibration, Verification, and Maintenance of the Temperature /Relative Humidity (T/RH) Meter	QA quarterly review
NIOX MINO	Inspection/ maintenance	Ensure that there are adequate tests left on the sensor for all visits to be completed that day.	On days it is used	SOP for Exhaled NO Measurement, Pg 11-12	QA field audit
	Cleaning	Wipe the external surfaces clean with disinfectant wipes or water as needed.	As needed	SOP for Exhaled NO Measurement, Pg 10	QA field audit
	Calibration	Performed by a qualified field staff	At the beginning of each day	SOP for Exhaled NO Measurement, Pg 7	QA field audit

Table 8 (continued): Equipment and devices used in this study and the corresponding protocols

AstraTouch™ Spirometer	Cleaning	Clean listed items	After each participant use	SOP for Spirometry and Anthropometry, Pg 20	QA field audit
	Inspection/ maintenance	Check rechargeable battery, check paper	On a daily basis	SOP for Spirometry and Anthropometry, Pg 21	QA field audit
	Calibration	Use calibration syringe	At the beginning of each day and then every 4 hours on the day that the spirometer is used	SOP for Spirometry and Anthropometry, Section A2	QA field audit
Piko electronic Peak Flow meter	Cleaning	Clean the Piko top section with low-flow water at room temperature	Between each participant	SOP for Piko Peak Flow Meter, Pg 2	QA field audit
	Inspection/ maintenance	Check battery	Between each participant	SOP for Piko Peak Flow Meter, Pg 1	QA field audit
EEL43M Smoke Stain Reflectometer	Calibration	Reflectometer will be calibrated (measurements of standard colored plates) by the reflectometer technician	Every time before use	SOP for Reflectance Analysis, Section D	QA lab audit
Laboratory refrigerator and freezer	Cleaning	Wipe the exterior and interior of each refrigerator with warm, soapy water and paper towels	Once per month or as needed	SOP for Verification and Maintenance of the Environmental Refrigerators and Freezers, Pg 5-6	QA quarterly review

B.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All calibration activities are listed in Table 8 and repeated here. All calibration procedures we are conducting are based on manufacture recommendations. We also include activities related to comparing measurements from equipment.

Flow meters will be compared to each other every 3 months by a member of field staff, and the results will be reviewed by the QA/QC officer. Flow meters will be calibrated annually by the product's manufacturer. A Bubble flow meter, which is NIST traceable, will be provided by ARB to reference the BIOS meter as a transfer standard. To identify drift from original calibration, calibration of the BIOS meters will be conducted quarterly. Please refer to the SOP for Flow Meter Calibration in Appendix D1.

Reflectometer will be calibrated by the reflectometer technician every time before use. Calibration involves measurements of standard colored plates. The calibration procedure is described in the SOP for Reflectance Analysis in Appendix D1.

NIOX-Mino, which measures exhaled NO, will be calibrated at the beginning of each day that it is used as instructed in the product manual. Calibration will be conducted by a qualified member of the field staff.

Every 6 months, we will co-locate the HOBO temperature and relative humidity data loggers in a group of 4 to make sure their readings are consistent, following the procedure in the SOP for HOBO Co-location. Field staff will conduct co-location test and QA/QC officer will make sure the co-location test is conducted.

Spirometry must be calibrated at the beginning of each day and then every 4 hours on the day that the spirometer is used, using the 3L calibration syringe, following the procedure of SOP for Spirometry and Anthropometry in Appendix D1.

B.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

<u>Project supplies and consumables</u>

- Air cleaner units
- Air cleaner replacement filters
- HVAC replacement filters
- Teflon filters, coming in cases
- PUF substrates, coming in cases
- Ozone Ogawa filters
- NO_2 Ogawa filters
- Amber vials (to hold ozone/ NO_2 filters)
- Dust stream filters
- Vials (to hold dust filters)

- DUSTSTREAM™ attachment
- eNO cartridges
- Piko flow meter mouth pieces
- Spirometry mouth pieces

The project coordinator is responsible for the maintenance and availability of all sampling equipment. Project staff will visually inspect all supplies on arrival to ensure they do not appear to be damaged, confirm that the items received were the exact items ordered, and confirm that the right number of items is received. Ordering and storing of all equipment will be done at the project coordinator's discretion. Supply tracking and ordering is managed by the project manager using an excel spreadsheet to ensure supplies will be on hand when needed. The PI will be notified if supplies arrive damaged.

B.9 NON-DIRECT MEASUREMENTS

B.9.1 Outdoor temperature/RH

A map of meteorological monitoring stations in Fresno and Riverside areas has been created, available at http://batchgeo.com/map/0c267cbe124e25fbd146e291fa9d3775. The closest air monitoring station to a particular field site will be located based on the address of the house/field site, and the website will automatically calculate the distance and indicate the closest monitoring station. Outdoor temperature and relative humidity data in all meteorological monitoring stations during the whole sampling period will be downloaded from http://www.arb.ca.gov/aqmis2/metselect.php. We will match the temperature and relative humidity data in the database based on selected station and selected period. The data downloading will follow the SOP for Calibration, Verification, and Maintenance of the Temperature /Relative Humidity (T/RH) Meter.

B.10 DATA MANAGEMENT

B.10.1 Paper Files

All paper documentation (field logs, calibration logs, laboratory logs, chain of custody forms, questionnaires and dairies, consent forms) will be scanned daily to create an electronic back-up and stored on a secure server. All paper records will be stored in locked file cabinets in field offices. Once transported back to Dr. Bennett's lab in UC Davis, all paper documentation will be maintained in locked file cabinets by the project coordinator.

Upon returning from the field, field personnel will review log sheets for completeness, and scan them, upload to a secured UC Davis server, and then store the hardcopy in the participant folder in a locked file cabinet or lock box. The data entry staff will review all log sheets within three days and perform quality control evaluation, i.e. checking if the handwriting is readable or there is any typo, and if all the records are sensible and data

are in the acceptable range. Once log sheets have been initialed by the data entry staff, any questions or concerns regarding a field log will be brought to the attention of the project coordinator who will answer the question, solve the problem, or notify the PI. As a quality control step, 10% of the log sheets will be double entered by a second data entry staff. The consistency of the double entries will be checked by the QA/QC officer quarterly.

B.10.2 Electronic Files

Electronic data will be downloaded from the monitoring instruments, including spirometor, Peak Flow meter, and HOBO temperature and relative humidity data logger, using a field computer on a daily basis. All data will be immediately uploaded to the secure UC Davis server. Analytical data on reflectance obtained from UC Davis lab will be immediately saved in the secured server. Data will only include participant ID, and will not be stored with any identifying information.

Electronic data will be saved on the secure UC Davis server, protected by password. The server and the database are maintained by the IT staff of the UC Davis Department of Public Health Sciences. Only those personnel directly associated with the project will be permitted to access the data. Every staff has their own assigned username and password that only they know. Passwords are not recoverable by IT staff. Any manipulations of the data will occur in a separate spreadsheet that is clearly labeled and filed in a separate folder than the raw data. These files will either have identifiers removed before export or the analysis files will be stored in encrypted volumes that are password protected.

The files containing the information linking the participant ID and the personal identifying information are stored in an encrypted, password protected file. This data cannot be exported from the database except in hard-copy/paper form to be used for conducting visits. Addresses, contact information, group assignment, participant ID are printed out for use during home visits. Those papers are kept either in a locked office, a locked vehicle, or on a person until they are destroyed after each visit.

B.10.3 Pollutant Data Files from Outside Laboratories

Data for particle, ozone and NO_2 samples will be received from Wisconsin and RTI laboratories electronically and saved in the secure network folder by the project coordinator. Project personnel will check the Chain of Custody Forms to ensure that data of all samples were received. Data for lab blanks, field blanks, and any extreme outliers will be briefly checked for accuracy. The QA/QC manager will double check that data are uploaded.

B.10.4 Project Database

Data from questionnaires and field logs will be entered/imported into the project database weekly. The database systems that house the research data and associated tracking activities are backed up nightly to a secure, encrypted repository in the form of a database

export. All baseline participant information is matched to field sampling information and health measurement data by the participant ID and visit number, i.e. pre-intervention, 6-month, 12-month, 18-month, and 24-month visit. Environmental measurement data, such as PM, Ozone/NO2, reflectance data, are linked to field sampling information by filter/PUF ID and then linked to other data through the participant ID and visit number.

Quarterly quality assurance checks will be made on the database to check the distribution of data entries, for completeness, reasonableness (e.g., time spent outdoor should be less than 24 hours, school days within 14-day period should be no more than 10 days), and accuracy. A more complete list of checks will be developed as data analysis proceeds. A list of reasonable ranges will be developed for all questions for which a reasonable range can be developed. If a value is outside the reasonable range, the original data source will be checked to determine if the error occurred during data entry or in the field.

C. Assessment and Oversight

C.1 ASSESSMENTS AND RESPONSE ACTIONS

A readiness review will be conducted prior to initiation of fieldwork by the project coordinator. This will entail an equipment inventory, review of data management techniques, evaluation of instrument calibrations, and review of SOPs with field staff.

Field and lab audits will occur every 3 months for the first year and every 6 months after that, and will be conducted by the QA/QC officer. The quality assurance officer will report any deviations from the sampling protocol and other apparent problems with sampling design, processes and handling to the PI.

The project coordinator will be responsible for quarterly assessments of the sampling process. The primary investigator will be responsible for quarterly assessments of the entire project. Field staff will meet at least monthly to assess protocols, discuss any problems or suggestions for improvements to procedures. Full project team meetings will be held at least once a quarter to report on the status of the project and any recent data findings.

Briefings with field staff will be conducted every month in the first three months, every 3 months for the first year, and every 6 months after that, to review field experience, potential changes to protocol, and suggested improvements. We do not anticipate any changes to the protocols after the protocol for a given field visit type has been in use for more than a month. This information will be used to evaluate methods for potential changes.

C.2 REPORTS TO MANAGEMENT

Project reports will be written and submitted to the California Air Resource Board (ARB) quarterly and at the end of the project.

Results of all internal and external performance and system audits will be distributed to all key project personnel and project management quarterly. Problem areas and corresponding implemented solutions will be discussed in these reports quarterly and protocols will be adjusted accordingly, if needed. The QA officer will produce quarterly QA reports and report on any preliminary QA results from the field studies (e.g., collocation data). These reports will be submitted with the quarterly reports to the ARB. A final report addressing all quality assurance issues including precision, accuracy, completeness, and the results of any field or laboratory audits will be prepared by the QA assurance officer and reviewed by the PI.

D. Data Validation and Usability

D.1 DATA REVIEW, VERIFICATION, AND VALIDATION

All data will be evaluated for completeness and correctness. Field logs will be input into the computer weekly and will be reviewed by the field staff while being entered. They will be subject to a quality control check, including whether all logs are completed and legible, whether signatures required in all logs are complete, and whether there is unaddressed flag. Field logs will not be considered complete without the final review, which will be done as part of data entry by the data entry staff. As part of the field log evaluation, flows, sampling time, handling and anomalies will be reviewed.

Specifically, flows that deviate more than 10% of the end of sampling will be flagged. Any samples that have flows that deviate more than 30% will be void. If the total sample time deviates more than 10% from 5-9 days, the sample will be flagged. The sample will be considered invalid if the total sample time deviates more than 25% from 5-9 days. Data from samples with extreme distortion or contamination will be void and any samples experiencing minor contamination or distortions will be flagged. The field personnel will be trained by the project manager to minimize sample contamination and distortion. Flagged samples will be used in preliminary data analysis. Data analysis may also be conducted with removal of some or all flagged samples, to be determined while data analysis is being conducted. Void samples will not be used in data analysis.

For health measures, recall questionnaire will be cross-checked with corresponding questions in the symptom diaries. We will also look at changes in pulmonary function over time, with each subject serving as his/her own control in this cross-over design.

D.2 VERIFICATION AND VALIDATION METHODS

The project coordinator will be responsible for verifying and validating all data. Data are initially validated as described above and according to the following table. the list will appear on the field log with a checkbox in front of it and the appropriate checkbox will be checked. If problems occur and cannot be solved by staff, the QA/QC officer and PI will be informed and the PI is responsible for determining a course of action.

Table 9: List of Potential QC Flags

Field Data Codes

The following codes will be used to indicate the specified types of data quality concerns:

Code	Meaning
For environmental measures	
POP	Pump is off when staff take down the samples, due to participant disconnecting the power to the pump box.
POT	Pump is off when staff take down the samples, due to the timer turning off the pump because the visit was delayed and occurred more than 9 days from the set-up visit.
POU	Pump is off when staff take down the samples, due to unknown reasons.
PD	PEM detached from pump (for personal sampling only)
E	Sampling equipment appears damaged.
PF	Pump flow is out of acceptable range.
D	Sample duration is out of range.
Other	Other reason not listed
For dust collection	
FO	Sampled floor only
BO	Sampled bed only
S	Small Area
C	Sample is spilled/dropped
Other	
For health measures	
U	Participant did not understand instructions.
F	Participant was not able to complete for other reasons.
R	Participant refused health measure.
Rhw	Participant refused height and weight measurements.
Other	

Lab Data Codes

Code	Meaning
For analytical results	
C	Sample contaminated or destroyed before or during analysis
ND	Data below detection limit.
NA	Data not reported by laboratory

D.3 RECONCILIATION WITH USER REQUIREMENTS

The quality of all environmental and/or health response data generated and processed shall be assessed for accuracy, precision, completeness, comparability and

representativeness, based upon this Project Plan. The results of the QA/QC will be taken into consideration when conducting data analyses and reporting study results. Limitations associated with the data will be included in the final report.

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Appendix A. Home Visit Scheduling Strategy

Sampling will begin in September 2013. During the first 6 months of enrollment, staff will enroll participants for 2 weeks out of every month, with interventions installed in the other two weeks each month. Field staff will spend two months in Fresno followed by a month in Riverside. Each week, the target enrollment is 16.6 participants, and thus we will schedule 19 participants for enrollment visits, assuming some will cancel and we will end up with either 16 or 17 participants each week. Based on the number of cancelations, this number may be adjusted. As we will have two teams, this will be 2-3 visits per day per team, most likely in the late afternoon or early evening hours on Monday - Thursday. The same schedule will be followed two weeks later. If there are any problems adhering to the protocol in the field, modifications may be made.

Field staff will spend two months in Fresno followed by a month in Riverside roughly every three months throughout the project to conduct home visits. Ideally, participants will be seen any time in the appropriate month, in other words, visits 6 months apart within a four-week window. However, it is highly likely that participants will reschedule, which will change their visit week. Considering that seasonal changes are not that great over a few weeks period, flexibility is needed to accommodate the rescheduling possibilities. Without flexibility, we will end up with people missing visits. After carefully considering the goal of seasonal consistency in sampling with the goal of obtaining complete data, we decided to provide six-week target windows and to overschedule in the first few weeks of the sampling months, as illustrated below, to accommodate participants that may reschedule to a later week. We need a simple system as the study is already very complex and thus cannot institute a complex system to ideally match weeks. Too much complexity will lead to errors and missed visits.

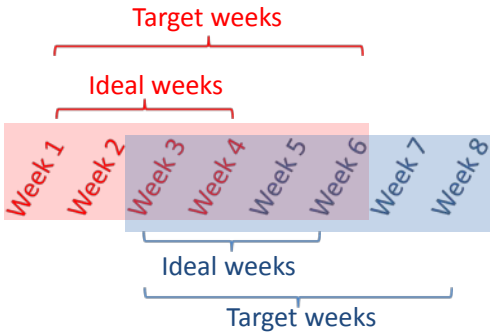


Figure 1. Visit scheduling chart for Fresno particpants

For Fresno participants with a two-month window, participants are assigned to a week number (1 to 8 in a roughly 2-month period) based on what week number their initial visit was. Specifically, participants started in weeks 1-4 will ideally be scheduled in weeks 1-6, prioritizing schedule into weeks 1-3. People started in weeks 5-8 will ideally be scheduled in weeks 3-8 (Figure 1). As people inevitably reschedule at their two-week confirmation call, we will have availability in later weeks. Assuming all people schedule equally throughout the scheduling weeks, the vast majority will be within two weeks of their target time, while providing maximum flexibility to the staff. Should a participant not be available in their scheduled weeks, they can be rescheduled in any of the eight

weeks. If they cannot be scheduled in any of the eight weeks, they will be recoded as having a missed visit.

All Riverside participants will be sampled in a 4-week window in a given season. They can be scheduled any time in the 4-week window. If a Riverside participant cannot be scheduled in the 4-week window, it will be counted as a missed visit.

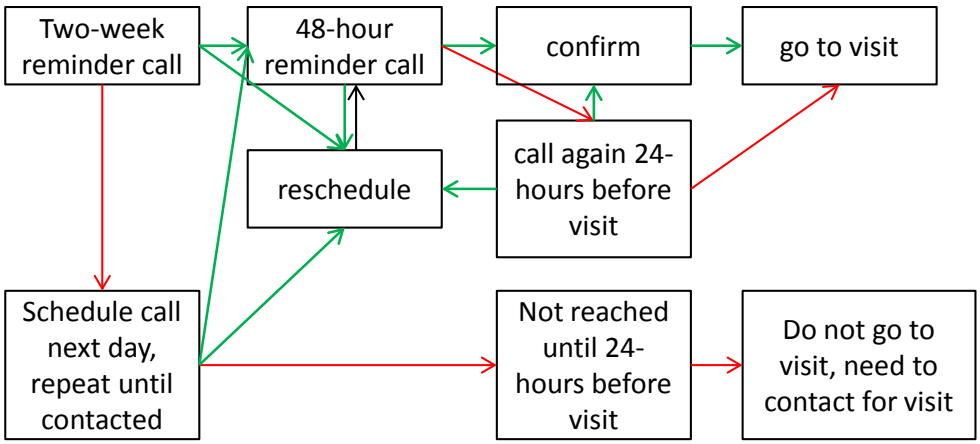


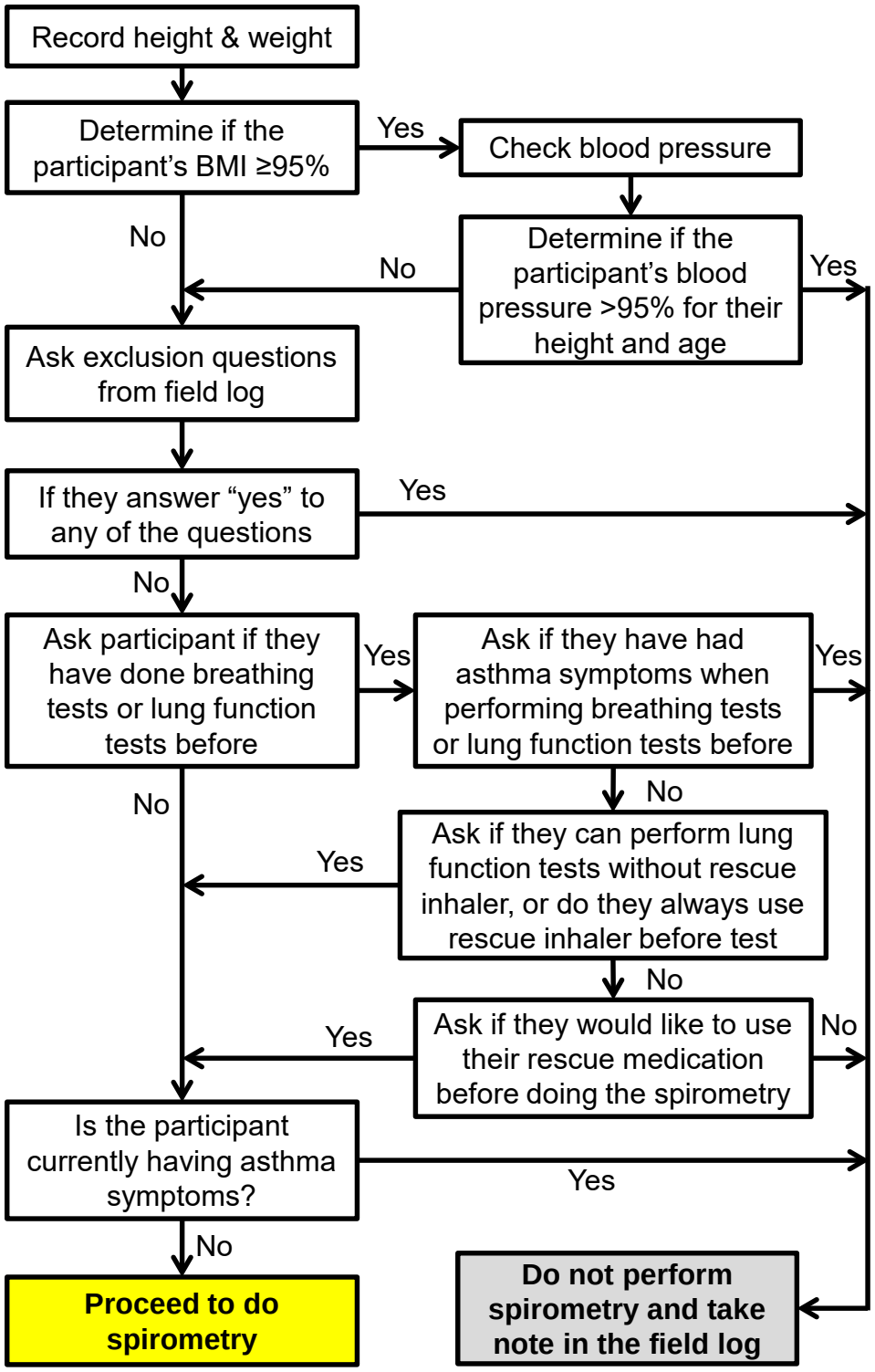
Figure 2. Home visit reminder strategy (Green arrow links the consequences after reaching participants on the phone; red arrow links the consequences if not be able to reach participants.)

Home visits will be scheduled three months in advance at the previous Symptom Recall telephone interview. Participants will receive reminder calls several times, as illustrated in Figure 2. Two weeks before the scheduled visit date, the calendar system will post the participants ID that we need to call to remind participants. They will be included in the to-be-contacted list automatically generated by the system. The participants will receive a confirmation call two weeks before the visit. If we reach them, we either confirm or reschedule. When a visit is approaching, a reminder call will be scheduled for 48 hours prior to the visit.

Once a participant is on the to-be-contacted list for a visit, the participant will be called every day. If they are unable to be reached on a given day, they will be added to the list of individuals that need to be contacted the following day. On the last day we can schedule visits in an area, everyone still on the to-be-contacted list will be marked as “not completed” for that visit type in the subject tracking database. We will continue to try to reach them to schedule them for the next encounter.

Every effort will be made to contact the individuals that are hard to reach, for example, to vary time of day to call. We will also use email if they have provided on email address for contact. If they have provided more than one phone number, multiple numbers will be tried.

Appendix B. Decision Tree for Spirometry



Exclusion questions:

1. Has your child had an injury to the chest or surgery (operation) on his/her lungs, chest or abdomen, in the last 3 months?

2. Has your child had a detached retina or an operation (surgery) on his/her eyes, in last 3 months?
3. Has your child been hospitalized for any heart problems, in the last 3 months?
4. Is your child currently using medicine for tuberculosis?

Appendix C. Procedure Overview Documents

This appendix includes procedure for handling PM filters and PUFs and procedure for handling Ozone/NO_2. These two overview documents integrate steps from various protocols to give a brief overview of the tracking and handling of sampling media. For more detail, please refer to the various protocols.

Procedure for handling PM filters and PUFs

Definitions:

Filter/PUF ID – Predefined during the pre-weigh process in the Wisconsin laboratory.

Sampler ID – Numbered in order for each of the cascade impactors and PEMs.

Sample ID – A combination of three sections: 1) the filter/PUF ID followed by 2) a code indicating the type of sampler, including "P2" (for 1.8 LPM PEM), "P4" (for 4.0 LPM PEM), or "CI" (for cascade impactor), and 3) 2-digit sampler number.

Household ID – Five digits ID, starting with "8" for Fresno participants and "9" for Riverside participants.

Loading date: Date sample media was loaded into sampler.

Unloading date: Date sample media was removed from sampler.

Set-up date: Date sampler was installed at the home

Take-down date: Date sampler was removed from participant's home.

Procedure:

PUFs arrive from Wisconsin with a bar-coded PUF ID label stuck to the PUF holder. Four additional labels for each PUF will be included in the same shipment. The PUF ID will come typed on the Wisconsin Chain of Custody Form with the shipment.

Filters will be purchased by the Wisconsin Lab and sent to Wisconsin for gravimetric measurement. The filters will be placed in a container each with a barcode label attached by a lab technician at the Wisconsin Lab. After gravimetric measurement, they will be sent to UC Davis, along with extra barcode labels. The reflectometer technician in Dr. Bennett's lab in UC Davis will measure and record the reflectance value for each filter.

While preparing for field trips in the UC Davis lab, filters/PUFs are inspected, loaded into the sampler, either the PEM or cascade impactor, and the filter/PUF ID, sampler ID,

and the date loaded is recorded in the lab log by the lab technician. The set-up field log is partially filled out by the lab technician. Filter/PUF ID labels are placed in three places, one on the sampler, one on the set-up field log, and one on the lab log. The extra label is placed with filter/PUF case. All these activities are conducted following the SOP for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly and SOP for Personal Environmental Monitors (PEMS) Cleaning, Assembly, and Disassembly, located in Appendix D1. The Set-up Field Log is placed in a resealble bag with the sampler.

During the sample deployment visit, flow rate, location, set-up date, and other relevant information is recorded on the set-up field log by the field staff, following the SOP for Indoor/Outdoor Air Quality Field Sampling in Appendix D1. The field log is scanned at the field office when the staff is back from the field trip.

During the sample retrieval visit, the filter/PUF ID is recorded by hand on the take-down field log along with other relevant information. The filter/PUF ID is written on the bag which the sampler is placed in when it gets picked up. Household ID and pick-up date are also written on the bag. A “D” or “B” is marked on the bag if the sample is a duplicate or field blank, respectively. All of these activities are conducted by the field staff.

Upon return to the field office, the filter/PUF ID is logged into UC Davis Chain of Custody Form by handwriting the sample ID and sampler number. The take-down date is recorded on the UC Davis Chain of Custody Form. The field log is scanned. All of these activities are conducted by the field staff.

The electronic copies of both set-up and take-down field logs are uploaded onto the UC Davis secure server immediately after scanning, accessible only by personnel directly associated with the project. The hard copies are kept in the field office temporarily and are transported back to UC Davis lab with samples.

After transporting the sampler back to the UC Davis lab, the filters/PUFs are logged into UC Davis Chain of Custody Form. When taking the filter/PUF out of the sampler, the filter/PUF is recorded on the lab log by the lab technician and it is checked that it is in same sampler as recorded when the filter/PUF was loaded into the sampler. This is marked on the lab log by checking the square marked “unload match”. The take-down date and household ID from the bag are recorded on lab log as is the unloading date. A “D” or “B” is written in the lab log if the sample is duplicate or field blank, respectively.

Filter/PUF is logged into Wisconsin Chain of Custody Form when sent back to Wisconsin.

Once gravimetric analysis is completed at Wisconsin, the samples are sent back to UC Davis. Reflectance measurements are completed for all PM2.5 indoor and outdoor samples by the reflectometer technician.

The individual conducting each activity will initial all forms after they have filled them out.

Procedure for handling Ozone/NO_2 filters

Definitions:

Batch #: Number printed on packaging by Ogawa. This is based on production batch and there are multiple vials with this number.

Vial #: Number assigned to each vial.

Sample ID: Beginning with "O" or "N" followed by 3-digit consecutive numbers, given when loading the filter into sampler

Household ID – Five digits ID, starting with "8" for Fresno participants and "9" for Riverside participants.

Loading date: Date sample media was loaded into sampler.

Unloading date: Date sample media was removed from sampler.

Set-up date: Date sampler was placed in the home

Take-down date: Date sampler was removed from participant's home.

Procedure:

Ozone/NO_2 filters come from Ogawa, in a vial of 40 filters per vial. Each vial is printed with a batch number. Each vial is numbered. Three labels will be printed for each filter at the Harvard School of Public Health and mailed to UC Davis.

The lab technician prepares samples for field trips in the UC Davis lab. Filters are opened and inspected, and logged into the lab log. Three filters from each vial will be reserved as field blanks. Filters are loaded into the Ogawa samplers, and the Batch number, Vial number, filter ID and loading date are recorded in the lab log. The set-up field log is partially filled out by the lab technician, placing a filter/PUF ID label on the field log, and recording the Batch number. Filter ID labels are placed on the sampler, set-up field log and lab log. All these activities are conducted following the SOP for Ogawa Sampler (Ozone/NO2) Cleaning, Assembly, and Disassembly, which is located in Appendix D1.

The field staff deploys the sample in the field. During each visit, either ozone or NO_2 is measured, but not both. The field blank is left in the field unopened in a closed amber jar attached outside the pump box close to PM sampling inlet during the measurement period. The field log is scanned at the field office when the field staff is back from the field trip.

During the sample retrieval visit, the filter ID is recorded by the field staff on the take-down field log along with other relevant information. The filter ID is written on the bag which the sampler is placed in when it gets picked up. Household ID and take-down date are also written on the bag. A “D” or “B” is marked on the bag if the sample is duplicate or field blank, respectively.

Upon return to the field office, the filter is logged into UC Davis Chain of Custody Form by handwriting the sample ID and sampler number when it goes into the field fridge by the field staff. The take-down date is recorded on the UC Davis Chain of Custody Form. The field log is scanned.

The electronic copies of both set-up and take-down field logs are uploaded onto the UC Davis secured server immediately after scanning, accessible only by personnel directly associated with the project by the field staff. The hard copies are kept in the field office temporally and are transported back to UC Davis lab with samples.

After transporting the sampler back to the UC Davis lab, the filters are logged into the UC Davis Chain of Custody Form when it gets to lab fridge. When lab technician takes the filter out of the sampler, the filter ID is recorded on the lab log. The take-down date and household ID from bag are recorded on lab log as is the unloading date. A “D” or “B” is written in the lab log if the sample is duplicate or field blank, respectively.

Filter is logged into UC Davis Chain of Custody Form when sent to RTI.

The individual conducting each activity will initial all forms after they have filled them out.

Field Audit Report: February 2016
Asthma/Filtration Project Air Quality Measurements
Prepared by Chuck McDade, UC Davis, February 2016
Addendum July 2016

A field sampling audit was conducted in support of the Asthma/Filtration Project. The audit was conducted on February 3, 2016, in the Fresno area. The audit was conducted by Chuck McDade. In summary, the audit did not identify the need for any changes in procedures, recordkeeping, or training. Some minor changes to the project Standard Operating Procedures (SOPs) are recommended, described below.

Two project employees were present for the audit, Carina Perez and Alex Cervantez. They are the only employees who currently perform the field sampling. They also perform the sampling in Riverside.

Carina and Alex were both trained in the field. Carina was the first to join the project and she was trained by Rebecca Moran. Alex joined shortly thereafter and he was trained by both Rebecca and Carina. Teflon filters are loaded at the field laboratory by Carina, who spent two weeks at the project laboratory at UC Davis to be trained on the Teflon loading procedure.

Three check sheets were provided for the major field activities: pump box check, site set-up, and site take-down. The check sheet is a condensed form of the SOP describing the essential steps in list form. It provides a simple yet thorough description for easy referral as needed during the field work. Carina and Alex use these check sheets to guide their work.

It should be noted that the check sheets differ from the SOPs in some small details, although these differences would not be expected to result in changes in data quality. For example, the pump box SOP directs the operator to write “Do not use” on a pump box with a noisy fan whereas the check sheet specifies writing “Fan bad.” According to Carina and Alex the check sheets evolved from the SOPs and represent best practices based on field experience. **Audit recommendation:** At the end of the study revise the SOPs to match the check sheets. Doing so will provide accurate descriptions of the actual procedures for reference by data users.

The audit began at the project’s field laboratory at the UC Kearney Agricultural Center at Parlier, south of Fresno. Carina and Alex demonstrated the preparation of pump boxes and inlets for the day’s site set-up operations. All steps were performed thoroughly and accurately, following the pump box check sheet. They also demonstrated packing and loading the boxes with the equipment, supplies, and samples needed for the day’s activities.

Two procedures were not observed during the audit: loading the Teflon filters into the samplers and launching the HOBOs for deployment later in the day. Carina had performed these activities earlier in the day, so the equipment was ready to go by the time the audit began. Carina is the only person who loads the Teflon filters and, as noted above, she was trained in the project lab in Davis. **Audit recommendation:** The cascade impactor (CI) and personal environmental monitor (PEM) SOPs still indicate that the Teflon filter loading is performed in Davis. The SOPs should be edited to indicate that

the loading is performed in the field lab. Field loading was initiated early in the study to minimize the time that the filter is in the sampler and thus minimize the potential for contamination by the sampler o-rings. Loading the filters in the field is a worthwhile procedure.

Two activities are performed quarterly: leak testing and flowmeter comparisons. These activities were not being performed on the day of the audit.

The audit continued with two take-down visits In Fresno and a set-up visit in Selma. A second set-up visit had been planned in Biola but the family had moved unannounced so that visit was aborted. Carina and Alex followed all of the steps on the take-down and set-up check sheets. Both of them are thorough and meticulous in their work and seem to take pride in doing a good job. They completed all of the required field log sheets with no errors or omissions. Carina and Alex were uniformly polite and respectful to the homeowners and to the children.

Summary

The audit did not identify the need for any changes in procedures, recordkeeping, or training. Carina and Alex are both highly proficient and they perform their duties with care and skill.

Some improvements in documentation were recommended above. To summarize them:

1. Update the SOPs at the end of the study to reflect the exact procedures that were employed. In particular, edit the SOPs to match the procedures described on the check sheets.
2. Update the laboratory SOPs to note that the Teflon filters are loaded in the field laboratory, not in the Davis laboratory.

Addendum, July 2016

A second audit was conducted at the Parlier field laboratory on July 12, 2016, to observe the loading of the Teflon filters and to examine the cleanliness of the samplers. Carina Perez always loads the Teflon filters and she demonstrated the procedure using filters that were to be deployed to the field later that day. Carina typically loads the filters on the day of deployment, although sometimes she will load them the night before if the first home visit is scheduled for early in the day.

Carina followed the loading procedures as described in the SOP for both the CI and the PEM. The SOPs were recent, current versions, dated June 28, 2016. She checked all of the sample labels carefully and recorded the loading date on the plastic bag that contains each unit. Before starting she verified that the torque screwdriver was set to the designated 60 in-oz, and she was careful to complete each screw using the torque screwdriver.

Carina cleaned the work area thoroughly before starting the procedure and she was careful to touch the filter only on its support ring, using forceps. In one deviation from the SOP she did not wear gloves, although she washed her hands before beginning. Carina said she had discussed omitting gloves with

Rebecca Moran, and they had concluded it was not necessary. Low field blank concentrations throughout the study confirm that using bare hands does not contaminate the filters.

Alex Cervantez described the cleaning procedures for the pump boxes and inlets. After each use all components are cleaned using Kimwipes, with special attention paid to components that are prone to getting dusty, such as fan enclosures. There was no visible dust on the pump boxes or the inlets, so it appears that the cleaning procedure is thorough.

As concluded after the first audit in February, the audit did not identify the need for any changes in procedures, recordkeeping, or training. Carina and Alex are both highly proficient and they perform their duties with care and skill.

Laboratory Audit Report: 2015-16
Asthma/Filtration Project Air Quality Measurements
Prepared by Chuck McDade, UC Davis, March 2016

Introduction

Three laboratory audits are being conducted in support of the Asthma/Filtration Project. All of the audits are taking place at the Center for Health and the Environment facility at UC Davis. This facility supports the Asthma/Filtration Project by preparing fresh substrates to be sent to the field sites and by downloading exposed substrates that have been returned from the field. Three separate activities are performed in batches, with the timing dependent upon the availability of samples for each:

1. Unloading and loading cascade impactors and personal environmental monitors (approximately monthly)
2. Unloading and loading Ogawa ozone samplers (seasonally)
3. Performing reflectance measurements (seasonally)

Session 1 – Cascade Impactors and Personal Environmental Monitors, September 1, 2015

The first audit session was conducted on September 1, 2015, at the Center for Health and the Environment facility on the south campus of UC Davis. The audit was conducted by Chuck McDade. Lei An Ilan, a student employee, demonstrated the procedures. Debbie Bennett observed the audit.

Five procedures were demonstrated:

1. Unloading the cascade impactor (CI)
2. Unloading the personal environmental monitor (PEM)
3. Loading the cascade impactor (CI)
4. Loading the personal environmental monitor (PEM)
5. Cleaning and re-greasing the PEM impaction surface

A "Cheat Sheet" was provided for each procedure. The Cheat Sheet is a condensed form of the SOP describing the essential steps in list form. It provides a simple yet thorough description for easy referral by the lab technician as needed. The Cheat Sheet is also the primary reference for new employees while they are being trained.

Lei An demonstrated each of the procedures, following all of the steps expertly and meticulously. It was apparent that she has been well-trained and has a great deal of experience with the procedures. She was very comfortable with all of the steps. She demonstrated sample recordkeeping by making entries in the laboratory logbook and by placing barcoded labels in the logbook and on the samplers. Lei An understood the purpose of each entry and label and she had a routine developed for setting out the labels on the table so they would be applied in the proper order. The audit did not identify the need for any changes in procedures, recordkeeping, or training.

It is worth noting that the filters are not loaded into the samplers in the laboratory but are shipped to the field in petri dishes and loaded by the field crew. Doing so minimizes the time that the filter is in the sampler and thus minimizes the potential for contamination by the o-rings. Shipping the filters in petri dishes is a worthwhile procedure.

The Cheat Sheets provide a useful condensed rendition of the SOPs. The SOPs themselves, however, need to be formally updated. The working copies in the laboratory contain hand-written entries that document small changes or additions that have occurred during the course of the study. For historical documentation these handwritten changes should be incorporated into the final versions of the SOPs or the handwritten copies should be scanned to form the final versions. This work would be best done near the end of the study to incorporate all additions that might yet be applied. The applicable SOPs are:

1. Standard Operating Procedures for Cascade Impactor (CI) Cleaning, Assembly, and Disassembly (dated 1/9/14)
2. Standard Operating Procedures for Personal Environmental Monitors (PEMS) Cleaning, Assembly, and Disassembly (dated 1/9/14)

Session 2 – Ogawa Ozone Samplers, September 19 and 21, 2015

The second audit session was conducted on September 19 and 21, 2015, at the Center for Health and the Environment facility on the south campus of UC Davis. The audit was conducted by Chuck McDade. Anacary Ramirez, a student employee, demonstrated the procedures. This audit focused on the procedures associated with the Ogawa ozone sampler.

Three procedures were demonstrated:

1. Disassembling the Ogawa sampler (September 19)
2. Cleaning the Ogawa sampler (September 19)
3. Assembling the Ogawa sampler (September 21)

Anacary demonstrated each of the procedures, following all of the steps expertly and meticulously. It was apparent that she has been well-trained and has a great deal of experience with the procedures. She has been servicing the Ogawa samplers since the beginning of the summer sampling period. Anacary demonstrated sample recordkeeping by making entries in both the assembly and disassembly logbooks and by placing labels in the logbooks and on the samplers. Anacary understood the purpose of each entry and label and she had a routine developed for setting out the labels on the table so they would be applied in the proper order. The audit did not identify the need for any changes in procedures, recordkeeping, or training.

One deviation from the Ogawa sampler SOP should be noted. The SOP on file was developed at Harvard and reflects their procedures. The Ogawa cylinders are assembled in sets of five. The Harvard SOP indicates that all five should be assembled piece by piece, i.e., all five screens should be set in place, then all five filters, etc., until all five cylinders are completely assembled. For this study, however, each

of the five cylinders is assembled completely before moving on to the next. According to Rebecca Moran, the procedure was changed because the UC Davis glovebox is small compared to the Harvard glovebox so it is more practical to work on one cylinder at a time.

The UC Davis procedure does not need to be changed, but the SOP should be annotated to reflect the differences. The purpose of the piece-by-piece assembly by Harvard was to minimize the filter exposure time during assembly, but UC Davis accomplishes the same goal by replacing the cap on the filter vial after each filter is removed. In fact, the UC Davis procedure may result in even less exposure time. With the Harvard procedures all five filters would be left exposed if there were a delay in assembling any one of the cylinders, but this is not the case with the UC Davis procedure. The applicable SOP is:

Standard Operating Procedure for Ogawa Sampler (Ozone/NO2) Cleaning, Assembly, and Disassembly (dated 7/10/13)

Session 3 – Reflectance Measurements, March 18, 2016

The reflectance measurements audit was conducted on March 18, 2016, at the Center for Health and the Environment facility on the south campus of UC Davis. The audit was conducted by Chuck McDade. Alison Pinto, a student employee, demonstrated the procedures. This audit was conducted much later than the prior two audits because reflectance measurements are conducted infrequently.

Alison is currently the only student employee who performs the reflectance measurements, and she has been doing so since Fall 2013. Alison was trained by Rebecca Moran. In the rare instance when Alison is unavailable Rebecca serves as the backup operator.

Alison followed the procedures described in the SOP titled “Standard Operating Procedure for Reflectance Analysis” dated 03/01/2016. This SOP was updated from the version dated 07/10/2013 to more accurately reflect the actual procedures being used. The 2013 version had been adapted by UC Davis from the SOP used at Harvard. The 2016 version incorporated additional changes to more closely describe the exact procedures being used in this study. Some details were different because UC Davis has a newer model of the reflectometer than the one used at Harvard. For example, the Harvard instrument has knobs to adjust the instrument gain, whereas the newer UC Davis version has a single “CAL” button to reset the gain. The fundamental procedures are identical in the two SOPs; the differences lie in the operational details. The 2016 version should be considered the official SOP for this study.

Alison followed the procedures in the SOP with accuracy and care. It was apparent that she has been performing the measurements for a long time and that she is very comfortable with the procedures. No corrective action is needed.

The laptop computer associated with the reflectometer is old and the keypad sometimes requires some manipulation to get it to respond. It did respond in every case so there does not seem to be any

negative effect on data quality or data capture. As a caution, however, it may be necessary to replace the laptop at some point.

The measurements of the Working Standard Blank filter require some physical adjustment of the filter orientation along with judgment by the operator. Teflon, by its nature, is inhomogeneous, with lighter and darker stripes faintly visible on the filter surface. When measuring the reflectance of the Working Standard Blank, Alison has been trained to move the filter or the optical head very slightly until the reflectance reading reaches its maximum, indicating that the light is focused on one the "white" parts of the filter surface. This procedure strives for consistency from one measurement to the next. Alison is very skilled at locating the maximum reading. If she were to miss the maximum reading, however, the associated uncertainty appeared to be less than one percent, based on the variability in the readings as she moved the head around while searching for the maximum.

In summary, the reflectance measurements appear to be conducted with care and in compliance with the SOP. The audit did not identify the need for any changes in procedures, recordkeeping, or training.

Session 4 – Leak Testing, September 22, 2016

The leak testing audit was conducted on September 22, 2016, at the Center for Health and the Environment facility on the south campus of UC Davis. The audit was conducted by Chuck McDade. Rebecca Moran and Debbie Bennett demonstrated the procedures. This audit was conducted after the conclusion of the field measurements.

Two types of leak testing were demonstrated: PEM and CI leak testing and pump box leak testing. Rebecca Moran first demonstrated the PEM and CI leak testing, following the SOP entitled "Standard Operating Procedure for PEM and CI Leak Testing." She followed the procedures precisely and no leaks were found in any of the units that were tested during the audit. Approximately 10 percent of the PEMs and CIs are to be leak tested now that the study is complete as a final spot check on the network. The results of each leak test are recorded on the leak testing log sheet.

All PEMs and Cis were leak tested by UC Davis staff prior to the beginning of the field campaign. In addition, Jeff Williams of ARB conducted further leak tests approximately six months into the study when he cleaned and inspected the units. There was no evidence of systematic leaks in any of these tests.

Debbie Bennett demonstrated the pump box leak testing procedure, following the SOP entitled "Standard Operating Procedure for Pump Box Leak Testing." These tests were performed prior to the beginning of the field campaign to identify the possibility of systematic design flaws that might cause leaks during the course of the study. These pre-study tests met the acceptance criteria so the pumps boxes were deployed to the field to be used for the duration of the study.

In summary, the leak testing procedures are sound, the SOPs are being followed precisely, and there is no evidence of systematic leaks in the sampling network.

Quality Assurance Report: O-Ring Assessment
Asthma/Filtration Project Air Quality Measurements
Prepared by Chuck McDade, UC Davis, August 2015
Addendum, May 2016

EXECUTIVE SUMMARY

Air quality measurements have been underway for the Asthma/Filtration Project since late 2013. During that time five different types of o-rings have been used to secure the Teflon© filters in the cascade impactors (CI) and personal exposure monitors (PEM). The five types of o-rings have been designated as Harvard, Viton, red, black, and Atlantic. There has been evidence of filter mass contamination due to some of the types of o-rings.

The Harvard and Viton o-rings exhibit no significant contamination so the measurement data can be used with confidence. The red o-rings result in significant contamination, contributing most of the measured mass in some lightly-loaded samples. Data from the red o-ring samples should be adjusted for contamination (increasing the uncertainty of the final result) or should not be used at all. The black and Atlantic o-rings exhibit some contamination when the filter remains in the sampler for more than about two weeks, but not when the filter is removed sooner. However, blank contamination data for the long-stored samples are sparse and erratic so it is difficult to establish a reliable adjustment factor.

INTRODUCTION

Air quality measurements are being performed as part of the ARB Asthma/Filtration Project to document the environmental conditions under which the filtration and health effects measurements are conducted. Fine particulate measurements are performed using two devices - cascade impactors (CI) and personal exposure monitors (PEM). Each CI and PEM contains a Teflon© filter secured by an o-ring. The CI and PEM designs were developed by Harvard University and have been used successfully by Harvard for many years.

Several types of o-rings were used during the early stages of the asthma study, beginning in late 2013. There has been evidence of filter mass contamination due to some of the types of o-rings. This report describes data analysis conducted to determine which o-rings contributed to significant contamination and to assess whether or not the affected data can be adjusted to account for the contamination.

Five types of o-rings have been used thus far in the Asthma/Filtration Project and each will be assessed in this report. The five types are:

1. Red - For the current Asthma/Filtration Project this different o-ring was substituted for the o-ring typically used in the CI and PEM in an attempt to minimize air leakage into the samplers. Early pre-intervention testing, however, revealed significant contamination related to the red o-rings. The red o-rings have not been used since the early stages of the study. This report provides recommendations regarding the possible use of the data from the red o-rings.
2. Black - A black o-ring was substituted for the red o-ring once the red o-ring contamination was revealed. These black o-rings were ordered and provided by Harvard and were nominally comparable to the o-rings that Harvard typically uses in their CI and PEM. Initially the black o-

rings exhibited minimal contamination but later it was observed that they were subject to contamination when left in the sampler for an extended period, nominally more than two weeks. This report provides recommendations regarding the possible use of the data from the black o-rings.

3. Atlantic – Once Harvard was notified of the contamination from the black o-rings they recommended that replacement black o-rings be ordered directly from Atlantic, a small company that had successfully provided o-rings to Harvard in the past. The Atlantic o-ring was found to exhibit contamination following prolonged storage, much like the black o-ring. The Atlantic o-rings were used for only a half-dozen measurement sets in August 2014.
4. Harvard – As a stopgap measure following the contamination problems with the black and Atlantic o-rings Harvard pulled the o-rings out of all of the samplers they had in stock and provided them for use in the asthma study. Eighty of these used o-rings were available, enough to keep the study going but not sufficient for a long-term solution.
5. Viton - Once it was determined that neither the red nor the black o-rings could deliver acceptable results there was a search for a commercially available alternative. The Viton o-ring was found to provide minimal contamination so it has been used for much of the Asthma/Filtration Project fine particulate measurements, along with the used Harvard o-rings.

The principal motivation for this assessment was to determine whether or not the data from filter samples contaminated by o-rings could be salvaged and, if so, to recommend an approach for adjusting the data to account for the contamination. Those recommendations are provided in this report, along with an assessment of contamination from each type of o-ring that was used.

Airborne mass is also determined in the asthma study using polyurethane foam (PUF) cartridges. There was, however, no evidence of contamination in the PUF blanks. Therefore this report addresses only the Teflon© filter samples and their associated o-ring contamination.

DATA USED IN THIS ASSESSMENT

Blank and sampling data were provided by Debbie Bennett in a spreadsheet prepared by her assistant, Katya Roudneva. The spreadsheet is dated July 10, 2015, and is titled “Air Sampling Data Set 07102015.xlxs.” A data dictionary was delivered along with the data set to provide a description of each variable. The data set is the comprehensive data set for the entire project so it includes all of the measurement data along with descriptive metadata such as the time, location, and type of each sample.

For this assessment the data were filtered by type of sampler (CI or PEMS), by type of o-ring, and by blank or ambient sample, in order to create data subsets representing specific sampling configurations. The result was twenty different subsets of the data (two sampler types times five o-ring types times two sample types). Only the primary sample results were used; collocated duplicates were not included so as not to skew the statistical analysis.

Plots and statistical results presented in this report are identified by the subset of data used in each analysis. For example, a plot might be labeled PEM, Black O-rings, Blank Data.

ANALYSIS AND RESULTS

Contamination from o-rings is assessed by examining the mass of material measured on field blanks, filters that are mounted into the sampler but are not sampled with ambient air. Mass that appears on field blanks can be assumed to result from contamination and not from atmospheric particles. Three questions need to be answered in evaluating blank contamination:

1. Are the blank levels significant or important compared to typical measured atmospheric concentrations?
2. If contamination is significant are the blank levels sufficiently consistent to use as an adjustment factor?
3. If an adjustment factor is applied then what is its contribution to the overall uncertainty of the measurement?

To answer these three questions a set of statistical measures was applied to each of the twenty subsets of the data to calculate the average value, median value, and standard deviation of each subset. The results of these calculations are listed in Table 1 and the results from each type of o-ring are discussed in the following text. The average, median, and standard deviation results shown in Table 1 were obtained using Excel functions.

Table 1: Statistical Results for Each of the 20 Data Subsets

Sampler	O-ring	Sample Type	# Data Points	Average, mg	Median, mg	Std. Dev., mg
CI	Red	Blank	9	0.77	0.72	0.25
CI	Red	Sample	12	1.80	1.69	0.62
PEM	Red	Blank	8	0.41	0.42	0.16
PEM	Red	Sample	12	0.94	0.83	0.45
CI	Black	Blank	37	0.03	0.01	0.04
CI	Black	Sample	330	0.35	0.32	0.19
PEM	Black	Blank	46	0.03	0.01	0.07
PEM	Black	Sample	331	0.36	0.28	0.25
CI	Atlantic	Blank	5	0.04	0.02	0.04
CI	Atlantic	Sample	6	0.17	0.17	0.11
PEM	Atlantic	Blank	2	0.00	0.00	0.00
PEM	Atlantic	Sample	5	0.11	0.13	0.05
CI	Harvard	Blank	4	0.00	0.00	0.00
CI	Harvard	Sample	53	0.11	0.10	0.06
PEM	Harvard	Blank	3	0.00	0.01	0.00
PEM	Harvard	Sample	55	0.17	0.13	0.40
CI	Viton	Blank	40	0.00	0.00	0.01
CI	Viton	Sample	350	0.14	0.13	0.10
PEM	Viton	Blank	39	0.00	0.00	0.00
PEM	Viton	Sample	346	0.21	0.14	0.32

Red O-rings

The red o-rings exhibited significant contamination. For both CI and PEM the median blank value is around half of the median measured ambient value. In other words, contamination accounts for around half of the mass measured on a sampled filter at the median concentration. Figures 1 and 2 show the distribution of measured mass on the sampled ambient filters for CI and PEM, respectively. In each plot the vertical red line indicates the median blank level. For the lowest concentration samples contamination can account for most of the measured mass.

Figure 1 – Red line represents median blank value

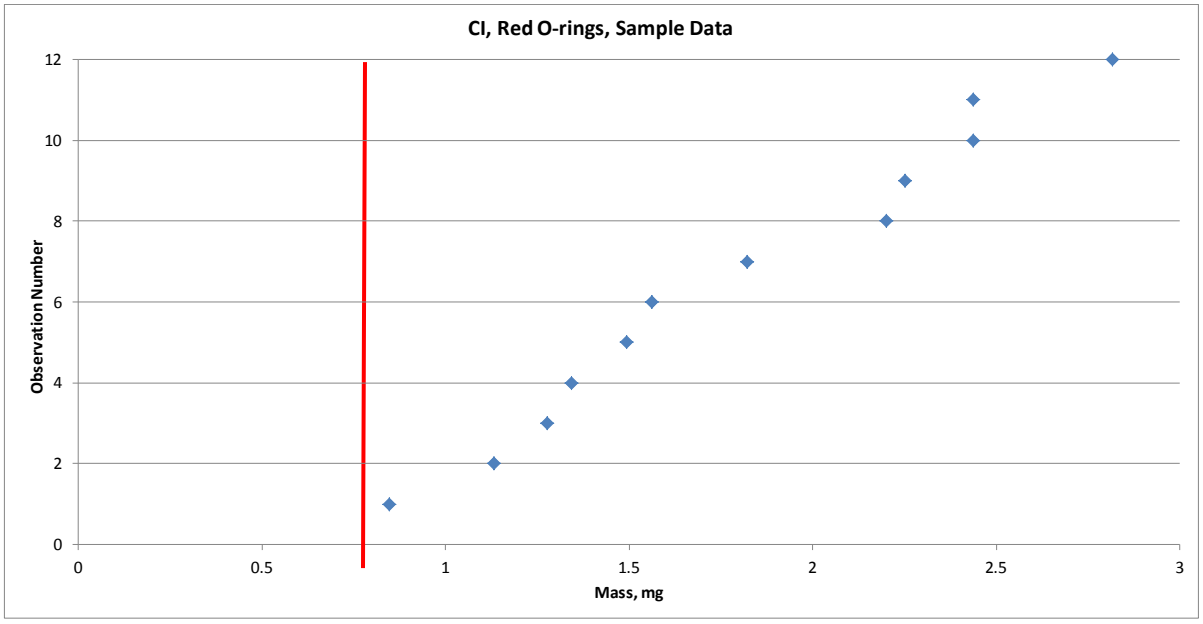
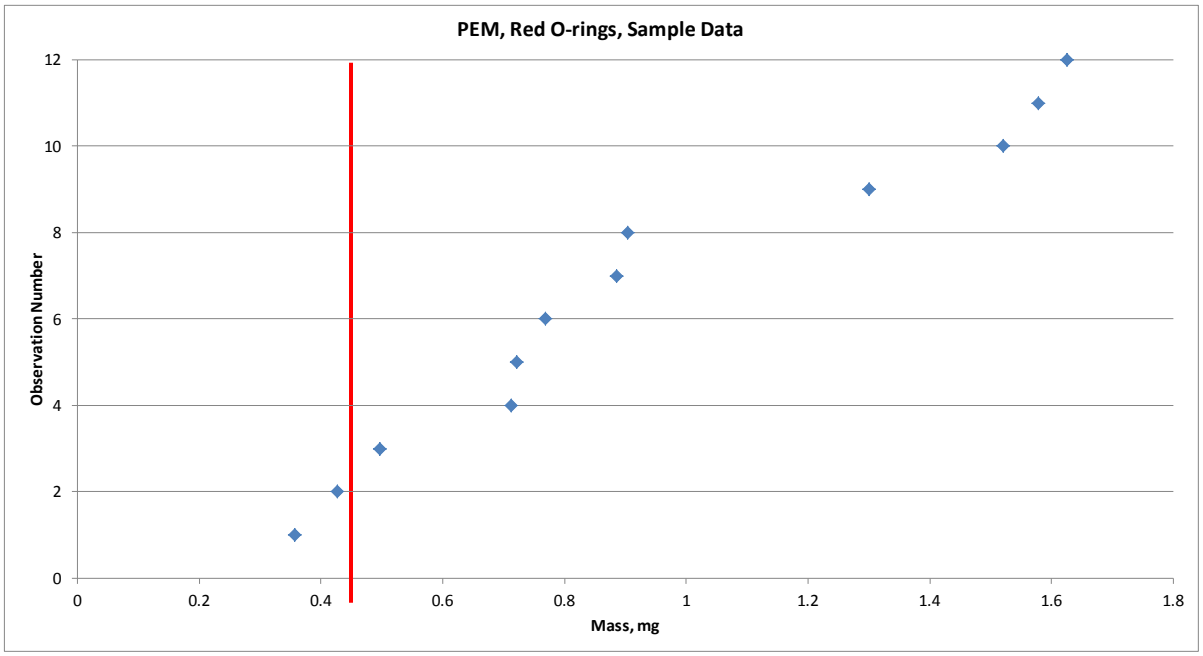


Figure 2 - Red line represents median blank value



These results strongly suggest that a correction factor should be applied to account for the significant contamination in the samples. Otherwise the ambient concentrations will be substantially overstated, especially for the more lightly-loaded samples. A recommended approach would be to use the blank correction algorithm applied to ion measurements in the National Park Service IMPROVE fine particulate network. For each data subset in IMPROVE (usually a month of samples) the median field blank value for that subset is subtracted from each measured concentration to yield an adjusted, artifact-corrected value. For the Asthma/Filtration Project that subtracted median value would be 0.72 mg for CI and 0.42 mg for PEM (see Table 1).

Applying a blank correction increases the uncertainty of the reported concentration values. If the blank levels are fairly stable then the added uncertainty is minimal, but if the blanks are highly variable then the added uncertainty can be substantial. Hence, the uncertainty contributed by the blank subtraction is related to the standard deviation of the blank values.

Blank-corrected ion concentrations in IMPROVE are calculated using a form of equation 1:

$$C = \frac{(A - B)}{V} \tag{1}$$

Where C is the corrected concentration, A is the direct measurement from the filter, B is the median blank value used to correct A, and V is the sampled air volume. The uncertainty, σ, of the concentration C is calculated using a form of equation 2:

$$\sigma = \frac{\sqrt{{\sigma_{dfb}}^2 + 2 * B * {f_a}^2 * (A - B) + (f_a * (A - B))^2 + (f_V * (A - B))^2}}{V} \tag{2}$$

Here, σ_{dfb} is the standard deviation of the field blank measurements, f_a is the fractional analytical uncertainty, and f_v is the fractional volume uncertainty.

The uncertainty contributed by the blank correction is not related to the fractional analytical uncertainty nor to the fractional volume uncertainty. Therefore, in estimating the blank correction uncertainty we need only consider the first term within the square root bar. In other words, the uncertainty contributed by the blank correction can be estimated by the standard deviation of the field blank measurements. For CI this standard deviation is 0.25 mg, compared to adjusted measurement data ranging from near zero to around 2 mg. For PEM this standard deviation is 0.16 mg, compared to adjusted measurement data ranging from near zero to around 1.5 mg. So, for both CI and PEM the uncertainty contributed by the blank correction is around 10% for the most heavily loaded samples and increases proportionately for more lightly loaded samples.

Black O-rings

The black o-rings present a more complex picture than do the red o-rings. The median blank values for both CI and PEM are less than 5% of the median sample values, a proportion to cause little concern for

contamination. With the black o-rings, however, there is evidence of contamination if the blanks remain in the sampler for an extended time, nominally more than about two weeks.

Figures 3 and 4 illustrate the mass observed on blank filters with black o-rings as a function of the number of days that the filter was loaded in the sampler, for CI and PEM, respectively. Note the different axis scales in the two figures.

Figure 3 – CI blank values as a function of days in sampler

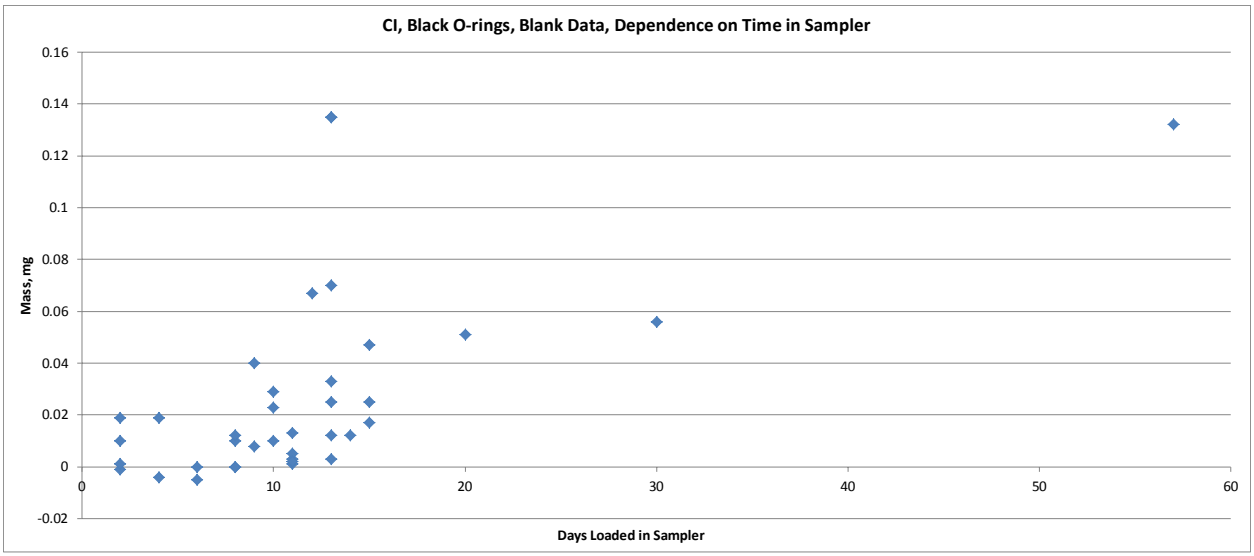
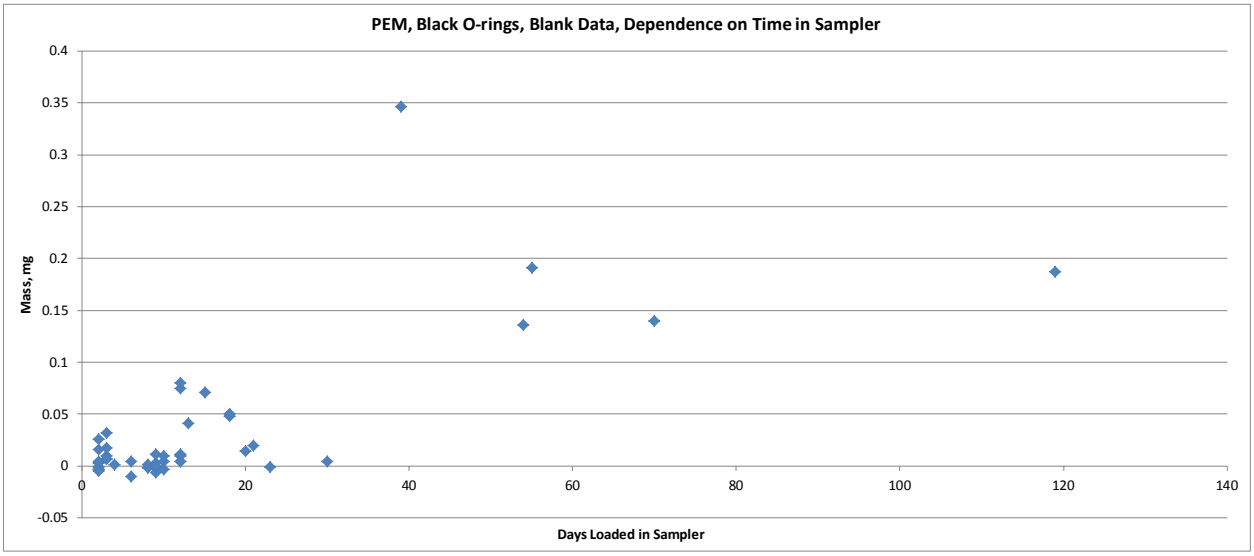


Figure 4 – PEM blank values as a function of days in sampler



It is clear that there is little contamination for about the first two weeks. Beyond that period the behavior is erratic and there are few blank filter data points to establish an adjustment factor, only six points for CI and 13 points for PEM. The statistical results for these >14 day blanks are:

CI: Median = 0.05 mg Standard Deviation = 0.04 mg
PEM: Median = 0.05 mg Standard Deviation = 0.10 mg

Figures 5 and 6 show the distribution of measured mass on the sampled filters that remained in the sampler for more than 14 days for CI and PEM, respectively. For both types of sampler approximately 90% of the samples collected using black o-rings remained in the sampler for more than 14 days. In each plot the vertical red line indicates the median blank level for samples left in the sampler for more than 14 days, 0.05 mg in both plots.

For the lowest concentration samples contamination can account for most of the measured mass, and for about half the samples contamination can represent 20% or more of the measured mass, perhaps suggesting that applying a correction factor would be wise. However, the uncertainty contributed by applying the blank correction (the standard deviation) is almost as large as the correction itself for CI and is twice as large as the correction for PEM. On balance it would seem best not to apply a correction because it is so poorly determined, but rather to acknowledge during data analysis that some samples may be influenced by contamination that is erratic and difficult to predict.

Figure 5 – Red line represents median blank value for >14 day samples

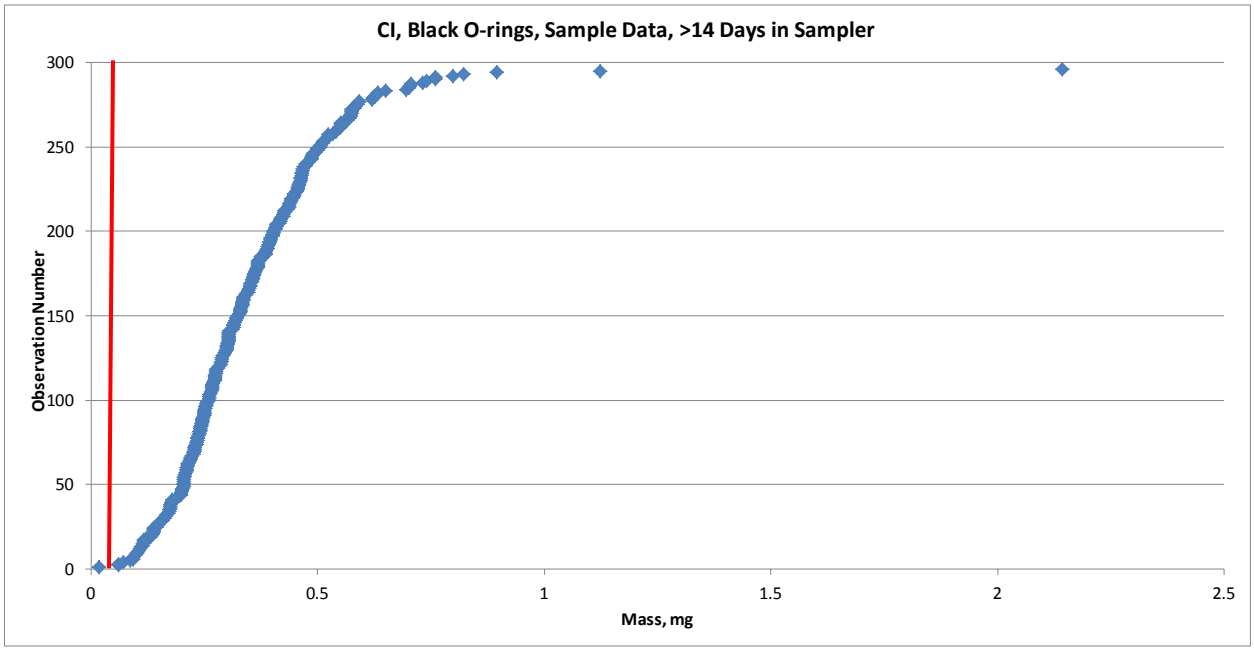
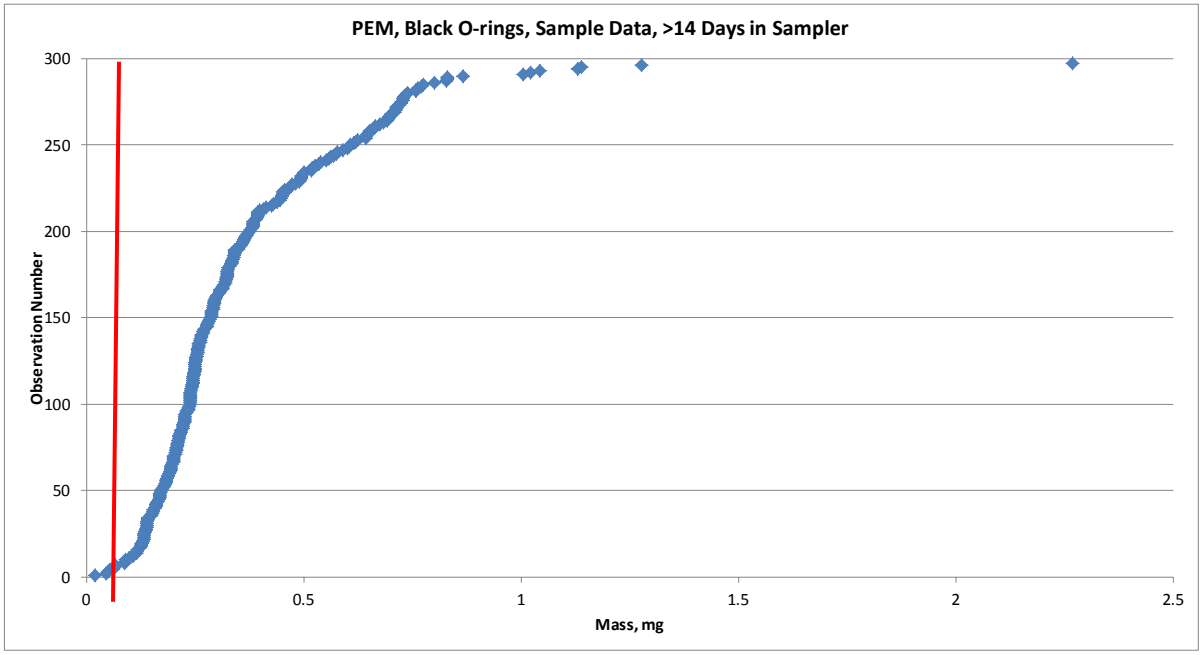


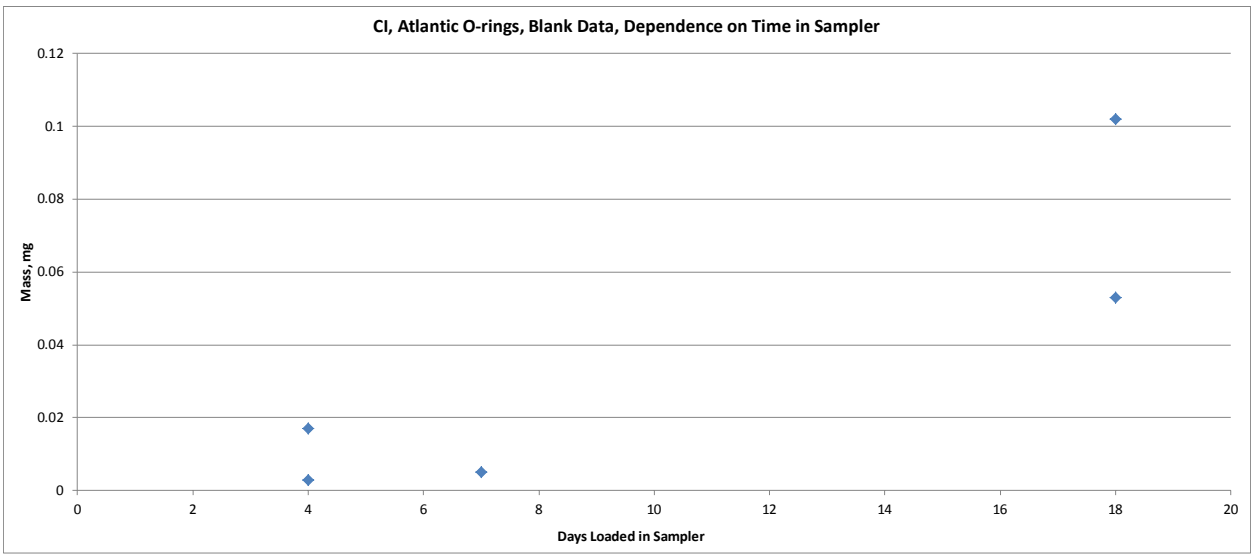
Figure 6 – Red line represents median blank value for >14 day samples



Atlantic O-rings

As listed in Table 1 only limited data are available for the Atlantic o-rings. They were used for only a half-dozen measurement sets in August 2014. Furthermore, they exhibited behavior similar to the black o-rings, with evidence of increased contamination when filters remained in the sampler more than 14 days. Figure 7 shows the results from five CI blanks that were collected with Atlantic o-rings, shown as a function of the number of days in the sampler.

Figure 7 – CI blank values as a function of days in sampler



There are only two blanks that remained in the sampler more than 14 days, both at 18 days. Both of these blanks exhibited elevated concentrations compared to the other blanks, suggesting time-dependent contamination similar to that observed with the black o-rings. There were only two PEM blanks with the Atlantic o-rings, both loaded for seven days and both showing concentrations near zero.

Because the Atlantic o-ring blank data are so limited it is not realistic to establish a statistically reliable correction factor. Similar to the black o-rings it would seem best not to apply a correction because it is so poorly determined, but rather to acknowledge during data analysis that some samples may be influenced by contamination that is erratic and difficult to predict.

Harvard and Viton O-rings

For both the Harvard and Viton o-rings the analysis is simple and straightforward. From Table 1 it can be seen that the median blank levels and the standard deviations are either 0.00 or 0.01 mg in all cases. Thus, there is no evidence of contamination for either of these o-ring types and the data can be used with confidence without correction.

CONCLUSIONS

The Harvard o-rings and the Viton o-rings currently in use in the study exhibit no significant contamination. Going forward there should be no concerns about sample contamination. Ongoing monitoring of field blank levels should confirm that the samples are free of contamination.

The red o-rings that were used early in the study contributed significant contamination. Samples collected using the red o-rings should be adjusted using the median field blank values. If no adjustment is applied then the data should not be used in data analysis since they are biased significantly high. Applying the blank correction contributes 10% to the uncertainty of the most heavily loaded samples and proportionately more to the uncertainty of lightly loaded samples.

For the black and Atlantic o-rings there is evidence of contamination if the blanks remain in the sampler for an extended time, nominally more than about two weeks. Beyond two weeks the behavior is erratic and there are few blank filter data points to establish an adjustment factor. Thus, it would seem best not to apply a correction because it is so poorly determined, but rather to acknowledge during data analysis that some samples may be influenced by contamination that is erratic and difficult to predict. The study participants might want to consider further experiments to better establish a correction factor for the black o-rings, perhaps one that is numerically related to the time spent in the sampler. Black o-ring field blanks could be stored in the sampler for various periods beyond two weeks. The results could provide a larger and richer data set for developing a reliable correction factor.

ADDENDUM, MAY 2016
FURTHER TESTS OF POSSIBLE BLACK O-RING CONTAMINATION

The results described above indicate evidence of contamination when black o-ring blanks remained in the sampler for more than about two weeks. Subsequent laboratory experiments were conducted to confirm the reliability of samples that were placed in the sampler for two weeks or fewer. Filters were placed in the sampler and then remained in the laboratory at the Center for Health and the Environment at UC Davis. The samplers were not disturbed during the test period. Filters were weighed at the University of Wisconsin laboratory following standard procedures.

Tests were conducted for either one or two weeks and used both the PEM and CI samplers. Ten filters were tested, as follows:

- 10/23-10/30/15 (1 week), 2 PEM and 2 CI
- 6/24-7/9/15 (2 weeks), 1 PEM and 1 CI
- 10/30-11/13/15 (2 weeks), 2 PEM and 2 CI

Using the same metrics as used in Table 1 the gravimetric mass results were:

- Average = 0.00 mg
- Median = 0.00 mg
- Standard Deviation = 0.01 mg

These results reflect the entire set of 10 filters, but the results are the same when the data are sorted by sampler type (PEM or CI) or by test length (1 or 2 weeks).

These results suggest that there is no significant contamination when black o-rings remain in either type of sampler for two weeks or fewer. The average, median, and standard deviation are comparable to those found using the Harvard or Viton o-rings (see Table 1).

As discussed in the section on black o-rings in the original report (above), approximately 90% of the samples remained in the sampler for more than 14 days (see Figures 5 and 6). The subsequent one and two week laboratory tests do not provide any additional insight into these data. However, for the 10% that remained in the sampler for 14 days or fewer we can be confident that these samples were not subjected to significant contamination. Figures 8 and 9 plot the distribution of measured mass on the sampled filters that remained in the sampler for fewer than 14 days for CI and PEM, respectively. Note that the range of concentrations is generally similar to that plotted in Figures 5 and 6, although Figures 5 and 6 exhibit a few high outliers that are not observed in Figures 8 and 9.

The results of these one to two week black o-ring tests merit revisiting the conclusions in the original August 2015 report (page 9 of this report). Based on the recent black o-ring tests we now know that we have three types of reliable data, apparently unaffected by o-ring contamination: Harvard o-rings, Viton o-rings, and black o-rings left in the sampler 14 days or fewer. Samples collected using these o-rings

represent the great majority of samples collected in the entire study and they provide a rich data set. Moreover, most of the contaminated o-rings were used in pre-intervention tests. Since comparison to pre-intervention is secondary, it seems more defensible to eliminate the poor quality data, and focus just on the primary analysis. Thus, the revised recommendation is to eliminate the potentially contaminated samples and use only the reliable data from the Harvard o-rings, Viton o-rings, and black o-rings left in the sampler 14 days or fewer.

Figure 8 – CI mass for ≤14 day samples

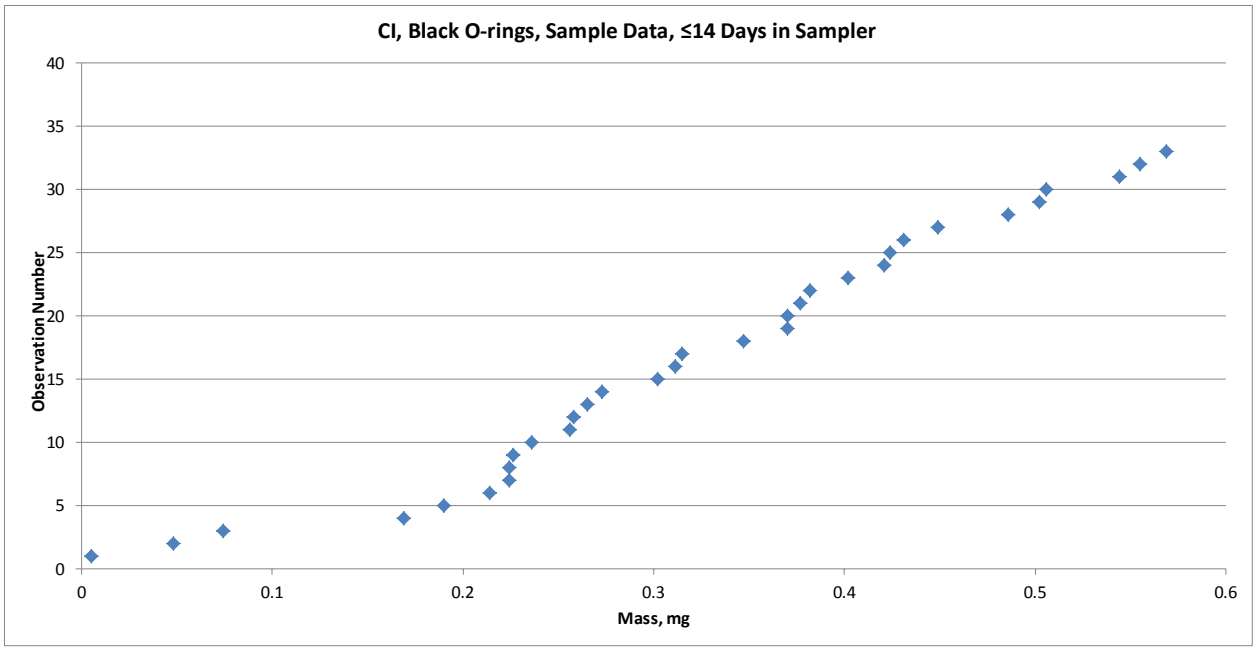
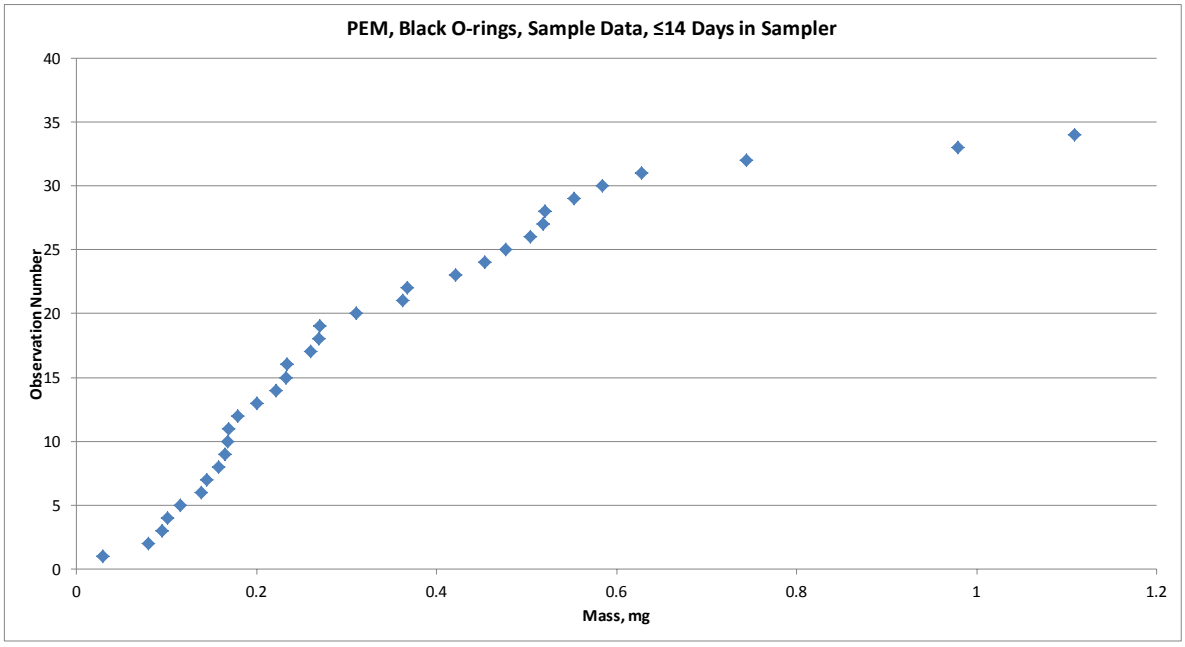


Figure 9 – PEM mass for ≤14 day samples



APPENDIX F: ANALYSIS

Contents ***Page***

Statistical Plan

BENEFITS OF HIGH EFFICIENCY FILTRATION TO CHILDREN WITH ASTHMA

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January 23, 2017

Table of Contents

I. Overview

The objectives of this study are briefly as follows:

Objective 1: In homes of children with asthma, determine the extent to which the use of a) high efficiency central filtration, and b) high efficiency portable air cleaners reduces indoor concentrations of $PM_{0.2}$, $PM_{2.5,}$ and PM_{10}, and the resulting personal exposures, and the extent to which filtration reduces indoor concentrations of ozone.

Objective 2: Determine the extent to which the use of a) high efficiency filtration in central filtration systems and b) high efficiency portable air cleaners reduces asthma symptoms, emergency room (ER) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.

Objective 3: In homes of children with asthma, measure indoor and outdoor concentrations of $PM_{0.2}$, $PM_{2.5,}$ PM_{10}, and estimate resulting personal exposures.

Our primary assessment of the intervention will use generalized linear mixed-effects (GLMM) regression models in order to provide the most efficient analysis of the available data from our randomized placebo self-controlled crossover study. This regression strategy allows us to account for important features of our longitudinal study data, including a variety of response variable distributions (e.g. continuous, binary, and counts) the need to account for time-varying confounders, especially seasonal effects, and partial follow-up from subjects not completing all scheduled assessments. Although generalized linear mixed-effects models will be our preferred approach, alternative regression approaches for clustered longitudinal data may be required in cases where the stringent modeling assumptions for GLMM are violated or when numerical algorithms are not able to converge on valid estimates. In these cases, either generalized estimating equations or survey data analysis methods for clustered data from comparative experiments will be used, at the discretion of Dr. Tancredi, a faculty statistician highly experienced in the application of all three of these approaches, in consultation with ARB.

Our primary analysis data set will use an intention-to-treat approach that considers participants as belonging to the experimental conditions in which they were randomized. Statistical analyses will estimate the intervention-specific effects of filtration by comparing periods with real versus sham filtration, with appropriate statistical adjustments to estimated effects, confidence intervals and test statistics to account for the study design and to minimize confounding by other covariates influencing the distribution of study outcomes.

Prior to analysis, descriptive and graphical summaries of all study variables, including assessments for the presence of outliers will be completed. Univariate and multivariate summaries of the distributions of specified variables of interest will include key descriptive parameters (mean, key percentiles, minimum and maximum values, relative frequencies for categorical data). Tables and graphical summaries of environmental measurements will be presented (box plots or histograms). If necessary, variables will be transformed to meet modeling assumptions (i.e. variance stabilization) so that generalized linear models (for single time point outcomes) and generalized linear mixed effects regression models can be used.

To account for response distributions, standard link functions will be used (e.g. logistic links for binary outcomes, log links for count data and identity links for linear regression models of continuous outcomes). Independent variables will include binary indicator variables for randomization strata (to adjust for stratification) and each of the two experimental intervention conditions and time-varying binary indicators for real vs. sham filtration.

To maximize the efficiency of the analysis, measures collected at the time of enrollment may be included as independent variables, to statistically adjust for characteristics that may be associated with between-person differences in outcomes. Random effects will be used to account for within-person correlation in the vector of repeatedly measured outcomes. The effects of each intervention will be assessed by the intervention-specific adjusted mean difference in outcomes in real vs. sham filtration periods. In addition, between-intervention comparisons of real vs. sham filtration contrasts will be estimated, to compare the interventions on effectiveness. We will also make statistical comparisons between the measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally adjusted measurements from the true and sham filtration periods. Additional fixed effects specified prior to model fitting will be included to adjust statistically for study stratum identifiers, covariates and/or mediators or modifiers of intervention effects. In addition, offset terms may be specified in logistic or Poisson regression models to account for such subject-to-subject variations in exposure periods as, for example, when the number of potential school days lost in the past two weeks varies due to vacations and holidays. The regression modeling framework will also allow us to assess the relationship between changes in exposure and changes in health and pollution outcomes.

Specifics for each objective are listed by objective in subsequent sections of the statistical analysis plan.

II. Variable List

Below is a list of variables that will be collected and a brief description of how those variables will be operationalized. Some of the variables that will be used as covariates include a description of why they might influence the outcome.

II.A. Environmental Outcome Variables

1. Indoor levels of $PM_{2.5,}$ PM_{10}, and $PM_{0.2}$, and ozone - one-week integrated indoor concentration for each measurement.

2. Indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone - calculated by dividing the one-week integrated measured indoor concentration by the one-week integrated outdoor concentration.

3. Indoor/outdoor reflectance ratios – one-week average of the indoor/outdoor reflectance ratio which is calculated by dividing the indoor reflectance value by the outdoor reflectance value. Reflectance values are correlated with black carbon concentrations.

II.B. Health Outcome Variables

1. Number of days with asthma symptoms over a two week period from the two-week Recall Questionnaire. We will determine the maximum number of days during the two-week recall period with symptoms, defined as the largest value among the following three variables: (i) number of days with wheezing, tightness in the chest, or cough because of asthma (Q1 in the Recall Questionnaire), (ii) number of days that the child had to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough (Q2 in the Recall Questionnaire), or (iii) number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough (Q5 in the Recall Questionnaire). This method of counting "symptom days" has been used in the National Cooperative Inner-City Asthma Study (Evans et al., 1999). Multiple symptom types are considered, as different individuals experience different symptoms from their asthma.

2. Number of days that the participating children used their rescue inhaler for relief of asthma symptoms during a two-week period. This is obtained through the Recall Questionnaire, the number of days using inhalers is the greater number between Q3 (daytime use) and Q6 (nighttime use) in the Recall Questionnaire.

3. Unplanned health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma over the one-year true/sham filtration period
   a. overnight hospitalization (Q22 in the Recall Questionnaire, summed across four recall questionnaires),
   b. emergency room visit (Q23 in the Recall Questionnaire, summed across four recall questionnaires),
   c. clinic visit (Q24 in the Recall Questionnaire, summed across four recall questionnaires),
   d. receiving steroids treatment (Q25 in the Recall Questionnaire, summed across four recall questionnaires).

4. MiniPAQLQ score (ranging between 1 and 7) with three outcomes. The standard scoring system was developed for use with the instrument.
   - symptoms (mean of the responses to each of the Q1- Q6)
   - emotional function (mean of the responses to each of the Q7- Q10)
   - activity limitation (mean of the responses to each of the Q11- Q13)

5. Exhaled NO - The participant will try to complete two successful attempts, but may only have one or no successful attempts. If they have two successful attempts, the average of the two attempts will be used. If they only have one successful attempt it will be used in the analysis.

6. Spirometry: A list of measures including Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), ***and*** FEV1/FVC will be obtained, and all measures will be considered as outcomes. All parameters are expressed as a percentage of the expected value. The percentage of the expected value is determined by comparing the actual value to the distribution of values for children of the same age and height, using the data from NHANES

[4]. This allows us to account for changes as children grow. The participant will make multiple attempts at spirometry and we will take their best attempt of all acceptable attempts for each measure. So, for example, if their best FEV1 was on their first attempt and their best total volume was on their second attempt we would take the FEV1 from the first attempt, and the total volume from their second attempt. The pre-intervention spirometry values will also be used to classify asthma severity discussed below.

7. Days of missing school due to asthma, expressed as a proportion of days of missing school versus the total number of school days during a two-week period. This variable is collected through two instruments (Q7 and Q8 in the Recall Questionnaire). To account for variation in possible school days missed, this variable will be analyzed using either a grouped response data (with a logistic link) or with an offset term specified in a Poisson model.

Data will be collected, but not used for statistical analysis:

8. Total number of inhalations a child used during a two week period. This is obtained through two measures: 1) sum of Q8a in the Symptom Diary over the two-week recall period, and 2) days that the participating child used their rescue inhaler/puffer during the day for relief of asthma symptoms (Q3 in the Recall Questionnaire) × number of puffs/inhalations that the participating child used each day (Q4 in the Recall Questionnaire).

9. Days of missing work for parents due to child asthma, expressed and modeled relative to the total number of work days during a two-week recall period (Q9 in the Recall Questionnaire), using similar approaches as described above for missing school days.

10. Number of times having respiratory diseases over one year, expressed as the sum of times of having all listed diseases in Q26 in the Recall Questionnaire over the one-year true and sham filtration periods.

11. Allergy symptoms, summed from recall questionnaire questions 11 – 13, and 18 – 20. These questions are consistent with similar questions utilized in the Nelson et. al. paper to derive a symptom score [1].

12. From the two-week diary, we obtain the number of "symptom days" with any of the following: waking up during the night (Q1 in the Symptom Diary), coughing (Q4 in the Symptom Diary), wheezing (Q5 in the Symptom Diary), or have to slow down or stop activities (Q6 in the Symptom Diary) because of asthma during the diary-recording period. A day is considered a symptom day if they answered one, two, or three in their numeric response for a given question. We are combining the answers for these four questions to provide a comparable measure to that provided in the Recall Questionnaire.

13. The overall condition of asthma, recorded as continuous integers indicating how bothered the participant is by their asthma (0-not at all /1-a little bit / 2-quite a bit / 3-a lot) and expressed as the average value over a two-week period (Q3 in the Symptom Diary).

II.C. Health-related Covariates

Planned to be included in the statistical analysis as effect modifiers for the primary health outcomes:

1. Asthma severity, defined based on the asthma guideline provided by the National Heart, Lung, and Blood Institute/National Asthma Education and Prevention program presented in the table below. Asthma severity will be determined based on the spirometry measurements obtained at the pre-intervention visit and symptoms recorded in the first Symptom Recall Questionnaire. We will refer to guidance provided with the table to classify participants. Participants with more or less severe asthma may differentially respond to improved air quality.

    a. Table 1: Guideline for determining asthma severity provided by the National Heart, Lung, and Blood Institute/National Asthma Education and Prevention program

Determine Severity When Initiating Therapy

Components of Severity		Classification of Asthma Severity (5-11 years of age)			
		Intermittent	Persistent		
			Mild	Moderate	Severe
Impairment	Symptoms	≤2 days/week	>2 days/week but not daily	Daily	Throughout the day
	Nighttime awakenings	≤2x/month	3-4x/month	>1x/week but not nightly	Often 7x/week
	SABA* use for symptom control (not prevention of EIB†)	≤2 days/week	>2 days/week but not daily	Daily	Several times per day
	Interference with normal activity	None	Minor limitation	Some limitation	Extremely limited
	Lung function	• Normal FEV_1‡ between exacerbations • FEV_1 >80% predicted • FEV_1/FVC§ >85%	• FEV_1 = >80% predicted • FEV_1/FVC >80%	• FEV_1 = 60-80% predicted • FEV_1/FVC = 75-80%	• FEV_1 <60% predicted • FEV_1/FVC <75%
Risk	Exacerbations requiring oral systemic corticosteroids	0-1/year	≥2/year		
		Consider severity and interval since last exacerbation Frequency and severity may fluctuate over time for patients in any severity category			
		Relative annual risk of exacerbations may be related to FEV_1			
Recommended Step for Initiating Therapy See bar chart on the following page for treatment steps		Step 1	Step 2	Step 3, medium-dose ICS‖ option and consider short course of oral systemic corticosteroids	Step 3, medium-dose ICS option, or step 4
		In 2-6 weeks, evaluate level of asthma control that is achieved and adjust therapy accordingly.			

    b. Notes: EIB is “Exercise induced bronchoconstriction”, FEV_1 is “forced expiratory volume in 1 second”, FVC is “forced expiratory vital capacity”, ICS is “inhaled corticosteroids” and SABA is “short-acting beta agonists”.

2. Controller medicine use: specifically, controller medication taken in the past 3 months (Q14-16 in the Recall Questionnaire), and taking the controller medication regularly as instructed (Q11 in the Baseline Questionnaire Part 1; Q14-16 in the Recall Questionnaire). The primary measure will be taken from the Recall Questionnaire. The variable will be categorical with the number of controller medications the participant is

taking which is defined as taking 5/7 of the prescribed dosage, or taking a controller medicine at ½ the desired dosage (i.e. once per day as opposed to twice a day). Participants using or not using a maintenance medicine may differentially respond to improved air quality.

3. Whether or not the participant had a cold or the flu during the same two-week period (Q10 in the Recall Questionnaire for the recall period). Having cold or flu may trigger asthma symptoms.

4. Allergy, expressed as ever having a problem with sneezing, or a runny, or a blocked nose when he / she did not have a cold or the flu, or having been diagnosed by a physician as having hay fever or allergic rhinitis, or having an itchy rash that comes and goes for at least 6 months, or having ever diagnosed with eczema or atopic dermatitis (Q4-Q7 in the Baseline Questionnaire Part 1). These are time-invariant binary covariates for each participant. A variable for having allergy and a pet will also be created. Having allergies may result in differential response to the air cleaners, with a greater decrease in symptoms for allergic children.

Collected but not planned to be included in the statistical analysis:

5. BMI, collected every 6 months – Participants with a high BMI may have nutritional deficiencies that reduce their potential to respond to improvements in indoor air quality.

6. Asthma triggers, binary variables (Q9 in the Baseline Questionnaire Part 1). Participants with particular triggers may be more or less likely to respond to the intervention.

7. Taking Acetaminophen, a binary variable (Q12 in the Baseline Questionnaire Part 1; Q17 in the Recall Questionnaire). There might be differences in asthma symptoms between the participants taking and not taking Acetaminophen.

8. Having an asthma action plan, a binary variable (Q10 in the Baseline Questionnaire Part 1, Q21 in the Recall Questionnaire). There might be differences in asthma symptoms between the participants having and not having an asthma action plan.

II.D. Exposure-related Covariates

Some of the following covariates are thought to influence indoor levels while others are thought to influence health endpoints directly. We note that those covariates that influence indoor levels directly will also influence health endpoints; however, they are not included in models for health endpoints because I/O ratios are included in those models directly. The variables in the first list are planned to be included in the statistical analysis listed (either I/O $PM_{2.5}$ correlation analysis or primary health outcomes as effect mediators:

1. Corresponding outdoor levels of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone - one-week integrated outdoor concentration for each indoor measurement. This will influence indoor levels. (I/O $PM_{2.5}$)

2. Filtration utilization. For stand-alone air cleaners this is expressed as the volume of air going through the air cleaners divided by the value that would have gone through if they were run continuously at the recommended settings. This is calculated for the individual weeks when air sampling is conducted and for the 6-month periods between sampling events. For the central system this is expresses as the time the system ran divided by the recommended amount of time for the system to run. This is calculated for the individual weeks when air sampling is conducted and for the two 3-month periods proceeding each recall interview. More significant reductions in pollution levels are anticipated with greater filtration utilization. (Primary Health Outcomes, I/O $PM_{2.5}$)

3. Open door usage, expressed as the proportion of nights that the child's bedroom door is left open over a one-week period, (Q11 in the Symptom Dairy), which is relevant to both the one-week measurement period and also relevant to the three months prior to the diary. We assume the open door usage is consistent through the recall period, and we will match the period where appropriate. Theoretically, if a child closes the door, he/she may have more significant health improvements. (Primary Health Outcomes)

4. Open window usage, expressed as the proportion of days that windows are left open for more than two hours over a one-week period (Q16 in the Symptom Dairy), which is relevant to both the one-week measurement period and also relevant to the three months prior to the diary, as window use is assumed to be consistent over time. Smaller reductions in pollution levels are anticipated when doors and windows are left open as this increases the air exchange rate. (I/O $PM_{2.5}$ approaches unity)

5. Frying or sautéing, expressed as the number of days frying or sautéing on a stove was conducted (Q13 in the Symptom Diary) over a one-week period. Households with indoor cooking sources may have higher indoor/outdoor ratio of $PM_{2.5}$ and $PM_{0.2}$. (I/O $PM_{2.5, 0.2}$)

6. Having furry pets, four-level categorical variable: no pet, outdoor pets, pets in the house, pets in the house coupled with pet allergy (Q14 in the Baseline Questionnaire Part 1; Q32 and Q33 in the Recall Questionnaire). Furry pet dander may trigger asthma symptoms. (Primary Health Outcomes)

7. Distance to roadway (Q22 in Baseline Questionnaire Part 2), expressed as a binary variable with living within one block of busy road considered close to roadway. Traffic generated particles may be more likely trigger asthma symptoms. (Primary Health Outcomes)

8. Presence of gas stove/oven, expressed as the number of days per week using stove/oven for cooking for more than 1 hour (sum of Q9 and Q10 in Baseline Questionnaire Part 2) among the households having a gas cooking stove/range/oven (who answered "yes" to Q47 and Q48 in the Baseline Questionnaire, Part 1). Using gas stove/range/oven is likely associated with higher indoor levels of $PM_{2.5}$ and $PM_{0.2}$.

9. Mold and water damage in child's home, expressed as a binary variable indicating if there is either mold or water damage in child's home. This variable will be constructed to indicate if there has ever been mold or water damage in the child's home to date (Q15-Q17 in Baseline Questionnaire Part 2; Q44 in the Baseline Questionnaire, Part 1; Q27 to Q30 in the Recall Questionnaire). Mold and water damage may be related to elevated occurrence of asthma symptoms.

10. Indoor smoking, expressed as a proportion of number of days that anyone smoked in the home (Q12 in the Symptom Diary) over a two-week period. Households with indoor smoking sources may have higher indoor levels.

11. Wood burning or candle burning, expressed as the number of days having a fire, using a wood burning stove, or burning candles or incense in the home (Q14 in the Symptom Diary) over the one-week measurement period. Households with these sources may have higher indoor/outdoor ratio of $PM_{0.2}$ and $PM_{2.5}$. We may sum this variable with frying/sautéing.

Collected but not planned to be included in the statistical analysis:

12. Whether there is anyone who currently spends time with the participating child who smokes around him/her (Q13 in the Baseline Questionnaire Part 1; Q31 in the Recall Questionnaire), and the frequency they smoke (Q31a in the Recall Questionnaire). Places they smoke (Q13a in the Baseline Questionnaire Part 1) will be reported.

13. Frequency of using the fan over stove when cooking (Q11 in Baseline Questionnaire Part 2), categorical variable with responses: all the time/most of the time/about half the time/rarely/never. Using fan over stove while cooking is expected to reduce indoor/outdoor ratios of $PM_{2.5}$ and $PM_{0.2}$.

14. Frequency of using gas stove/oven, expressed as the number of days per week using stove/oven for cooking for more than 1 hour (sum of Q9 and Q10 in Baseline Questionnaire Part 2) among the households having a gas cooking stove/range/oven (who answered "yes" to Q47 and Q48 in the Baseline Questionnaire, Part 1). Using gas stove/range/oven is likely associated with higher indoor levels of $PM_{2.5}$ and $PM_{0.2}$.

15. Whether or not a household uses the stove or oven to heat home in the winter mornings (Q12-Q13 in Baseline Questionnaire Part 2). Households using stove or oven to heat home in the winter morning may have higher indoor/outdoor ratios of $PM_{2.5}$ and $PM_{0.2}$.

16. Spray cleaning products or spray air freshener, expressed as number of days using these products in the home (Q15 in the Symptom Diary). Households with these sources may have higher indoor/outdoor ratio of $PM_{0.2}$.

17. Living close to sources (Q23 in Baseline Questionnaire Part 2).

18. Wood smoke in the neighborhood due to wood burning (Q34 in the Recall Questionnaire). We will also check the incidences of wild fire during the study period on public website (http://www.fire.ca.gov/). These will be checked when outlier outdoor concentrations are observed.

19. Removing shoes when entering the home (Q20 in Baseline Questionnaire Part 2). Homes where participants remove shoes when entering may have lower I/O ratio of $PM_{2.5}$.

20. Having door mat at the front and back doors (Q39 and Q40 in the Baseline Questionnaire, Part 1). Houses with door mat at the front and back doors may have lower I/O ratio of $PM_{2.5}$.

21. Having problems with any listed pests (Q21 in Baseline Questionnaire Part 2). Droppings or body parts of cockroaches and other pests can trigger asthma.

22. Frequency that child sleeps in the room where he/she usually sleeps (Q23-24 in the Baseline Questionnaire, Part 1). If the participant does not sleep in their room, they will not benefit from the air cleaner in their room.

23. New paint and furniture in the room where child usually sleeps (Q25-26 in the Baseline Questionnaire, Part 1). Chemicals in new paint and new furniture may trigger asthma symptoms.

24. Brand and model of vacuum (Q33 and Q34 in the Baseline Questionnaire, Part 1).

25. Time spent indoors at home, expressed as the average hours per day on days recorded (Q17 in the Symptom Diary). Spending more time indoors may result in a greater improvement in symptoms as they have more exposure to filtered indoor air.

26. Time spent outdoors, expressed as the average hours per day on days recorded (Q18 in the Symptom Diary). Spending more time outdoors may have higher exposure to outdoor air pollution.

II.E. Housing Covariates

Planned to be included in the statistical analysis listed (either I/O $PM_{2.5}$ or primary health outcomes):

1. Age of home, collected as integers and converted to a binary variable differentiating homes built before and after 1977, (Q2 in the Baseline Questionnaire Part 2). Older homes may have greater air exchange rates and thus less significant reductions in pollution levels. (I/O $PM_{2.5}$)

2. Presence of air conditioning (Q31 in the Baseline Questionnaire, Part 1). Homes with central air-conditioning tend to have lower air exchange rates, and thus we anticipate

more significant reductions in pollution levels. Window units and swamp coolers will not be considered in this variable. (I/O $PM_{2.5}$)

3. Presence of a swamp cooler, (Q31a in the Baseline Questionnaire, Part 1). Homes that use swamp coolers have very high air exchange rates and thus we anticipate less significant reductions in pollution levels (primarily ozone) in homes with swamp coolers. (I/O $PM_{2.5}$)

Collected but not planned to be included in the statistical analysis:

4. Presence of gas dryer, gas water heater, or portable gas/kerosene heater (Q54 and Q56 in the Baseline Questionnaire, Part 1). Homes that use gas dryer, gas water heater, portable gas/kerosene heater may have higher indoor level of NO_2.

5. Ground cover (Q38 in the Baseline Questionnaire, Part 1) - This will help explain if any outlier of outdoor PM concentrations are observed.

6. Flooring in the house, expressed as having carpet or vinyl (Q45 in the Baseline Questionnaire, Part 1). Having carpet in the house may be related to elevated I/O ratio of $PM_{2.5}$, and having vinyl in the house may be related to elevated asthma symptoms.

Socioeconomic Variables
Planned to be included in the statistical analysis for the primary health outcomes

1. Highest education of the parent with higher level of education.

2. Household income, expressed as a categorical variable.

II.F. Summary Statistics

Summary statistics will be provided for all items collected in the Baseline Questionnaire, with the exception of information on mattress size which was collected solely for the purpose of determining what size mattress cover was needed. For categorical variables, the number of participants answering in each category will be provided. For most continuous variables in the questionnaire, such as age of home, categorical groupings will be provided. For time with windows open, the mean, standard deviation, and a series of percentile values will be presented. For many questions relating to home characteristics, response rates will be provided for Fresno and Riverside separately. For health related questions, response rate will be provided for the whole group, as well as for primary and secondary questions separately. For remaining question, response rates will be presented for the group as a whole.

For the recall and mini PAQLQ, summary statistics will be provided for the Baseline period, the True periods, and the Sham periods. Data will be presented for the whole group and separately for primary and secondary participating children. The mean, standard distribution and a series of percentile values will be presented for the continuous variables. Yes/no responses will be presented as the proportion of the population with each response.

Table 2 below summarizes how variables used as continuous outcomes or covariates will be presented in the report.

Table 2. List of how each variable will be presented in final report

	Variable description	Note
Environmental Measurements	Indoor levels of $PM_{2.5}$,PM_{10}, and $PM_{0.2}$, and ozone	a,x
	Outdoor levels of $PM_{2.5}$,PM_{10}, and $PM_{0.2}$, and ozone	a,x
	Indoor/outdoor ratio of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone	a,x
	Indoor/outdoor black carbon ratios	a,x
	Estimated personal exposure levels to $PM_{2.5}$ (from I & O data)	b,z
Health outcomes	Number of days with symptoms over two week period – recall	a,z
	Number of days that the participating children use their rescue inhaler/puffer during the day for relief of asthma symptoms during a two-week period – recall	a,z
	Number of puffs/inhalations in total did the participating child use during the two-week recall period– recall	a,z
	Days of missing school due to asthma– recall	a,z
	Days of missing work for parents due to child asthma	a,z
	Unplanned health care use and treatment over 1 year - presented separately for hospitalization, ER visit, clinic visit, and steroid treatments	a,z
	Number of times having cold over one year	b,z
	MiniPAQLQ score – all three outcomes presented separately	a,z
	Exhaled NO	a,z
	Spirometry measures: Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), FEV1/FVC, forced expiratory flow 25–75% (FEF 25–75),	a,z
Health covariates	Asthma Severity	c,y,
	Controller medicine use	a,z
Housing Covariates	Age of home	f,y
	Presence of air conditioning	c,y
	Use of a swamp cooler	c,y
	Mold and water damage	c,y
Exposure Covariates	Filtration utilization	b,x
	Window usage	a,y
	Door usage	c,y
	Indoor sources	c,z
	Smoking with children present	c,z
	Pets	c-e,z
	Time spent indoors at home	a
	Time spent outdoors	a

Note:

a) Each variable will be presented as:
   - Distribution of pre-intervention levels (mean, SD, min, max, percentiles)
   - Distribution of true levels (mean, SD, min, max, percentiles) (Distributions for PM concentrations and I/O ratios are shown for stand-alone air cleaner and central filtration respectively)
   - Distribution of sham levels (mean, SD, min, max, percentiles) (Distributions for PM concentrations and I/O ratios are shown for stand-alone air cleaner and central filtration respectively)

b) Each variable will be presented as:
   - Distribution of true levels (mean, SD, min, max, percentiles)
   - Distribution of sham levels (mean, SD, min, max, percentiles)

c) Presented as distribution of proportion of population with each score for each recall period

x) Each distribution will be presented for stand-alone and central filtration separately.

y) Each distribution will be presented for:
   - Whole cohort
   - By city

z) Distribution will be presented for whole cohort only

As noted above, summary statistics will be provided for all Baseline Questions. A sample of the questions included is listed below.

- Demographics
  - child's age (Screening Questionnaire)
  - child's gender (Screening Questionnaire)
  - child's grade in school (Q15 in the Baseline Questionnaire Part 1)
  - both child and caregiver's race (Q16 and 17 in the Baseline Questionnaire Part 1)
  - number of household members (Q18 in the Baseline Questionnaire Part 1)
  - caregivers' relation with the child (Q19 in the Baseline Questionnaire Part 1)
  - the relation with the child of the individual responding to the baseline questionnaire (Q1 in the Baseline Questionnaire Part 1)
  - education and employment of caregivers (Q19a and Q19b in the Baseline Questionnaire Part 1)
  - marriage status of caregivers (Q19c in the Baseline Questionnaire Part 1)
  - household income (Q21 in the Baseline Questionnaire Part 1)
  - health insurance coverage for child (Q22 in the Baseline Questionnaire Part 1)

- Home Characteristics
  - house type (Q37 in the Baseline Questionnaire, Part 1)
  - whether the house is rented or owned (Q1 in Baseline Questionnaire Part 2)
  - house age (Q2 in Baseline Questionnaire Part 2)
  - house size (square footage) (Q3 in Baseline Questionnaire Part 2)
  - how long the participant has lived in the current home (Q4 in Baseline Questionnaire Part 2)
  - location (basement/ground floor/2nd floor or higher) of Child's bedroom, main living area, kitchen area, and bathrooms (Q43 in the Baseline Questionnaire, Part 1)
  - type of heating system (Q27-29 in the Baseline Questionnaire, Part 1)

- presence of air conditioning (Q31 in the Baseline Questionnaire, Part 1)
- window use (Q5-Q8 in Baseline Questionnaire Part 2)
- cooking habits (Q9-Q14 in Baseline Questionnaire Part 2)
- mold and water damage (Q15-Q17 in Baseline Questionnaire Part 2)
- fragrance and candle use (Q18 in Baseline Questionnaire Part 2)

➢ Health History
- age diagnosed with asthma (Q2 in Baseline Questionnaire Part 1)
- ever been hospitalized because of asthma (Q3 in Baseline Questionnaire Part 1)

II.G. Other Questions

We ask if there are any unusual or specific events that influence the child's asthma (Q35 in the Recall Questionnaire). In some cases, the parent may report an event that is so extreme it justifies exclusion of the participant from the analysis. Reported events will be reviewed on a case-by-case basis by Drs. Bennett, Tancredi, Schenker, and Kenyon. The participants excluded from analysis will be reported in the final report, along with the description of the event that resulted in the participant being excluded.

At the end of the recall questionnaire, we engage the participant in conversation regarding any problems they may be having with the stand-alone air cleaner or central filtration system (Q36 in the Recall Questionnaire). This question is used to determine if any actions are needed during the study to correct the stated problem. If the information results in a result that investigators think may impact results of filtration, for example, a bad smell or a report that they did not use the air cleaner for a period of time, this information will be transferred to a "notes" variable in the air cleaner or central filtration dataset. Recall that objective information on air cleaner use is recorded directly in the computer on the stand-alone unit and is also recorded for the use of the central filtration system in the smart thermostat.

III. Specific Plan for Each Objective

III.A. Objective 1: Determine the extent to which the use of a) high efficiency central filtration, and b) high efficiency portable air cleaners reduce indoor concentrations and resulting exposure of PM0.2, PM2.5, and PM10, and the extent to which they reduce indoor concentrations of ozone.

We first conduct a correlation analysis to see which variables are correlated with concentrations. The correlated variables are then included as covariates in the standardized model.

III.A.1 Correlation Analysis

The correlation between both the I/O ratio and indoor concentration of $PM_{2.5}$ and a suite of variables that may potentially be related to *changes in filtration effectiveness* will be conducted, either using Spearman correlation analysis (for continuous or interval variables) or ANOVA (for categorical variables). For some variables, the relationship with the I/O ratio of $PM_{0.2}$ will also

be examined as specified. For those questions asked in the baseline questionnaire, correlation analysis will be conducted for *true and sham* environmental measures separately. For those questions asked at each recall period, separate correlation analysis will be conducted for periods with and without air filtration respectively.

We list the variables to be included in this analysis, along with whether or not they are time-varying or time-invariant, and whether or not they are continuous or categorical, below:

- Outdoor level of $PM_{2.5}$, time-varying continuous covariate with a unique value for each measurement period.
- Filtration utilization, a time-varying continuous covariate with a unique value for each measurement period.
- Open window usage, a time-varying continuous covariate with a unique value for each measurement period.
- Frequency of frying or sautéing, a time-varying continuous covariate with a unique value for each measurement period. This variable will also be correlated with the I/O ratio of $PM_{0.2}$.
- Wood burning or candle burning, a time-varying continuous covariate with a unique value for each measurement period. This variable will also be correlated with the I/O ratio of $PM_{0.2}$.
- Presence of a gas stove/oven, a time-invariant continuous covariate for each household. This variable will also be correlated with the I/O ratio of $PM_{0.2}$.
- Distance to roadway, a time-invariant binary covariate for each household, with be correlated with indoor $PM_{0.2}$ and $PM_{2.5}$ concentrations as opposed to the I/O ratios.
- Age of home, a time-invariant binary covariate for each household.
- Presence of air conditioning, a time-invariant binary covariate for each household.
- Presence of a swamp cooler, a time-invariant binary covariate for each household.

We will also run correlations of indoor concentrations as well as I/O ratios among pollutants, i.e., I/O ratio of PM2.5 vs. I/O ratio of PM10. Each outdoor concentration ($PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone) will be also be correlated with the corresponding indoor concentration.

III.A.2. Primary Analysis of Filtration Impacts and of Modifiers of Filtration Effects

The primary analysis will compare the values of the outcome variables between the periods having true filtration and not having filtration. In cases where we have values for the primary outcome at multiple time points with and without true filtration, all measured values are included in the model.

Outcome

- Indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone (primary outcome)
- Indoor concentrations of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone (secondary outcome)

Comparison of interest

- With and without true filtration
- Type of filtration: central filtration vs. stand alone air cleaner

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter
- City: Fresno vs. Riverside
- Household ID (random effect)

Potential modifiers (to understand the factors associated with heterogeneity of the treatment effect). The correlation matrix mentioned above will be used to select among candidate effect modifiers. Only those variables with statistical significant association (unless otherwise specified) will be considered in further analysis.

Statistical analysis

The primary analysis will be to compare the indoor levels using generalized linear mixed-effects regression models. For the t^{th} measurement on the i^{th} individual, $Y_{i,t}$ is the outcome,

$$E(Y_{i,t}) = \mu_{i,t}$$

$z_{i,t}$ is the matrix of covariates, where $Riverside_i$ is the reference level for the city variable and $Spring_{i,t}$ is the reference level for the season variable.

$$z_{i,t} = \begin{bmatrix} outdoor\ level_{i,t} \\ Fresno_i \\ summer_{i,t} \\ fall_{i,t} \\ winter_{i,t} \end{bmatrix}$$

$g(\mu)$ is a link function that depends on the outcome:

$g(\mu) = \mu$ for normal-distributed variables;

$g(\mu) = \log \mu$ for count or log-normal distributed variables;

$g(\mu) = \log ODDS = \frac{\mu}{1-\mu}$ for binary or proportion data in [0.1] range

The core model is

$$g(\mu_{i,t}|\gamma_i) = \beta_0 + z'_{i,t}\bar{\beta}_{covariates} + \beta_{true,SA} \times True_{i,t} + \beta_{HVAC} \times HVAC_i + \beta_{true,HVAC} \times True_{i,t} \times HVAC_i + \gamma_i \qquad \gamma_i \sim N(0, \sigma_N^2)$$

$True_{i,t}$ is a time-varying binary indicator for with (1) vs. without (0) true filtration,
$HVAC_i$ is a time-nonvarying binary indicator for whether the individual has been assigned to the HVAC (1) or the Stand-alone (0) filtration system study arm,
$\beta_{true,SA}$ explains the effect of filtration for stand-alone air cleaner; (as the adjusted mean within-house TRUE vs, SHAM difference);
$\beta_{true,SA} + \beta_{true,HVAC}$ explains effect of central filtration; (similarly)
$\beta_{true,HVAC}$ explains the difference between the effects of central filtration and Stand-alone filtration.

The goal is to be able to be able to see the differences with or without filtration and determine if there are differences between the systems.

When incorporating the actual use time of the filtration into the model, the $True_{i,t}$ term needs to be replaced by $True_{i,t} \times ActUse_{i,t}$.

Separate regression models will be specified for each outcome (indoor/outdoor ratios of $PM_{2.5}$, PM_{10}, and $PM_{0.2}$, and ozone). We will statistically adjust for the three listed independent variables (season, city, and household ID), and potentially outdoor concentration.

III.A.3. Assessment of Effect Modification (Heterogeneity of Treatment Effects)

To assess whether intervention effects are modified by candidate effect modifiers, a series of models based on the core model will be fitted, one effect modifier at a time. For each candidate effect modifier, interaction terms will be added to allow estimated intervention effects to vary according to the value of the candidate effect modifier. Nested likelihood ratio tests will be used to assess whether the model with effect modification provides statistically significant improvements in model fit, compared to the core model. For these tests, maximum likelihood estimation will be used for both the core model and the model enhanced with the additional interaction terms; the test statistic is -2 times the difference in model log-likelihoods, which is referred to a Chi-square distribution with degrees of freedom equal to the number of additional parameters estimated in the enhanced model to assess statistical significance ($p < 0.05$). To illustrate how the interaction terms would be specified, consider the candidate effect modifier NewHome, a binary indicator for whether a house was built after 1977:

$$\begin{gathered}\beta_{NH} \times NewHome_i \\ +\beta_{NH,true} \times True_{i,t} \times NewHome_i \\ +\beta_{NH,HVAC} \times HVAC_i \times NewHome_i \\ +\beta_{NH,HVAC,true} \times True_{i,t} \times HVAC_i \times NewHome_i\end{gathered}$$

The interpretation of these terms is
$\beta_{NH,true}$ explains whether new home modifies filtration effect for stand-alone filtration;
$\beta_{NH,true} + \beta_{NH,HVAC,true}$ explains whether new home modifies filtration effect for central filtration;
$\beta_{NH,HVAC,true}$ explains whether new home modifies central filtration/stand-alone and filtration effects.

Some variables are time-varying collected at each measurement point of the outcome variable, while some variables are time-invariant collected only at the beginning of the study and remain the same throughout the study (unless a household moves). In addition, some variables, such as, filtration utilization, windows/door usage, and indoor sources, will be initially included as continuous variables and may be converted to bivariate variables to facilitate the interpretation of results.

The heterogeneity of treatment effects analysis will be considered exploratory and hypothesis generating. For reporting purposes, we will enumerate the set of candidate effect modifiers that

were evaluated. Point and interval estimates will only be reported for the subset of candidate effect modifiers that resulted in statistically significant improvements in model fit.

III.A.4. Analysis for Black Carbon

We will compare the distribution of indoor/outdoor black carbon ratios obtained with and without true filtration to determine if there is a statistically significant difference between the distributions.

Outcome

- Indoor/outdoor reflectance ratios

Comparison of interest

- With and without true filtration

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter
- City: Fresno vs. Riverside
- Household ID (random effect)

Exploratory analysis considering the following potential modifiers (aim to understand the factors associated with heterogeneity of the treatment effect)

- Proximity to roadway
- Filtration utilization (as discussed before)
- Windows usage (as discussed before)

Statistical analysis plan

Similar to the primary analysis, we will also use generalized linear mixed-effects regression models for this analysis. We will statistically adjust for the three listed independent variables (season, city, and household ID). In a separate analysis, for each candidate effect modifier interactions with true/sham filtration will be included in a model. Some variables are time-varying collected at each measurement point of the outcome variable, while some variables are time-invariant collected only at the beginning of the study and remain the same throughout the study (unless a household moves). In addition, some variables, such as, filtration utilization, and windows usage, will be initially included as continuous variables and may be converted to categorical variables to facilitate the interpretation of results.

III.A.5. Comparison of Pre-Installation to Post-Installation Period

Data from the pre-installation period will be used to minimize observational measurement biases. Awareness bias may occur during the sham period, so that participants may change their behaviors, e.g., cooking less, which may result in changes in indoor levels of pollutants. Therefore, the pre-installation measurements were considered the baseline level. Regression models with similar specifications as described above will be used to perform statistical comparisons between the air quality measures collected during the enrollment period (prior to

installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods.

Outcome

- Indoor/outdoor ratio of $PM_{0.2-2.5}$ and $PM_{2.5-10}$
- Indoor concentrations of $PM_{0.2-2.5}$ and $PM_{2.5-10}$

Comparison of interest

- "pre-installation" vs. "with filtration" measurements: a binary variable
- "pre-installation" vs. "without filtration" measurements: a binary variable

Independent variables included in the model to account for study design

- Season, four-level categorical variable. Season will be adjusted, as pre-installation air quality will be only measured once in one season.
- City, two-level categorical variable
- Household ID variable (random effect)

Statistical analysis

Regression models with similar specifications as described above will be used to perform statistical comparisons between the concentration measurements collected during the enrollment period (prior to installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods. Season will be adjusted, as pre-installation information will be only collected in one season. Statistically adjusted mean differences between the "sham filtration" and "pre-installation" measurements will be used to characterize the net impact of participation on the study. Statistically adjusted mean differences between the "real filtration" and "pre-installation" measurements will be reported as exploratory findings representing the net impact of real versus sham filtration and participation in the study. We note some differences may arise between "pre-installation" and sham that are unrelated to participation. The differences calculated here can be compared to differences calculated between true and sham. No effect modification will be considered.

***III.B. Objective 2*: Determine the extent to which the use of a) high efficiency filtration in central filtration systems and b) high efficiency portable air cleaners reduces asthma symptoms, emergency room (ER) visits, hospitalizations, use of rescue inhalers, missed school days due to asthma, and other measures of asthma reduction in children with moderate to severe asthma.**

III.B.1. Primary Analysis of Real versus Sham Filtration Impacts and of Modifiers of Filtration Effects

Primary health outcome

From the two-week Recall Questionnaire, we determine the maximum number of days with symptoms, defined as the largest value among the following three variables: number of days with wheezing, tightness in the chest, or cough because of asthma; number of days that the child had

to slow down or stop his/her play or activities because of asthma, wheezing or tightness in the chest, or cough; or number of nights that the child woke up because of asthma, wheezing or tightness in the chest, or cough, during the two-week recall period.

Secondary health outcome

- Number of days that the participating children use their rescue inhaler during the day for relief of asthma symptoms during a two-week period as reported in the recall questionnaire – a time-varying continuous covariate.
- Days of missing school due to asthma as reported in the recall questionnaire– a time-varying continuous covariate.
- Days of missing work for parents due to child asthma. Only those who answered "yes" to working will be included in this analysis – a time-varying continuous covariate
- Health care use and treatment: the total number of utilizations of a given type of healthcare or treatment due to asthma over the one-year true/sham filtration period – a time-varying continuous covariate
    - overnight hospitalization
    - emergency room visit
    - clinic visit
    - receiving steroids treatment

- MiniPAQLQ score with three outcomes: symptoms, emotional function, and activity limitation –time-varying continuous covariates
- Exhaled NO – a time-varying continuous covariate
- Spirometry parameters: Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), and FEV1/FVC, time-varying continuous covariates.

Primary comparison of interest

- True versus sham filtration (binary variable)

Secondary comparison of interest

- Type of filtration: central filtration vs. stand alone air cleaner

Independent variables included in the model to account for study design

- Season: spring vs. summer vs. fall vs. winter
- City: Fresno vs. Riverside
- Household ID (random effect)

Exploratory analysis considering potential modifiers (aim to understand the factors associated with heterogeneity of the treatment effect) will be conducted only on the primary outcomes. Only those effect modifiers that are found to be significant in the primary analysis will be included in models for the secondary health outcomes. Methods for assessing effect modification are detailed above for Objective 1.

The three particulate matter size fractions will be evaluated as mediators (used to understand mechanism of action) of the intervention effects on the primary health outcomes, using statistical mediation analysis techniques as described by Mackinnon and Schluchter [2,3]. Only the size

fraction with the quantitatively largest mediated effect for the primary health outcome will be evaluated in mediation models involving secondary health outcomes.

Proposed mediators

- Indoor PM levels for $PM_{0.2}$, $PM_{2.5}$ and PM_{10}– a time-varying continuous covariate – there are two options: 1) the average of the two measurement periods within the true/sham period will be applied to the health outcomes collected at all time points during the true/sham period, or 2) the individual values for air pollution will be applied to the two measurement periods in the past six months.

Candidate Effect Modifiers

- Filtration utilization, a time-varying continuous covariate
- Asthma severity, a time-invariant categorical covariate for each participant.
- Controller medicine use, a time-varying categorical covariate
- Having a cold or the flu during the two-week recall period: For analyzing the Recall Questionnaire, we would only consider whether or not they've had a cold based on questions in the Recall Questionnaire. For exhaled nitric oxide, we will use the recall or the symptom diary information depending on the date of the measurement.
- Ever having allergies, a time-invariant binary covariate for each participant.
- Open doors usage, a time-varying continuous covariate with a unique value for each measurement period.
- Mold and water damage, a time-varying binary covariate with a unique value for each measurement period
- Having furry pets, a three-level time-varying categorical variable
- Presence of a gas stove, a time-invariant binary covariate for each household.
- Highest education of the parents, a time-invariant categorical covariate
- Household income, a time-invariant categorical covariate

Statistical analysis

All analysis will be done using the generalized linear mixed-effects regression models. Separate regression models will be specified for the health outcomes listed above. We will also perform a series of "effect modification analyses" to assess whether and by how much the impacts of filtration are modified by measured household and user characteristics. In addition, the difference of the primary health outcome, number of days with symptoms, between the true and sham filtration period will be calculated.

III.B.2. Comparison of Pre-Installation to Post-Installation Period

Pre-installation period is a period with least influence from the study. Awareness bias may occur during the sham period, so that participants may change their behaviors, e.g., use of medications, and thus symptoms. Therefore, the pre-installation measurements were most close to participants' current condition and were considered the baseline level.

Primary health outcome

- The number of days with symptoms over two week period obtained from the recall questionnaire.

Secondary health outcome

- Number of days that the participating children use their rescue inhaler/puffer during the day for relief of asthma symptoms during a two-week period.
- MiniPAQLQ score with three outcomes: symptoms, emotional function, and activity limitation –time-varying continuous covariates
- Exhaled NO – a time-varying continuous covariate
- Spirometry parameters: Forced vital capacity (FVC), Forced expiratory volume at 1.0 second (FEV1), and FEV1/FVC.

Primary comparison of interest

- "pre-installation" vs. "with filtration" measurements: a binary variable
- "pre-installation" vs. "without filtration" measurements: a binary variable

Independent variables included in the model to account for study design

- Season, four-level categorical variable.
- City, two-level categorical variable
- Household ID variable (random effect)

Statistical analysis

Regression models with similar specifications as described above will be used to perform statistical comparisons between the asthma symptom measures collected during the enrollment period (prior to installation of the filtration system) and the seasonally matched measurements from the true and sham filtration periods. Season will be adjusted, as pre-installation information will be only collected in one season. Statistically adjusted mean differences between the "sham filtration" and "pre-installation" measurements will be used to characterize the net impact of participation on the study. Statistically adjusted mean differences between the "real filtration" and "pre-installation" measurements will be reported as exploratory findings representing the net impact of real versus sham filtration and participation in the study.

III.C. Objective 3- Measure indoor and outdoor concentrations for children with asthma to PM0.2, PM2.5, PM10, and ozone, and resulting personal exposures.

Primary analysis of distribution of indoor and outdoor concentrations for children with asthma to PM0.2, PM2.5, PM10, and ozone

This objective is met by presenting summary statistics for the outcomes listed.

Modeled Personal Exposures

We will construct a basic personal model. Personal exposure results from the concentration in typical microenvironments and the typical time spent in that microenvironment. The personal

model will allow us to estimate children's personal exposures to $PM_{0.2}$, $PM_{2.5}$, and PM_{10}. This model will be applied to all participants' indoor concentrations. This can be expressed by the following equation:

$$Personal\ Exposure = C_1t_1 + C_2t_2 + C_3t_3 + ...C_nt_n$$

where C_i is the concentration in a given microenvironment and t_i is the time spent in that microenvironment. The subscript i refers to the specific microenvironment, with n being the number of microenvironments the individual was in over the course of the day.
We will use a typical distribution of the number of hours indoors at home and outdoors along with the typical number of hours indoors at school, and in transit for each age group, making adjustments as appropriate to create 24-hour days. We will use measured indoor and outdoor $PM_{0.2,}$ $PM_{2.5,}$ and PM_{10} levels for each participant, and look for representative values of $PM_{0.2,}$ $PM_{2.5,}$ and PM_{10} levels in schools and in transit from the literature, to determine the range of personal exposure. For each participant, we will calculate the estimated decrease in personal PM concentrations due to high-efficiency filtration.

We will compare exposures anticipated with and without indoor filtered air.

References

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2. Introduction to statistical mediation analysis. Mackinnon DP. Lawrence Erlbaum and Associates. 2008

3. "Flexible Approaches to Computing Mediated Effects in Generalized Linear Models: Generalized Estimating Equations and Bootstrapping". Multivariate Behavioral Research, 43(2) 268-288, 2008.

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Appendix F.2 Air Pollution Outcome Analyses

1. Indoor $PM_{0.2}$ concentrations
2. Indoor $PM_{2.5}$ concentrations
3. Indoor PM_{10} concentrations
4. Indoor $PM_{0.2-2.5}$ concentrations
5. Indoor $PM_{2.5-10}$ concentrations
6. $PM_{0.2}$ indoor/outdoor (I/O) ratios
7. $PM_{2.5}$ indoor/outdoor ratios
8. PM_{10} indoor/outdoor ratios
9. Outdoor $PM_{0.2-2.5}$ concentrations
10. Outdoor $PM_{2.5-10}$ concentrations
11. Reflectance indoor/outdoor ratios
12. Indoor ozone concentrations
13. Ozone indoor/outdoor ratios

Below is a description of the terms in two of the table types presented throughout this appendix that are not self-explanatory.

Tables with Parameter Estimates:

Contain regression coefficients and associated statistics

Effect – Parameters in the model, include Intercept and predictor variables

Estimate – regression coefficient (β coefficient); the change in outcome (Y, dependent variable) for 1-unit change in the predictor (X, independent variable), given all other predictor variables are held constant.

SE – Standard Error of the β coefficient

DF – Degrees of Freedom spend on each of the parameters

t Value, Chi-Square – test statistic for t-distribution, Chi-Square distribution

Pr >|t|, Pr > ChiSq – p-value corresponding to test statistic

Lower, Upper – 95% Confidence Interval for the estimated β coefficient

Tables with Type III Tests of Fixed Effects:

Contain hypothesis tests for the significance of each of the fixed effects specified in the model

Effect – Parameters in the model

Num DF – Degrees of freedom of the model (numerator as related to the F-statistic)

Den DF – Degrees of freedom of the error (denominator as related to the F-statistic)

F Value – test statistic for F distribution, F-statistic

Pr > F – p-value corresponding to F-statistic

1. Indoor $PM_{0.2}$ concentrations

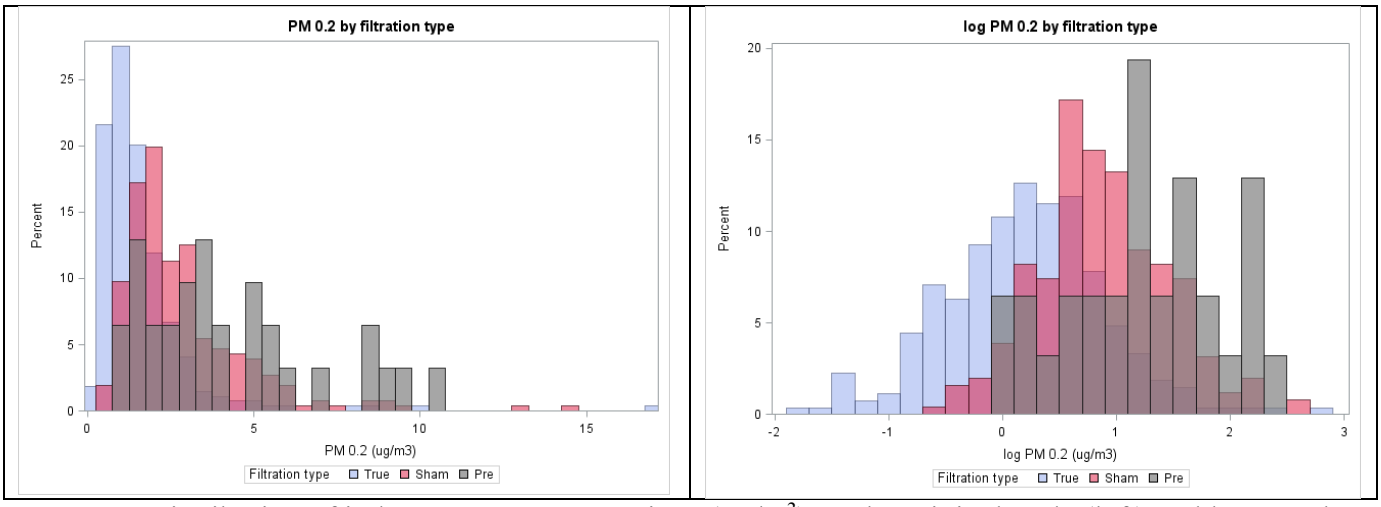


Figure 1.1: Distribution of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 1.1: Descriptive statistics for indoor $PM_{0.2}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Indoor PM 0.2 concentrations																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	42	1.2	0.52	1.2	0.7	1.5	48	0.2	0.64	0.2	-0.1	0.6	8	1.9	0.32	1.9	1.6	2.2
	Spring	37	0.6	0.49	0.6	0.3	0.9	37	0.2	0.76	0.2	-0.2	0.7	1	1.2	.	1.2	1.2	1.2
	Summer	33	0.7	0.57	0.7	0.4	1	41	0.1	0.74	0.1	-0.3	0.5	1	1.9	.	1.9	1.9	1.9
	Fall	30	1	0.57	0.9	0.6	1.4	41	0.6	0.87	0.6	0	1.1	5	0.9	0.46	1.1	0.7	1.3
Riverside	Winter	24	0.8	0.51	0.9	0.5	1.1	24	0.1	0.62	0.1	-0.5	0.6	1	1.8	.	1.8	1.8	1.8
	Spring	26	0.7	0.56	0.6	0.4	0.9	29	0.1	0.67	-0.1	-0.5	0.5	0	.	.	.	.	.
	Summer	21	0.8	0.59	0.8	0.6	1.1	22	0.3	0.4	0.3	-0.1	0.6	0	.	.	.	.	.
	Fall	16	0.8	0.42	0.7	0.5	1.1	27	0	0.48	0.1	-0.4	0.4	15	0.9	0.63	0.9	0.3	1.3

Stratified by city and season, the mean indoor $PM_{0.2}$ concentrations were higher during the pre-installation period compared with the sham and true filtration periods. Indoor $PM_{0.2}$ concentrations were higher during sham compared with the true filtration period (Table 1.1).

Table 1.2: Parameter estimates for log-normal mixed-effects model examining whether levels of indoor $PM_{0.2}$ differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				1.0509	0.1459	156	7.2	<.0001	0.7627	1.339
true			Sham	-0.4049	0.1216	366	-3.33	0.001	-0.644	-0.1657
true			True	-1.0538	0.1257	366	-8.39	<.0001	-1.301	-0.8067
true			Pre	0	.	.	.	.	.	.
season		Fall		0.1533	0.0673	366	2.28	0.0233	0.021	0.2857
season		Summer		0.03857	0.09384	366	0.41	0.6813	-0.146	0.2231
season		Winter		0.1969	0.07955	366	2.48	0.0137	0.04052	0.3534
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.1836	0.07438	366	2.47	0.014	0.03737	0.3299
area	Riverside			0	.	.	.	.	.	.

Table 1.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	366	97.67	<.0001
season	3	366	4.52	0.0040
area	1	366	6.1	0.0140

Table 1.4: Contrasts in log geometric mean $PM_{0.2}$ concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.4049	0.1216	366	3.33	0.0010	0.1657	0.6404
pre vs true	1.0538	0.1257	366	8.39	<.0001	0.8067	1.3010
sham vs true	0.6490	0.04964	366	13.07	<.0001	0.5514	0.7466

Table 1.5: Log Geometric Means (GM) of $PM_{0.2}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	0.8351	0.7524	0.9177	2.3050	2.1221	2.5035
True	0.1861	0.0905	0.2817	1.2045	1.0947	1.3254
Pre	1.2399	1.0044	1.4754	3.4553	2.7303	4.3728

Indoor Air Main Effects Model: The indoor $PM_{0.2}$ concentrations (log-transformed) were significantly higher in sham than in true filtration (0.65 [0.55, 0.75], p<0.0001) (Table 1.4). $PM_{0.2}$ levels were significantly higher at pre-installation than in sham and in true filtration (pre vs. sham: β=0.40 [95% CI: 0.17, 0.64], p=0.001; pre vs. true: 1.05 [0.81, 1.30], p<0.0001). The geometric means (GM) of indoor $PM_{0.2}$ concentrations at pre-installation, in sham, and in true filtration were 3.46 $\mu g/m^3$ [2.73, 4.37], 2.31 $\mu g/m^3$ [2.12, 2.50], and 1.20 $\mu g/m^3$ [1.09, 1.33], respectively (Table 1.5).

Table 1.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{0.2}$ concentrations, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	338	105.65	<.0001
hvac_ac	1	338	0.21	0.6443
true*hvac_ac	1	338	7.7	0.0058
season	3	338	5.16	0.0017
area	1	338	3.61	0.0583

Table 1.7: Contrasts in log geometric mean $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.7285	0.05695	338	12.79	<.0001	0.6164	0.8405
Central: Sham vs True	0.4185	0.09602	338	4.36	<.0001	0.2296	0.6074
Air Cleaner vs. Central diff in Sham vs. True diffs	0.3099	0.1117	338	2.78	0.0058	0.09025	0.5296

Table 1.8: Log Geometric Means (GM) of $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	0.8824	0.7812	0.9836	2.4167	2.1841	2.6741
Sham	Central	0.7623	0.6443	0.8804	2.1432	1.9047	2.4119
True	Air cleaner	0.1540	0.0437	0.2642	1.1665	1.0447	1.3024
True	Central	0.3438	0.1664	0.5213	1.4103	1.1810	1.6842

Sham vs. True Filtration Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between $PM_{0.2}$ concentrations and filtration status (p=0.01) (Tables 1.6-1.8), indicating that the differences in indoor $PM_{0.2}$ concentrations between sham and true filtration varied depending on the type of filtration system in the home. In homes with air cleaners, indoor $PM_{0.2}$ concentrations were 2.07 times higher in sham than in true filtration (β=0.73 [95% CI: 0.62, 0.84], p<0.0001); while in homes with central filtration, $PM_{0.2}$ concentrations were 1.52 times higher in sham (0.42 [0.23, 0.61], p<0.0001) (Table 1.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.31 [0.09, 0.53], p=0.01), showing that improvements in air quality with true filtration were 36% greater in homes with air cleaners than in homes with central filtration systems.

In homes with air cleaners, the GMs of $PM_{0.2}$ concentrations in sham and true filtration were 2.42 $\mu g/m^3$ [95% CI: 2.18, 2.67] and 1.17 $\mu g/m^3$ [1.04, 1.30], respectively (Table 1.8). In homes with central filtration, the GMs of indoor $PM_{0.2}$ concentrations in sham and true filtration were 2.14 $\mu g/m^3$ [1.90, 2.41] and 1.41 $\mu g/m^3$ [1.18, 1.68], respectively.

2. Indoor $PM_{2.5}$ concentrations

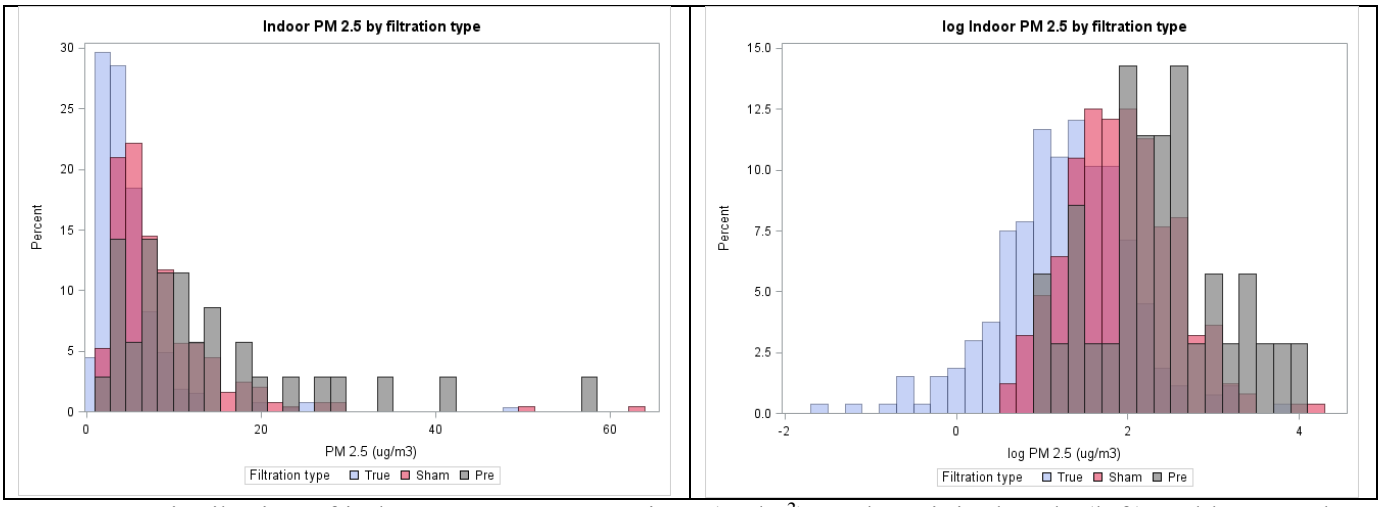


Figure 2.1: Distribution of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 2.1: Descriptive statistics for indoor $PM_{2.5}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Indoor PM 2.5 concentrations																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	41	2.3	0.60	2.5	1.9	2.8	47	1.4	0.71	1.4	0.9	1.9	9	3	0.49	3	2.6	3.4
	Spring	37	1.6	0.60	1.5	1.1	1.9	36	1.2	0.70	1.2	0.8	1.8	1	2.7	.	2.7	2.7	2.7
	Summer	33	1.6	0.54	1.7	1.4	1.9	41	1.1	0.67	1.1	0.7	1.6	4	2.7	1.04	2.4	1.9	3.4
	Fall	28	2.0	0.73	1.9	1.6	2.4	40	1.4	1.10	1.6	0.8	1.9	5	2	0.59	2.1	1.6	2.3
Riverside	Winter	23	1.9	0.50	2.0	1.4	2.3	24	1.2	0.66	1.2	0.8	1.7	1	2.9	.	2.9	2.9	2.9
	Spring	25	1.8	0.54	1.7	1.5	2.1	29	1.1	0.67	1.3	0.8	1.6	0	.	.	.	.	.
	Summer	22	1.9	0.49	1.9	1.7	2.3	23	1.4	0.42	1.4	1.2	1.8	0	.	.	.	.	.
	Fall	14	1.9	0.39	1.9	1.6	2.1	26	1.0	0.68	1.0	0.6	1.4	15	1.9	0.6	2	1.4	2.3

Stratified by city and season, the mean indoor $PM_{2.5}$ concentrations were higher during the pre-installation period compared with the sham and true filtration periods; indoor $PM_{2.5}$ concentrations were also higher during sham compared with the true filtration period (Table 2.1).

Table 2.2: Log-normal mixed-effects model examining whether levels of indoor $PM_{2.5}$ differ at pre-installation vs. post-installation (sham, true)

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				2.1983	0.151	156	14.56	<.0001	1.9	2.4966
true			Sham	-0.4878	0.1322	361	-3.69	0.0003	-0.7479	-0.2277
true			True	-1.1404	0.1348	361	-8.46	<.0001	-1.4055	-0.8753
true			Pre	0	.	.	.	.	.	.
season		Fall		0.1144	0.06851	361	1.67	0.0959	-0.02037	0.2491
season		Summer		0.06927	0.09222	361	0.75	0.4531	-0.1121	0.2506
season		Winter		0.3039	0.08441	361	3.6	0.0004	0.1379	0.4699
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.1214	0.08292	361	1.46	0.1439	-0.04162	0.2845
area	Riverside			0	.	.	.	.	.	.

Table 2.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	361	99.09	<.0001
season	3	361	6.79	0.0002
area	1	361	2.15	0.1439

Table 2.4: Contrasts in log geometric mean $PM_{2.5}$ concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.4878	0.1322	361	3.69	0.0003	0.2277	0.7479
pre vs true	1.1404	0.1348	361	8.46	<.0001	0.8753	1.4055
sham vs true	0.6526	0.05044	361	12.94	<.0001	0.5534	0.7518

Table 2.5: Log Geometric Means (GM) of $PM_{2.5}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	1.8931	1.8057	1.9805	6.6399	6.0842	7.2464
True	1.2405	1.1357	1.3454	3.4573	3.1134	3.8397
Pre	2.3809	2.1313	2.6305	10.8146	8.4258	13.8807

Indoor Air Main Effects Model: The indoor $PM_{2.5}$ concentrations (log-transformed) were significantly higher in sham than in true filtration (0.65 [0.55, 0.75], p<0.0001) (Table 2.4). $PM_{2.5}$ levels were significantly higher at pre-installation than in sham and in true filtration (pre vs. sham: β=0.49 [95% CI: 0.23, 0.75], p=0.0003; pre vs. true: 1.14 [0.88, 1.41], p<0.0001). The geometric means (GM) of indoor $PM_{2.5}$ concentrations at pre-installation, in sham, and in true filtration were 10.81 $\mu g/m^3$ [95% CI: 8.43, 13.88], 6.64 $\mu g/m^3$ [6.08, 7.25], and 3.46 $\mu g/m^3$ [3.11, 3.84], respectively (Table 2.5).

Table 2.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{2.5}$ concentrations, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	329	94.25	<.0001
hvac_ac	1	329	0.04	0.8417
true*hvac_ac	1	329	4.11	0.0434
season	3	329	7.77	<.0001
area	1	329	0.83	0.3635

Table 2.7: Contrasts in log geometric mean $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.7203	0.05732	329	12.57	<.0001	0.6075	0.833
Central: Sham vs True	0.4663	0.1097	329	4.25	<.0001	0.2505	0.6821
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2540	0.1253	329	2.03	0.0434	0.007551	0.5005

Table 2.8: Log Geometric Means (GM) of $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	1.9408	1.8359	2.0456	6.9643	6.2708	7.7338
Sham	Central	1.8325	1.6861	1.9790	6.2495	5.3984	7.2355
True	Air cleaner	1.2205	1.1017	1.3392	3.3889	3.0093	3.8160
True	Central	1.3663	1.1403	1.5923	3.9208	3.1277	4.9150

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between $PM_{2.5}$ concentrations and filtration status (p=0.04) (Tables 2.6-2.8), indicating that the differences in indoor $PM_{2.5}$ concentrations between sham and true filtration varied depending on the type of filtration system in the home. In homes with air cleaners, indoor $PM_{2.5}$ concentrations were 2.06 times higher in sham than in true filtration (β=0.72 [95% CI: 0.61, 0.83], p<0.0001); while in homes with central filtration, $PM_{2.5}$ concentrations were 1.59 times higher in sham (0.47 [0.25, 0.68], p<0.0001) (Table 2.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.25 [0.01, 0.50], p=0.04), showing that the improvements in air quality with true filtration were 29% greater in homes with air cleaners than in homes with central filtration systems.

In homes with air cleaners, the GMs of $PM_{2.5}$ concentrations in sham and true filtration were 6.96 $\mu g/m^3$ [95% CI: 6.27, 7.73] and 3.39 $\mu g/m^3$ [3.01, 3.82], respectively (Table 2.8). In homes with central filtration, the GMs of indoor $PM_{2.5}$ concentrations in sham and true filtration were 6.25 $\mu g/m^3$ [5.40, 7.24] and 3.92 $\mu g/m^3$ [3.13, 4.92], respectively.

3. Indoor PM_{10} concentrations

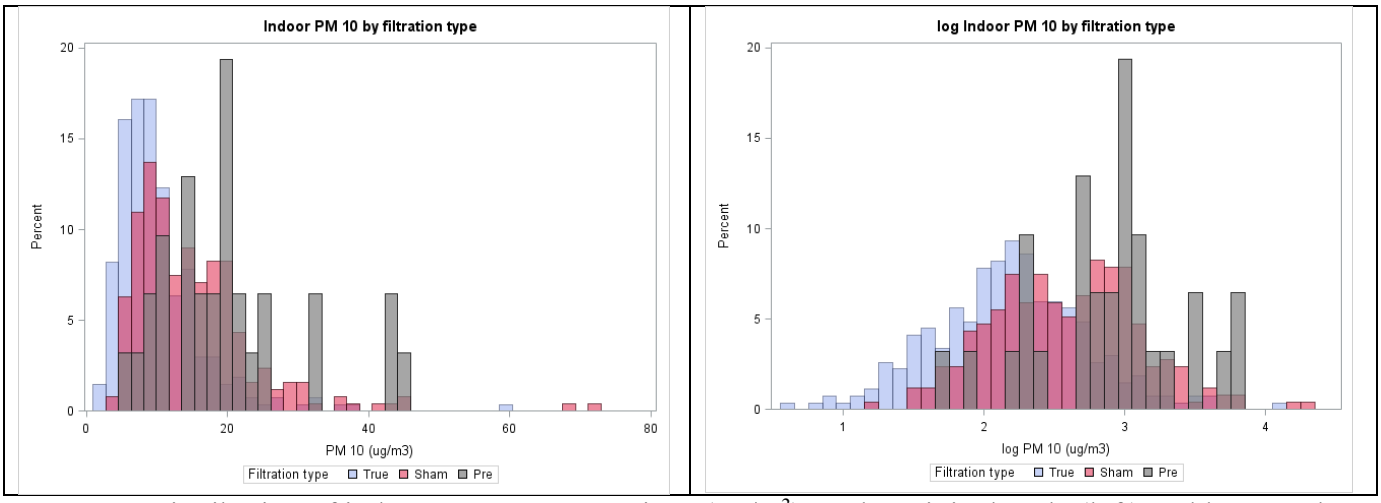


Figure 3.1: Distribution of indoor PM_{10} concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 3.1: Descriptive statistics for indoor PM_{10} concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Indoor PM 10 concentrations																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	42	2.8	0.47	2.9	2.4	3.1	48	2.2	0.50	2.3	2.0	2.5	8	3.3	0.45	3.3	2.9	3.8
	Spring	37	2.3	0.55	2.4	1.9	2.7	37	2.1	0.59	2.1	1.8	2.5	1	2.7	.	2.7	2.7	2.7
	Summer	33	2.5	0.47	2.4	2.1	2.8	40	2.2	0.45	2.2	1.8	2.6	1	3	.	3	3	3
	Fall	30	2.7	0.62	2.6	2.2	3.0	41	2.4	0.69	2.4	2.1	2.7	5	3	0.4	3	3	3.1
Riverside	Winter	24	2.5	0.43	2.6	2.2	2.8	24	2.1	0.41	2.2	1.8	2.4	1	3.3	.	3.3	3.3	3.3
	Spring	26	2.5	0.52	2.5	2.1	2.8	29	2.1	0.58	2.0	1.7	2.4	0	.	.	.	.	.
	Summer	20	2.5	0.37	2.5	2.2	2.8	22	2.2	0.35	2.2	1.9	2.5	0	.	.	.	.	.
	Fall	16	2.6	0.44	2.6	2.2	3.0	27	1.9	0.49	2.0	1.5	2.3	15	2.6	0.44	2.7	2.3	3

Stratified by city and season, the mean indoor PM_{10} concentrations were slightly higher during the pre-installation period compared with the sham and true filtration periods (Table 3.1).

Table 3.2: Log-normal mixed-effects model examining whether levels of indoor PM_{10} differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				2.6814	0.1088	156	24.63	<.0001	2.4664	2.8964
true			Sham	-0.334	0.08912	364	-3.75	0.0002	-0.5093	-0.1588
true			True	-0.7056	0.09235	364	-7.64	<.0001	-0.8872	-0.524
true			Pre	0	.	.	.	.	.	.
season		Fall		0.1593	0.04608	364	3.46	0.0006	0.06864	0.2499
season		Summer		0.1076	0.07603	364	1.42	0.1578	-0.0419	0.2571
season		Winter		0.2042	0.07249	364	2.82	0.0051	0.06161	0.3467
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.1491	0.06851	364	2.18	0.0302	0.01433	0.2838
area	Riverside			0	.	.	.	.	.	.

Table 3.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	364	66.19	<.0001
season	3	364	6.16	0.0004
area	1	364	4.73	0.0302

Table 3.4: Contrasts in log geometric mean PM_{10} concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.334	0.08912	364	3.75	0.0002	0.1588	0.5093
pre vs true	0.7056	0.09235	364	7.64	<.0001	0.524	0.8872
sham vs true	0.3716	0.0357	364	10.41	<.0001	0.3014	0.4418

Table 3.5: Log Geometric Means (GM) of PM_{10} concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	2.5397	2.4630	2.6164	12.6759	11.7400	13.6864
True	2.1681	2.0905	2.2457	8.7417	8.0890	9.4470
Pre	2.8737	2.7016	3.0458	17.7024	14.9036	21.0268

Indoor Air Main Effects Model: The indoor PM_{10} concentrations (log-transformed) were significantly higher in sham than in true filtration (0.37 [0.30, 0.44], p<0.0001) (Table 3.4). PM_{10} levels were significantly higher at pre-installation than in sham and in true filtration (pre vs. sham: β=0.33 [95% CI: 0.16, 0.51], p=0.0002; pre vs. true: 0.71 [0.52, 0.89], p<0.0001). The geometric means (GM) of indoor PM_{10} concentrations at pre-installation, in sham, and in true filtration were 17.70 $\mu g/m^3$ [95% CI: 14.90, 21.03], 12.68 $\mu g/m^3$ [11.74, 13.69], and 8.74 $\mu g/m^3$ [8.09, 9.45], respectively (Table 3.5).

Table 3.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in PM_{10} concentrations, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	336	58.92	<.0001
hvac_ac	1	336	0.15	0.6945
true*hvac_ac	1	336	10.01	0.0017
season	3	336	7.38	<.0001
area	1	336	3.4	0.0661

Table 3.7: Contrasts in log geometric mean PM_{10} concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.4369	0.04059	336	10.76	<.0001	0.3571	0.5168
Central: Sham vs True	0.1792	0.06996	336	2.56	0.0109	0.04156	0.3168
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2578	0.08149	336	3.16	0.0017	0.09747	0.4181

Table 3.8: Log Geometric Means (GM) of PM_{10} concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	2.5910	2.4999	2.6822	13.3431	12.1813	14.6172
Sham	Central	2.4288	2.2833	2.5743	11.3453	9.8090	13.1221
True	Air cleaner	2.1541	2.0663	2.2419	8.6201	7.8956	9.4112
True	Central	2.2496	2.0770	2.4222	9.4839	7.9805	11.2706

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between PM_{10} concentrations and filtration status (p=0.002) (Tables 3.6-3.8), indicating that the differences in indoor PM_{10} concentrations between sham and true filtration varied depending on the type of filtration system in the home. In homes with air cleaners, indoor PM_{10} concentrations were 1.55 times higher in sham than in true filtration (β=0.44 [95% CI: 0.36, 0.52], p<0.0001); while in homes with central filtration, PM_{10} concentrations were 1.20 times higher in sham (0.18 [0.04, 0.32], p=0.01) (Table 3.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.26 [0.10, 0.42], p=0.002), showing that improvements in air quality with true filtration were 29% greater in homes with air cleaners than in homes with central filtration systems.

In homes with air cleaners, the GMs of PM_{10} concentrations in sham and true filtration were 13.34 $\mu g/m^3$ [95% CI: 12.18, 14.62] and 8.62 $\mu g/m^3$ [7.90, 9.41], respectively (Table 3.8). In homes with central filtration, the GMs of indoor PM_{10} concentrations in sham and true filtration were 11.35 $\mu g/m^3$ [9.81, 13.12] and 9.48 $\mu g/m^3$ [7.98, 11.27], respectively.

4. Indoor $PM_{0.2\text{-}2.5}$ concentrations

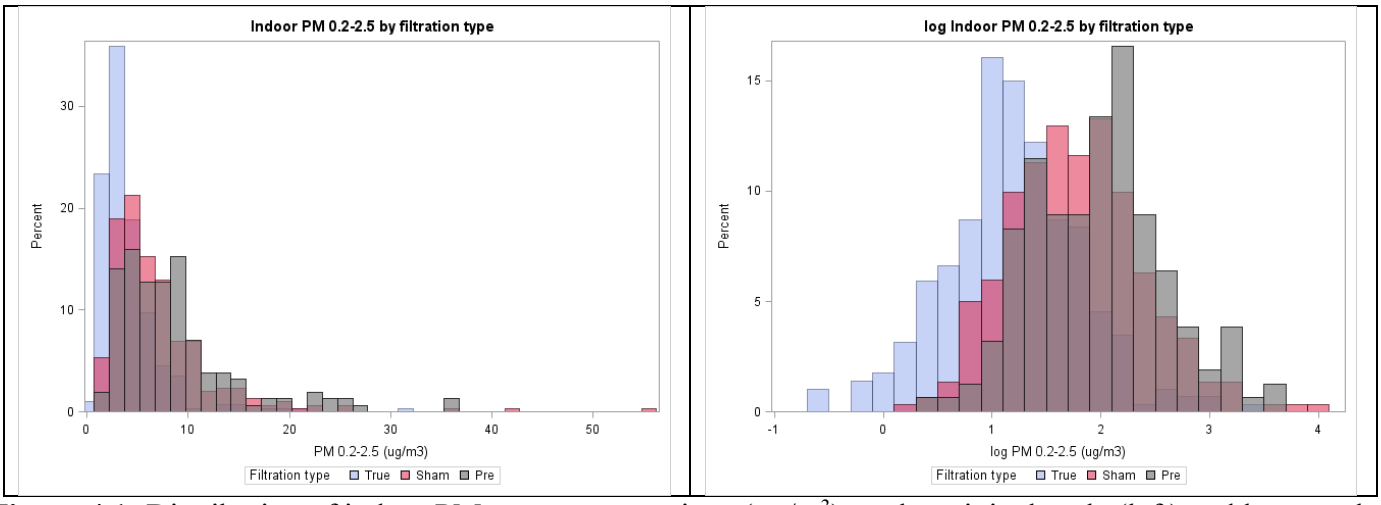


Figure 4.1: Distribution of indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 4.1: Descriptive statistics for indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Indoor PM 0.2-2.5 concentrations																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	42	2.1	0.57	2.2	1.7	2.5	48	1.4	0.62	1.4	1.0	1.8	26	2.6	0.57	2.6	2.1	3.1
	Spring	38	1.3	0.63	1.3	0.9	1.9	43	1.0	0.67	1.1	0.7	1.4	32	1.5	0.59	1.4	1.3	1.7
	Summer	41	1.5	0.50	1.6	1.2	1.8	52	1.1	0.47	1.0	0.8	1.4	27	1.8	0.55	1.7	1.5	2.2
	Fall	30	1.9	0.75	1.7	1.4	2.2	41	1.5	0.85	1.5	1.1	1.9	9	2.2	0.55	2.3	2	2.6
Riverside	Winter	24	1.7	0.48	1.8	1.3	2.1	24	1.2	0.51	1.2	0.9	1.5	1	2.6	.	2.6	2.6	2.6
	Spring	26	1.6	0.54	1.5	1.3	1.9	29	1.0	0.61	1.0	0.6	1.3	14	2.2	0.36	2.2	2	2.4
	Summer	22	1.8	0.42	1.8	1.4	2.1	23	1.4	0.36	1.4	1.0	1.7	30	2.1	0.36	2.1	1.8	2.3
	Fall	16	1.8	0.41	1.8	1.5	2.1	27	0.9	0.50	0.9	0.6	1.4	18	1.7	0.46	1.8	1.3	2.1

Stratified by city and season, the mean indoor $PM_{0.2\text{-}2.5}$ concentrations were higher during the pre-installation period compared with the sham and true filtration periods (Table 4.1).

Table 4.2: Log-normal mixed-effects model examining whether levels of indoor $PM_{0.2\text{-}2.5}$ differ at pre-installation vs. post-installation (sham, true)

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				1.7688	0.07313	167	24.18	<.0001	0.05	1.6244
true			Sham	-0.3042	0.04558	508	-6.67	<.0001	0.05	-0.3938
true			True	-0.8217	0.0529	508	-15.53	<.0001	0.05	-0.9257
true			Pre	0	.	.	.	.	.	.
season		Fall		0.2799	0.05985	508	4.68	<.0001	0.05	0.1623
season		Summer		0.1532	0.07592	508	2.02	0.0442	0.05	0.004013
season		Winter		0.4622	0.07815	508	5.91	<.0001	0.05	0.3087
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.04851	0.06783	508	0.72	0.4749	0.05	-0.08476
area	Riverside			0	.	.	.	.	.	.

Table 4.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	508	136.35	<.0001
season	3	508	20.16	<.0001
area	1	508	0.51	0.4749

Table 4.4: Contrasts in log geometric mean $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.3042	0.04558	508	6.67	<.0001	0.2147	0.3938
pre vs true	0.8217	0.0529	508	15.53	<.0001	0.7178	0.9257
sham vs true	0.5175	0.03932	508	13.16	<.0001	0.4403	0.5948

Table 4.5: Log Geometric Means (GM) of $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	1.7126	1.6333	1.7919	5.5434	5.1207	6.0008
True	1.1951	1.1100	1.2802	3.3039	3.0344	3.5974
Pre	2.0168	1.9279	2.1057	7.5142	6.8751	8.2128

Indoor Air Main Effects Model: The indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were significantly higher in sham than in true filtration (0.52 [0.44, 0.59], p<0.0001) (Table 4.4). Indoor $PM_{0.2\text{-}2.5}$ levels were significantly higher at pre-installation than in sham (β=0.30 [95% CI: 0.21, 0.39], p<0.0001) and compared with true filtration (0.82 [0.72, 0.93], p<0.0001). The geometric mean (GM) indoor $PM_{0.2\text{-}2.5}$ concentrations at pre-installation, in sham, and in true filtration were 7.51 $\mu g/m^3$ [6.88, 8.21], 5.54 $\mu g/m^3$ [5.12, 6.00], and 3.30 $\mu g/m^3$ [3.03, 3.60], respectively (Table 4.5).

Table 4.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{0.2\text{-}2.5}$ concentrations, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	2	505	64.92	<.0001
hvac_ac	1	505	0.07	0.7929
true*hvac_ac	2	505	5.02	0.0070
season	3	505	19.85	<.0001
area	1	505	0.46	0.4999

Table 4.7: Contrasts in log geometric mean $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.5790	0.04465	505	12.97	<.0001	0.4912	0.6667
Central: Sham vs True	0.2942	0.08019	505	3.67	0.0003	0.1367	0.4517
Air Cleaner vs. Central diff in Sham vs True diffs	0.2848	0.09277	505	3.07	0.0023	0.1025	0.4670
Air Cleaner: Pre vs Sham	0.3186	0.0503	505	6.33	<.0001	0.2198	0.4175
Central: Pre vs Sham	0.2615	0.102	505	2.56	0.0107	0.06104	0.4619
Air Cleaner vs Central diff in Pre vs Sham diffs	0.05715	0.1124	505	0.51	0.6114	-0.1637	0.2780
Air Cleaner: Pre vs True	0.8976	0.05577	505	16.09	<.0001	0.788	1.0072
Central: Pre vs True	0.5557	0.1274	505	4.36	<.0001	0.3055	0.8059
Air Cleaner vs. Central diff in Pre vs. True diffs	0.3419	0.1394	505	2.45	0.0145	0.06811	0.6157

Table 4.8: Log Geometric Means (GM) of $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Pre	Air cleaner	2.0567	1.9562	2.1572	7.8201	7.0724	8.6469
Pre	Central	1.9024	1.7128	2.0919	6.7020	5.5445	8.1003
Sham	Air cleaner	1.7380	1.6429	1.8332	5.6860	5.1701	6.2539
Sham	Central	1.6409	1.4860	1.7957	5.1598	4.4194	6.0237
True	Air cleaner	1.1591	1.0635	1.2547	3.1871	2.8965	3.5068
True	Central	1.3467	1.1540	1.5394	3.8447	3.1709	4.6618

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between $PM_{0.2\text{-}2.5}$ concentrations and filtration status (p=0.01) (Tables 4.6-4.8), indicating that the differences in indoor $PM_{0.2\text{-}2.5}$ concentrations between sham and true filtration, or between pre-installation and either sham or true filtration, varied depending on the type of filtration system in the home.

In homes with air cleaners, indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.78 times higher in sham than in true filtration (β=0.58 [95% CI: 0.49, 0.67], p<0.0001); while in homes with central filtration, $PM_{0.2\text{-}2.5}$ concentrations were 1.34 times higher in sham (0.29 [0.14, 0.45], p=0.0003) (Table 4.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.28 [0.10, 0.47], p=0.002), showing that the improvements in air quality with true filtration were 33% greater in homes with air cleaners than in homes with central filtration systems.

Comparisons of $PM_{0.2\text{-}2.5}$ levels between pre-installation and true filtration, separately in homes with air cleaners and those with central systems, also revealed modifying effects by filtration system in the home. In

homes with air cleaners, $PM_{0.2-2.5}$ concentrations were 2.45 times higher at pre-installation than in true filtration (0.90 [0.79, 1.01], p<0.0001); while in homes with central filtration, $PM_{0.2-2.5}$ levels were 1.74 times higher at pre-installation (0.56 [0.31, 0.81], p<0.0001) (Table 4.7). The difference in the pre-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.34 [0.07, 0.62], p=0.01), showing that the improvements in air quality with true filtration (compared with pre-installation levels) were 41% greater in homes with air cleaners than in homes with central filtration systems.

However, comparisons of $PM_{0.2-2.5}$ levels between pre-installation and sham, separately in homes with air cleaners and those with central systems, did not reveal statistically significant modifying effects by filtration system in the home. In homes with air cleaners, $PM_{0.2-2.5}$ concentrations were 1.38 times higher at pre-installation than in sham (0.32 [0.22, 0.42], p<0.0001); while in homes with central filtration, $PM_{0.2-2.5}$ levels were 1.30 times higher at pre-installation (0.26 [0.06, 0.46], p=0.01) (Table 4.7). The difference in the pre-sham log geometric mean differences between air cleaner and central system homes was not significant (0.06 [-0.16, 0.28], p=0.61), indicating that improvements in air quality for this size fraction did not vary much by home filtration system.

In homes with air cleaners, the geometric mean (GM) $PM_{0.2-2.5}$ concentrations at pre-installation, in sham and in true filtration were 7.82 [95% CI: 7.07, 8.65], 5.69 [5.17, 6.25], and 3.19 [2.90, 3.51], respectively (Table 4.8). In homes with central filtration, the GM $PM_{0.2-2.5}$ levels at pre-installation, in sham, and in true filtration were 6.70 $\mu g/m^3$ [5.54, 8.10], 5.16 $\mu g/m^3$ [4.42, 6.02], and 3.84 $\mu g/m^3$ [3.17, 4.66], respectively.

5. Indoor $PM_{2.5-10}$ concentrations

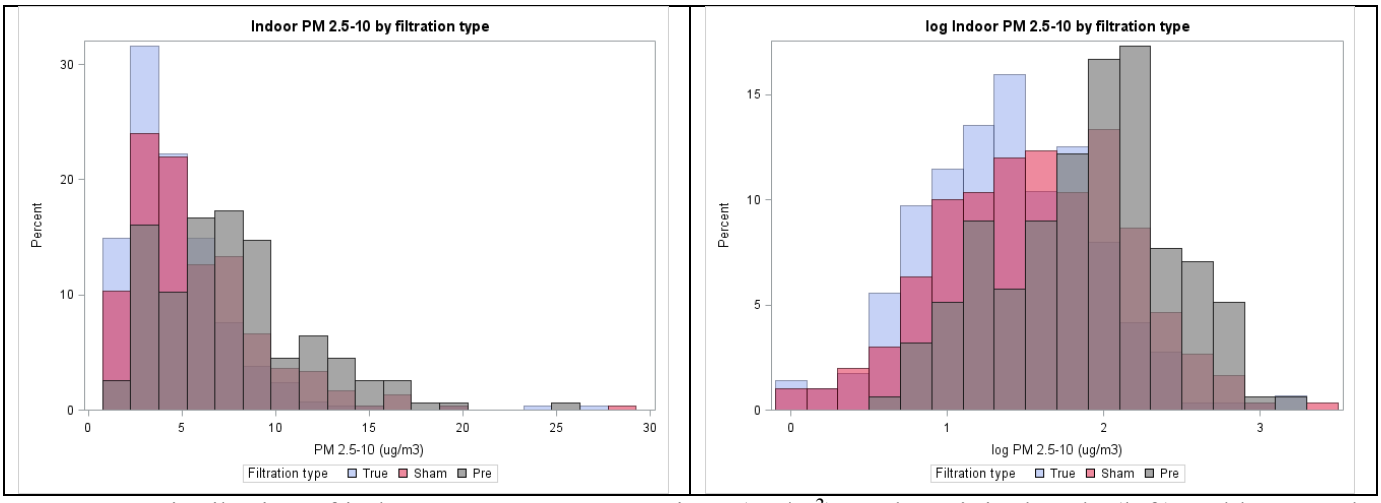


Figure 5.1: Distribution of indoor $PM_{2.5-10}$ concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 5.1: Descriptive statistics for indoor $PM_{2.5-10}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Indoor PM 2.5-10 concentrations																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	42	1.5	0.54	1.6	1.1	1.9	48	1.3	0.51	1.3	0.9	1.7	26	1.9	0.56	1.9	1.7	2.2
	Spring	38	1.3	0.61	1.3	0.8	1.9	43	1.3	0.57	1.3	1.0	1.7	32	1.7	0.56	1.6	1.2	2.1
	Summer	41	1.6	0.55	1.5	1.2	2.0	53	1.6	0.53	1.6	1.2	1.9	27	2	0.52	2	1.7	2.5
	Fall	30	1.6	0.60	1.6	1.2	2.0	41	1.5	0.59	1.5	1.1	1.9	9	2.3	0.36	2.3	2	2.5
Riverside	Winter	24	1.3	0.51	1.4	1.0	1.7	24	1.3	0.42	1.3	1.0	1.6	1	1.9	.	1.9	1.9	1.9
	Spring	26	1.5	0.68	1.5	1.0	1.7	29	1.3	0.63	1.3	0.9	1.7	14	2.2	0.5	2.1	1.9	2.6
	Summer	22	1.4	0.56	1.4	1.1	1.6	23	1.3	0.49	1.4	1.1	1.8	29	1.9	0.47	2.1	1.6	2.2
	Fall	16	1.7	0.60	1.5	1.4	2.1	27	1.2	0.59	1.2	0.7	1.6	18	1.6	0.51	1.7	1.1	2

Stratified by city and season, the mean indoor $PM_{2.5-10}$ concentrations were higher during the pre-installation period compared with the sham and true filtration periods (Table 5.1).

Table 5.2: Log-normal mixed-effects model examining whether levels of indoor $PM_{2.5-10}$ differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				1.7686	0.08093	166	21.85	<.0001	1.6088	1.9284
true			Sham	-0.4024	0.03894	510	-10.33	<.0001	-0.4789	-0.3259
true			True	-0.4991	0.03887	510	-12.84	<.0001	-0.5754	-0.4227
true			Pre	0	.	.	.	.	.	.
season		Fall		0.06906	0.03971	510	1.74	0.0826	-0.00895	0.1471
season		Summer		0.1131	0.07731	510	1.46	0.1441	-0.03879	0.265
season		Winter		-0.01066	0.07832	510	-0.14	0.8918	-0.1645	0.1432
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.1206	0.07631	510	1.58	0.1147	-0.02934	0.2705
area	Riverside			0	.	.	.	.	.	.

Table 5.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	510	85.62	<.0001
season	3	510	3.87	0.0094
area	1	510	2.5	0.1147

Table 5.4: Contrasts in log geometric mean $PM_{2.5-10}$ concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.4024	0.03894	510	10.33	<.0001	0.3259	0.4789
pre vs true	0.4991	0.03887	510	12.84	<.0001	0.4227	0.5754
sham vs true	0.0967	0.03227	510	3.00	0.0029	0.03331	0.1601

Table 5.5: Log Geometric Means (GM) of $PM_{2.5-10}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	1.4694	1.3800	1.5588	4.3466	3.9749	4.7531
True	1.3727	1.2913	1.4541	3.9460	3.6375	4.2806
Pre	1.8717	1.7851	1.9583	6.4993	5.9602	7.0873

Indoor Air Main Effects Model: The indoor $PM_{2.5-10}$ concentrations (log-transformed) were significantly higher in sham than in true filtration (0.10 [0.03, 0.16], p=0.003) (Table 5.4). $PM_{2.5-10}$ levels were significantly higher at pre-installation than in sham (β=0.40 [95% CI: 0.33, 0.48], p<0.0001) and compared with true filtration (0.50 [0.42, 0.58], p<0.0001). The geometric mean (GM) $PM_{2.5-10}$ concentrations at pre-installation, in sham, and in true filtration were 6.50 $\mu g/m^3$ [95% CI: 5.96, 7.09], 4.35 $\mu g/m^3$ [3.97, 4.75], and 3.95 $\mu g/m^3$ [3.64, 4.28], respectively (Table 5.5).

Table 5.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{2.5-10}$ concentrations, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	2	507	39.31	<.0001
hvac_ac	1	507	0.77	0.3804
true*hvac_ac	2	507	9.4	<.0001
season	3	507	3.3	0.0202
area	1	507	2.54	0.1118

Table 5.7: Contrasts in log geometric mean $PM_{2.5-10}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.149	0.03584	507	4.16	<.0001	0.07855	0.2194
Central: Sham vs True	-0.09563	0.06459	507	-1.48	0.1394	-0.2225	0.03128
Air Cleaner vs. Central diff in Sham vs True diffs	0.2446	0.07438	507	3.29	0.0011	0.09847	0.3907
Air Cleaner: Pre vs Sham	0.4298	0.04317	507	9.96	<.0001	0.345	0.5147
Central: Pre vs Sham	0.3204	0.08805	507	3.64	0.0003	0.1474	0.4933
Air Cleaner vs Central diff in Pre vs Sham diffs	0.1095	0.09753	507	1.12	0.2621	-0.08212	0.3011
Air Cleaner: Pre vs True	0.5788	0.04241	507	13.65	<.0001	0.4955	0.6621
Central: Pre vs True	0.2247	0.08332	507	2.7	0.0072	0.06103	0.3884
Air Cleaner vs. Central diff in Pre vs. True diffs	0.3541	0.09361	507	3.78	0.0002	0.1702	0.538

Table 5.8: Log Geometric Means (GM) of $PM_{2.5-10}$ concentrations ($\mu g/m^3$) for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Pre	Air cleaner	1.9292	1.8292	2.0293	6.8840	6.2289	7.6088
Pre	Central	1.6974	1.5383	1.8564	5.4597	4.6567	6.4007
Sham	Air cleaner	1.4994	1.3953	1.6034	4.4790	4.0362	4.9699
Sham	Central	1.3770	1.1989	1.5551	3.9630	3.3165	4.7356
True	Air cleaner	1.3504	1.2596	1.4412	3.8590	3.5240	4.2258
True	Central	1.4726	1.2903	1.6549	4.3606	3.6339	5.2326

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between $PM_{2.5-10}$ concentrations and filtration status ($p<0.0001$) (Tables 5.6-5.8), indicating that the differences in indoor $PM_{2.5-10}$ concentrations between sham and true filtration, or between pre-installation and either sham or true filtration, varied depending on the type of filtration system in the home.

In homes with air cleaners, indoor $PM_{2.5-10}$ concentrations (log-transformed) were 1.16 times higher in sham than in true filtration ($\beta=0.15$ [95% CI: 0.08, 0.22], $p<0.0001$); while in homes with central filtration, $PM_{2.5-10}$ concentrations did not differ significantly between sham and true filtration (-0.10 [-0.22, 0.03], $p=0.14$) (Table 5.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.24 [0.10, 0.39], $p=0.001$), showing that the improvements in air quality with true filtration were 28% greater in homes with air cleaners than in homes with central filtration systems.

Comparisons of $PM_{2.5-10}$ levels between pre-installation and true filtration, separately in homes with air cleaners and those with central systems, also revealed modifying effects by filtration system in the home. In homes with air cleaners, $PM_{2.5-10}$ concentrations were 1.78 times higher at pre-installation than in true filtration (0.58 [0.50, 0.66], p<0.0001); while in homes with central filtration, $PM_{2.5-10}$ levels were 1.25 times higher at pre-installation (0.22 [0.06, 0.39], p=0.01) (Table 5.7). The difference in the pre-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.35 [0.17, 0.54], p=0.0002), showing that the improvements in air quality with true filtration (compared with pre-installation levels) were 42% greater in homes with air cleaners than in homes with central filtration systems.

However, comparisons of $PM_{2.5-10}$ levels between pre-installation and sham, separately in homes with air cleaners and those with central systems, did not reveal statistically significant modifying effects by filtration system in the home. In homes with air cleaners, $PM_{2.5-10}$ concentrations were 1.54 times higher at pre-installation than in sham (0.43 [0.35, 0.51], p<0.0001); while in homes with central filtration, $PM_{2.5-10}$ levels were 1.38 times higher at pre-installation (0.32 [0.15, 0.49], p=0.0003) (Table 5.7). The difference in the pre-sham log geometric mean differences between air cleaner and central system homes was not significant (0.11 [-0.08, 0.30], p=0.26), indicating that improvements in air quality for this size fraction did not vary much by home filtration system.

In homes with air cleaners, the geometric mean (GM) $PM_{2.5-10}$ concentrations at pre-installation, in sham and in true filtration were 6.88 $\mu g/m^3$ [95% CI: 6.23, 7.61], 4.48 $\mu g/m^3$ [4.04, 4.97], and 3.86 $\mu g/m^3$ [3.52, 4.23], respectively (Table 5.8). In homes with central filtration, the GM $PM_{2.5-10}$ levels at pre-installation, in sham, and in true filtration were 5.46 $\mu g/m^3$ [4.66, 6.40], 3.96 $\mu g/m^3$ [3.32, 4.74], and 4.36 $\mu g/m^3$ [3.63, 5.23], respectively.

6. $PM_{0.2}$ Indoor/Outdoor ratios

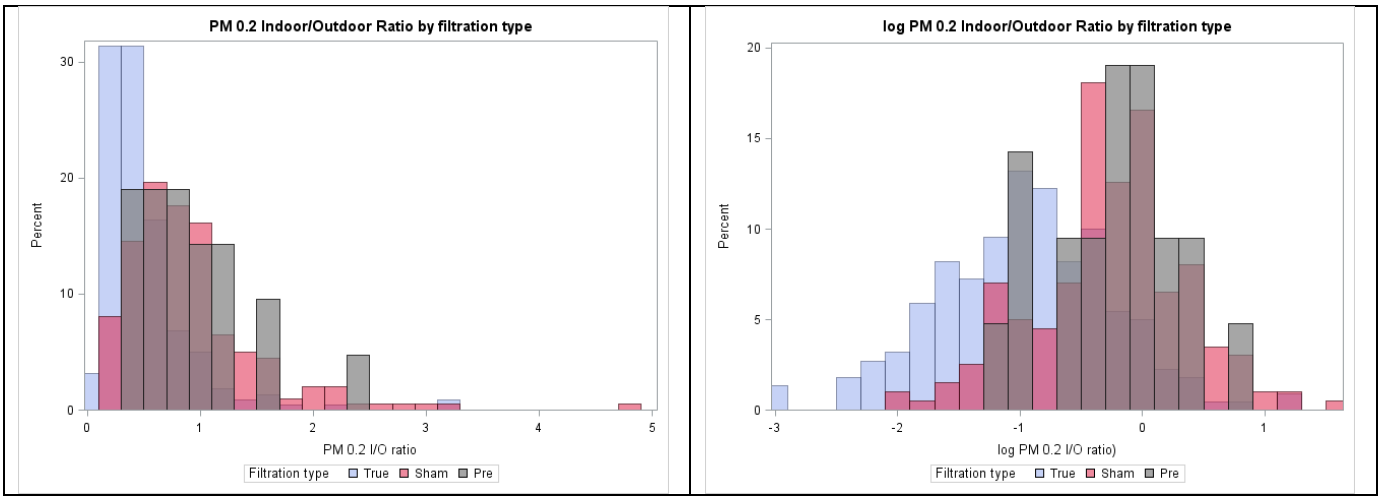


Figure 6.1: Distribution of $PM_{0.2}$ indoor/outdoor ratios on the original scale (left) and log *e* scale (right)

The PM indoor/outdoor ratios appear to be log-normally distributed.

Table 6.1: Descriptive statistics for $PM_{0.2}$ indoor/outdoor ratios (log-transformed) during pre-installation, sham and true filtration periods, stratified by city and season

		Log PM 0.2 I/O ratios																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	32	0.2	0.42	0.2	-0.1	0.6	35	-1.0	0.67	-1.0	-1.5	-0.5	4	-0.2	0.18	-0.2	-0.3	-0.1
	Spring	29	-0.2	0.6	-0.2	-0.4	0.1	31	-0.9	0.70	-0.9	-1.3	-0.5	0	.	.	.	.	.
	Summer	24	-1.0	0.53	-1.1	-1.3	-0.7	32	-1.4	0.73	-1.3	-1.8	-0.9	1	0.5	.	0.5	0.5	0.5
	Fall	27	-0.4	0.55	-0.3	-0.7	-0.1	35	-0.7	0.95	-0.7	-1.3	0.1	3	-0.4	0.58	-0.5	-1	0.2
Riverside	Winter	10	-0.2	0.72	0	-0.4	0.3	17	-0.7	0.62	-0.6	-1.1	-0.2	0	.	.	.	.	.
	Spring	25	-0.1	0.53	-0.2	-0.4	0.1	27	-0.9	0.66	-1.0	-1.5	-0.5	0	.	.	.	.	.
	Summer	16	-0.6	0.48	-0.5	-0.9	-0.2	18	-0.8	0.32	-0.8	-1.0	-0.6	0	.	.	.	.	.
	Fall	16	-0.4	0.36	-0.4	-0.5	-0.2	25	-1.2	0.56	-1.0	-1.5	-0.8	13	-0.3	0.58	-0.2	-0.6	0

Stratified by city and season, the mean $PM_{0.2}$ indoor/outdoor ratios were higher during the pre-installation period compared with the true filtration period only (Table 6.1).

Table 6.2: Log-normal mixed-effects model examining whether levels of $PM_{0.2}$ indoor/outdoor ratios differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				-0.1164	0.1454	141	-0.8	0.425	-0.4038	0.1711
true			Sham	-0.05353	0.1169	272	-0.46	0.6473	-0.2836	0.1766
true			True	-0.7228	0.1209	272	-5.98	<.0001	-0.9608	-0.4848
true			Pre	0	.	.	.	.	.	.
season		Fall		-0.1005	0.07514	272	-1.34	0.182	-0.2485	0.04738
season		Summer		-0.4256	0.09801	272	-4.34	<.0001	-0.6185	-0.2326
season		Winter		0.1152	0.0893	272	1.29	0.198	-0.06058	0.291
season		Spring		0	.	.	.	.	.	.
area	Fresno			-0.0359	0.07943	272	-0.45	0.6517	-0.1923	0.1205
area	Riverside			0	.	.	.	.	.	.

Table 6.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	272	65.76	<.0001
season	3	272	13.62	<.0001
area	1	272	0.2	0.6517

Table 6.4: Contrasts in log geometric mean $PM_{0.2}$ indoor/outdoor ratios by filtration status in the log-normal mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.05353	0.1169	272	0.46	0.6473	-0.1766	0.2836
pre vs true	0.7228	0.1209	272	5.98	<.0001	0.4848	0.9608
sham vs true	0.6692	0.05993	272	11.17	<.0001	0.5513	0.7872

Table 6.5: Log Geometric Means (GM) of $PM_{0.2}$ indoor/outdoor ratios by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	-0.2906	-0.3743	-0.2068	0.7478	0.6878	0.8132
True	-0.9598	-1.0641	-0.8555	0.3830	0.3450	0.4251
Pre	-0.2370	-0.4681	-0.0059	0.7890	0.6262	0.9941

Indoor Air Main Effects Model: The $PM_{0.2}$ indoor/outdoor (I/O) ratios (log-transformed) were significantly higher in sham than in true filtration (0.67 [95% CI: 0.55, 0.79], p<0.0001) (Table 6.4). $PM_{0.2}$ I/O ratios were significantly higher at pre-installation than in true filtration (β=0.72 [95% CI: 0.48, 0.96], p<0.0001) but not compared with sham (0.05 [-0.18, 0.28], p=0.65). The geometric mean (GM) $PM_{0.2}$ I/O ratios at pre-installation, in sham, and in true filtration were 0.79 [95% CI: 0.63, 0.99], 0.75 [0.69, 0.81], and 0.38 [0.35, 0.43], respectively (Table 6.5).

Table 6.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{0.2}$ indoor/outdoor ratios, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	253	68.79	<.0001
hvac_ac	1	253	3.08	0.0803
true*hvac_ac	1	253	5.63	0.0184
season	3	253	13.45	<.0001
area	1	253	0.46	0.4974

Table 6.7: Contrasts in log geometric mean $PM_{0.2}$ indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.7551	0.06768	253	11.16	<.0001	0.6218	0.8884
Central: Sham vs True	0.4195	0.1243	253	3.38	0.0009	0.1747	0.6642
Air Cleaner vs. Central diff in Sham vs. True diffs	0.3356	0.1414	253	2.37	0.0184	0.05715	0.6141

Table 6.8: Log Geometric Means (GM) of $PM_{0.2}$ indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	-0.2754	-0.3808	-0.1700	0.7593	0.6833	0.8437
Sham	Central	-0.3063	-0.4378	-0.1748	0.7362	0.6455	0.8396
True	Air cleaner	-1.0305	-1.1496	-0.9115	0.3568	0.3168	0.4019
True	Central	-0.7258	-0.9292	-0.5223	0.4839	0.3949	0.5932

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between $PM_{0.2}$ indoor/outdoor (I/O) ratios and filtration status (p=0.02) (Tables 6.6-6.8), indicating that the differences in $PM_{0.2}$ I/O ratios between sham and true filtration varied depending on the type of filtration system in the home. In homes with air cleaners, $PM_{0.2}$ I/O ratios (log-transformed) were 2.13 times higher in sham than in true filtration (β=0.76 [95% CI: 0.62, 0.89], p<0.0001); while in homes with central filtration, $PM_{0.2}$ I/O ratios were 1.52 times higher in sham (0.42 [0.17, 0.66], p=0.001) (Table 4.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.34 [0.06, 0.61], p=0.02), showing that the improvements in air quality with true filtration were 40% greater in homes with air cleaners than in homes with central filtration systems.

In homes with air cleaners, the geometric mean (GM) $PM_{0.2}$ I/O ratios in sham and true filtration were 0.76 [95% CI: 0.68, 0.84] and 0.36 [0.32, 0.40], respectively (Table 6.8). In homes with central filtration, the GM $PM_{0.2}$ I/O ratios in sham and true filtration were 0.74 [0.65, 0.84] and 0.48 [0.39, 0.59], respectively.

7. $PM_{2.5}$ Indoor/Outdoor ratios

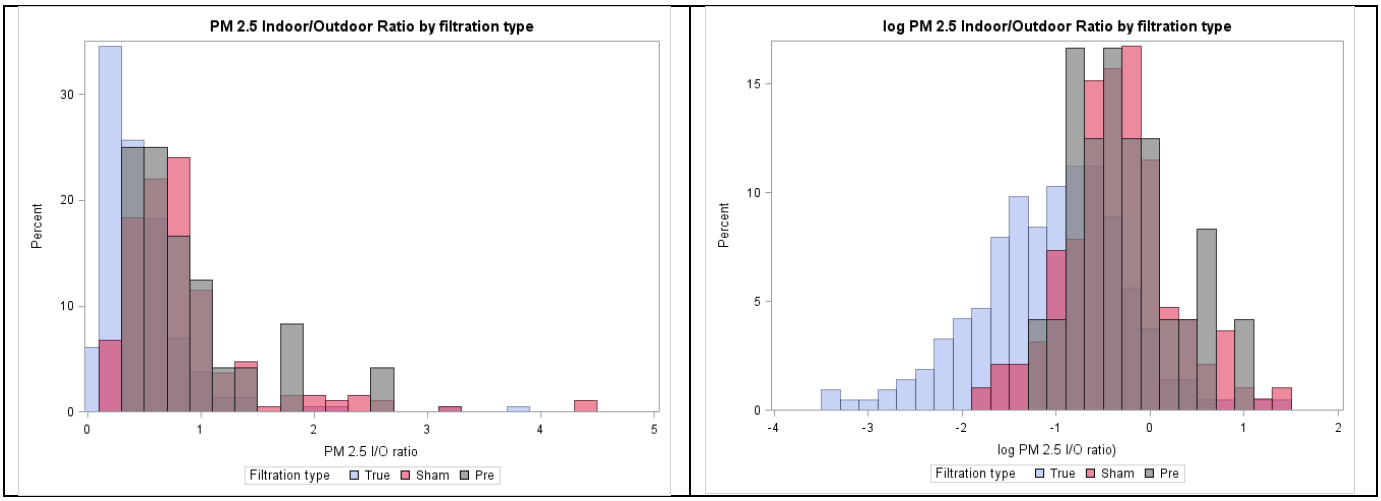


Figure 7.1: Distribution of $PM_{2.5}$ indoor/outdoor ratios on the original scale (left) and log *e* scale (right)

The PM indoor/outdoor ratios appear to be log-normally distributed.

Table 7.1: Descriptive statistics for $PM_{2.5}$ indoor/outdoor ratios (log-transformed) during pre-installation, sham and true filtration periods, stratified by city and season

		Log PM 2.5 I/O ratios																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	32	-0.3	0.55	-0.3	-0.5	-0.1	35	-1.6	0.68	-1.7	-2.0	-1.2	3	-0.5	0.08	-0.6	-0.6	-0.5
	Spring	30	-0.2	0.63	-0.3	-0.7	0.2	30	-0.9	0.70	-0.9	-1.2	-0.5	1	0.6	.	0.6	0.6	0.6
	Summer	23	-0.6	0.57	-0.5	-0.9	-0.2	32	-1.2	0.67	-1.1	-1.6	-0.7	3	0	0.58	-0.2	-0.5	0.6
	Fall	24	-0.6	0.59	-0.5	-0.9	-0.3	33	-1.0	1.14	-0.8	-1.5	-0.4	3	-0.6	0.44	-0.8	-0.9	-0.1
Riverside	Winter	10	-0.1	0.71	-0.1	-0.4	0.4	17	-0.7	0.57	-0.5	-0.9	-0.3	0	.	.	.	.	.
	Spring	23	-0.1	0.61	-0.3	-0.5	0.0	26	-0.9	0.58	-0.8	-1.5	-0.6	0	.	.	.	.	.
	Summer	15	-0.4	0.52	-0.5	-0.9	-0.1	18	-0.7	0.34	-0.8	-1.0	-0.5	0	.	.	.	.	.
	Fall	13	-0.3	0.44	-0.2	-0.6	0.0	23	-1.3	0.70	-1.3	-1.6	-0.7	14	-0.3	0.57	-0.3	-0.8	0

Stratified by city and season, the mean $PM_{2.5}$ indoor/outdoor ratios were higher during the pre-installation period compared with the true filtration period only (Table 7.1).

Table 7.2: Log-normal mixed-effects model examining whether levels of $PM_{2.5}$ indoor/outdoor ratios differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				0.1296	0.1353	141	0.96	0.3396	0.05	-0.1378
true			Sham	-0.2077	0.1129	258	-1.84	0.0670	0.05	-0.4301
true			True	-0.9039	0.1175	258	-7.69	<.0001	0.05	-1.1353
true			Pre	0	.	.	.	.	.	.
season		Fall		-0.2817	0.07358	258	-3.83	0.0002	0.05	-0.4266
season		Summer		-0.2413	0.095	258	-2.54	0.0117	0.05	-0.4284
season		Winter		-0.2899	0.09958	258	-2.91	0.0039	0.05	-0.486
season		Spring		0	.	.	.	.	.	.
area	Fresno			-0.1251	0.08991	258	-1.39	0.1652	0.05	-0.3022
area	Riverside			0	.	.	.	.	.	.

Table 7.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	258	70.52	<.0001
season	3	258	7.41	<.0001
area	1	258	1.94	0.1652

Table 7.4: Contrasts in log geometric mean $PM_{2.5}$ indoor/outdoor ratios by filtration status in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.2077	0.1129	258	1.84	0.0670	-0.01466	0.4301
pre vs true	0.9039	0.1175	258	7.69	<.0001	0.6725	1.1353
sham vs true	0.6962	0.06263	258	11.12	<.0001	0.5729	0.8195

Table 7.5: Log Geometric Means (GM) of $PM_{2.5}$ indoor/outdoor ratios by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	-0.3439	-0.4402	-0.2475	0.7090	0.6439	0.7808
True	-1.0401	-1.1529	-0.9273	0.3534	0.3157	0.3956
Pre	-0.1362	-0.3460	0.0737	0.8727	0.7075	1.0765

Indoor Air Main Effects Model: The $PM_{2.5}$ indoor/outdoor (I/O) ratios (log-transformed) were significantly higher in sham than in true filtration (0.70 [0.57, 0.82], p<0.0001) (Table 7.4). $PM_{2.5}$ I/O ratios were significantly higher at pre-installation than in true filtration (β=0.90 [95% CI: 0.67, 1.14], p<0.0001) and slightly higher than in sham (0.21 [-0.01, 0.43], p=0.07). The geometric means (GM) $PM_{2.5}$ I/O ratios at pre-installation, in sham, and in true filtration were 0.87 [95% CI: 0.71, 1.08], 0.71 [0.64, 0.78], and 0.35 [0.32, 0.40], respectively (Table 7.5).

Table 7.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in $PM_{2.5}$ indoor/outdoor ratios, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	237	63.65	<.0001
hvac_ac	1	237	0.81	0.3676
true*hvac_ac	1	237	2.37	0.1251
season	3	237	6.78	0.0002
area	1	237	2.36	0.1261

Table 7.7: Contrasts in log geometric mean $PM_{2.5}$ indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.7619	0.0682	237	11.17	<.0001	0.6275	0.8962
Central: Sham vs True	0.5136	0.1454	237	3.53	0.0005	0.2271	0.8000
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2483	0.1613	237	1.54	0.1251	-0.06955	0.5662

Table 7.8: Log Geometric Means (GM) of $PM_{2.5}$ indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	-0.3264	-0.4438	-0.2091	0.7215	0.6416	0.8113
Sham	Central	-0.3597	-0.5192	-0.2002	0.6979	0.5950	0.8186
True	Air cleaner	-1.0883	-1.2135	-0.9630	0.3368	0.2972	0.3817
True	Central	-0.8733	-1.1402	-0.6063	0.4176	0.3198	0.5454

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home did not significantly modify the association between $PM_{2.5}$ indoor/outdoor (I/O) ratios and filtration status (p=0.13) (Tables 7.6-7.8), indicating that the differences in $PM_{2.5}$ I/O ratios between sham and true filtration did not vary much based on the type of filtration system in the home; however, moderately greater sham-true differences were observed in homes with air cleaners than in homes with central systems. In homes with air cleaners, $PM_{2.5}$ I/O ratios were 2.14 times higher in sham than in true filtration in homes with air cleaners (β=0.76 [95% CI: 0.63, 0.90], p<0.0001); while in homes with central systems, $PM_{2.5}$ I/O ratios were 1.67 times higher in sham (0.51 [0.23, 0.80], p=0.001) (Table 7.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was not statistically significant (0.25 [-0.07, 0.57], p=0.13); nevertheless, there were slightly greater improvements in air quality with true filtration in homes with air cleaners compared to homes with central filtration systems.

In homes with air cleaners, the geometric mean (GM) $PM_{2.5}$ I/O ratios in sham and true filtration were 0.72 [95% CI: 0.64, 0.81] and 0.34 [0.30, 0.38], respectively (Table 7.8). In homes with central filtration, the GM $PM_{2.5}$ I/O ratios in sham and true filtration were 0.70 [0.60, 0.82] and 0.42 [0.32, 0.55], respectively.

8. PM_{10} Indoor/Outdoor ratios

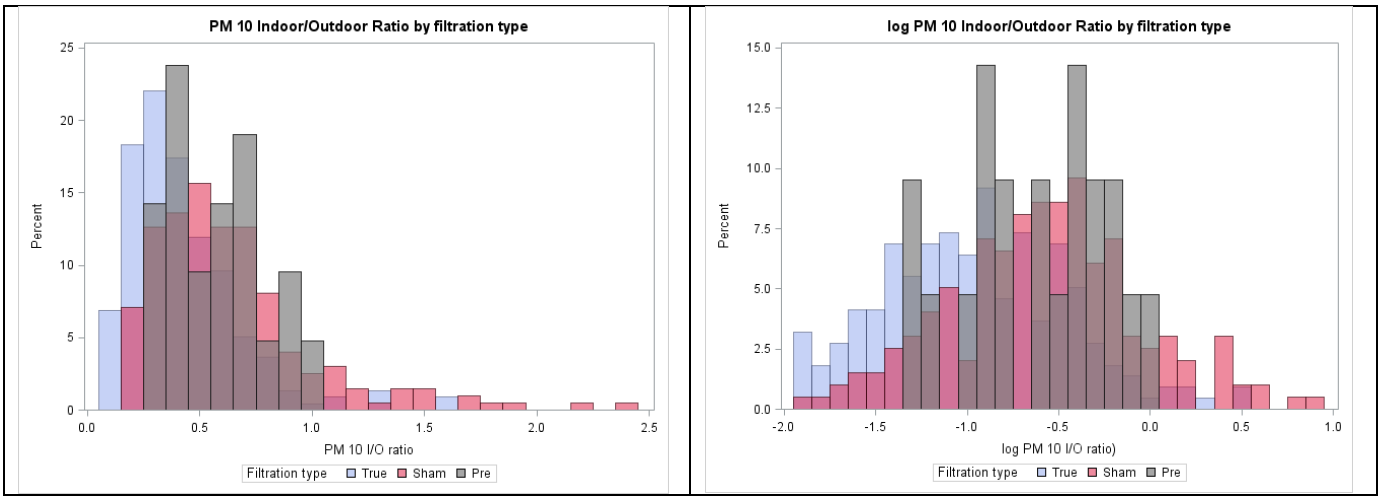


Figure 8.1: Distribution of PM_{10} indoor/outdoor ratios on the original scale (left) and log *e* scale (right)

The PM indoor/outdoor ratios appear to be log-normally distributed.

Table 8.1: Descriptive statistics for PM_{10} indoor/outdoor ratios (log-transformed) during pre-installation, sham and true filtration periods, stratified by city and season

		Log PM 10 I/O ratios																	
		Filtration status																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	32	-0.3	0.47	-0.3	-0.6	0.1	35	-1.1	0.54	-1.1	-1.4	-0.8	4	-0.4	0.29	-0.4	-0.6	-0.2
	Spring	29	-0.5	0.57	-0.5	-0.9	-0.2	31	-0.8	0.58	-0.8	-1.2	-0.4	0	.	.	.	.	.
	Summer	24	-1.1	0.52	-1.1	-1.4	-0.8	31	-1.3	0.46	-1.3	-1.6	-0.9	1	-0.6	.	-0.6	-0.6	-0.6
	Fall	27	-0.6	0.55	-0.6	-0.9	-0.4	35	-0.9	0.68	-0.8	-1.3	-0.5	3	-0.7	0.43	-0.9	-1	-0.2
Riverside	Winter	10	-0.5	0.59	-0.4	-0.6	0.0	17	-0.8	0.44	-0.7	-1.1	-0.4	0	.	.	.	.	.
	Spring	25	-0.5	0.40	-0.6	-0.7	-0.4	26	-1.0	0.53	-1.0	-1.3	-0.7	0	.	.	.	.	.
	Summer	15	-0.8	0.36	-0.8	-1.1	-0.4	18	-0.9	0.39	-1.0	-1.2	-0.5	0	.	.	.	.	.
	Fall	16	-0.6	0.38	-0.6	-0.8	-0.3	25	-1.3	0.50	-1.3	-1.6	-0.9	13	-0.7	0.45	-0.6	-0.9	-0.3

Stratified by city and season, the mean PM_{10} indoor/outdoor ratios were higher during the pre-installation period compared with the true filtration period only (Table 8.1).

Table 8.2: Log-normal mixed-effects model examining whether levels of PM_{10} indoor/outdoor ratios differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				-0.3905	0.09929	141	-3.93	0.0001	-0.5868	-0.1942
true			Sham	-0.07898	0.07509	269	-1.05	0.2938	-0.2268	0.06886
true			True	-0.4841	0.07783	269	-6.22	<.0001	-0.6374	-0.3309
true			Pre	0	.	.	.	.	.	.
season		Fall		-0.1774	0.05183	269	-3.42	0.0007	-0.2795	-0.07539
season		Summer		-0.3756	0.08214	269	-4.57	<.0001	-0.5373	-0.2138
season		Winter		-0.00945	0.0805	269	-0.12	0.9067	-0.1679	0.149
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.01985	0.07235	269	0.27	0.7841	-0.1226	0.1623
area	Riverside			0	.	.	.	.	.	.

Table 8.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	269	44.58	<.0001
season	3	269	13.85	<.0001
area	1	269	0.08	0.7841

Table 8.4: Contrasts in log geometric mean PM_{10} indoor/outdoor ratios by filtration status in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.07898	0.07509	269	1.05	0.2938	-0.06886	0.2268
pre vs true	0.4841	0.07783	269	6.22	<.0001	0.3309	0.6374
sham vs true	0.4052	0.04582	269	8.84	<.0001	0.315	0.4954

Table 8.5: Log Geometric Means (GM) of PM_{10} indoor/outdoor ratios by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
Sham	-0.6002	-0.6782	-0.5222	0.5487	0.5075	0.5932
True	-1.0054	-1.0917	-0.9190	0.3659	0.3356	0.3989
Pre	-0.5212	-0.6681	-0.3743	0.5938	0.5127	0.6878

Indoor Air Main Effects Model: The PM_{10} indoor/outdoor (I/O) ratios (log-transformed) were significantly higher in sham than in true filtration (0.41 [0.32, 0.50], p<0.0001) (Table 8.4). PM_{10} I/O ratios (log-transformed) were significantly higher at pre-installation than in true filtration (β=0.48 [95% CI: 0.33, 0.64], p<0.0001) but not compared with sham (0.08 [-0.07, 0.23], p=0.29). The geometric mean (GM) PM_{10} I/O ratios at pre-installation, in sham, and in true filtration were 0.59 [95% CI: 0.51, 0.69], 0.55 [0.51, 0.59], and 0.37 [0.34, 0.40], respectively (Table 8.5).

Table 8.6: Type III tests of fixed effect for log-normal mixed-effects model examining sham vs. true filtration differences in PM_{10} indoor/outdoor ratios, with an interaction term: filtration status x filtration system (TRUE × HVAC)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	250	36.66	<.0001
hvac_ac	1	250	0.69	0.4057
true*hvac_ac	1	250	5.68	0.0179
season	3	250	13.13	<.0001
area	1	250	0.07	0.7958

Table 8.7: Contrasts in log geometric mean PM_{10} indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.4771	0.04995	250	9.55	<.0001	0.3787	0.5755
Central: Sham vs True	0.2080	0.1014	250	2.05	0.0413	0.008294	0.4078
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2691	0.1129	250	2.38	0.0179	0.04666	0.4915

Table 8.8: Log Geometric Means (GM) of PM_{10} indoor/outdoor ratios for each level of the interaction term in the log-normal mixed-effects model

Filtration status	Central or Air Cleaner	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	-0.5764	-0.6722	-0.4807	0.5619	0.5106	0.6184
Sham	Central	-0.6429	-0.7778	-0.5079	0.5258	0.4594	0.6018
True	Air cleaner	-1.0535	-1.1489	-0.9582	0.3487	0.3170	0.3836
True	Central	-0.8509	-1.0470	-0.6548	0.4270	0.3510	0.5195

Sham vs. True Filtration Indoor Air Interaction Model: Having central filtration (vs. stand-alone air cleaners) in the home significantly modified the association between PM_{10} indoor/outdoor (I/O) ratios and filtration status (p=0.02) (Tables 8.6-8.8), indicating that the differences in PM_{10} I/O ratios between sham and true filtration varied depending on the type of filtration system in the home. In homes with air cleaners, PM_{10} I/O ratios were 1.62 times higher in sham than in true filtration (β=0.48 [95% CI: 0.38, 0.58], p<0.0001); while in homes with central filtration, PM_{10} I/O ratios were 1.23 times higher in sham central: 0.21 [0.01, 0.41], p=0.04) (Table 8.7). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.27 [0.05, 0.49], p=0.02), indicating 30% greater improvements in air quality with true filtration in homes with air cleaners than in homes with central filtration systems.

In homes with air cleaners, the geometric mean (GM) PM_{10} I/O ratios in sham and true filtration were 0.56 [95% CI: 0.51, 0.62] and 0.35 [0.32, 0.38], respectively (Table 8.8). In homes with central filtration, the GM PM_{10} I/O ratios in sham and true filtration were 0.53 [0.46, 0.60] and 0.43 [0.35, 0.52], respectively.

9a. Outdoor $PM_{0.2\text{-}2.5}$ concentrations, Including estimated outdoor values

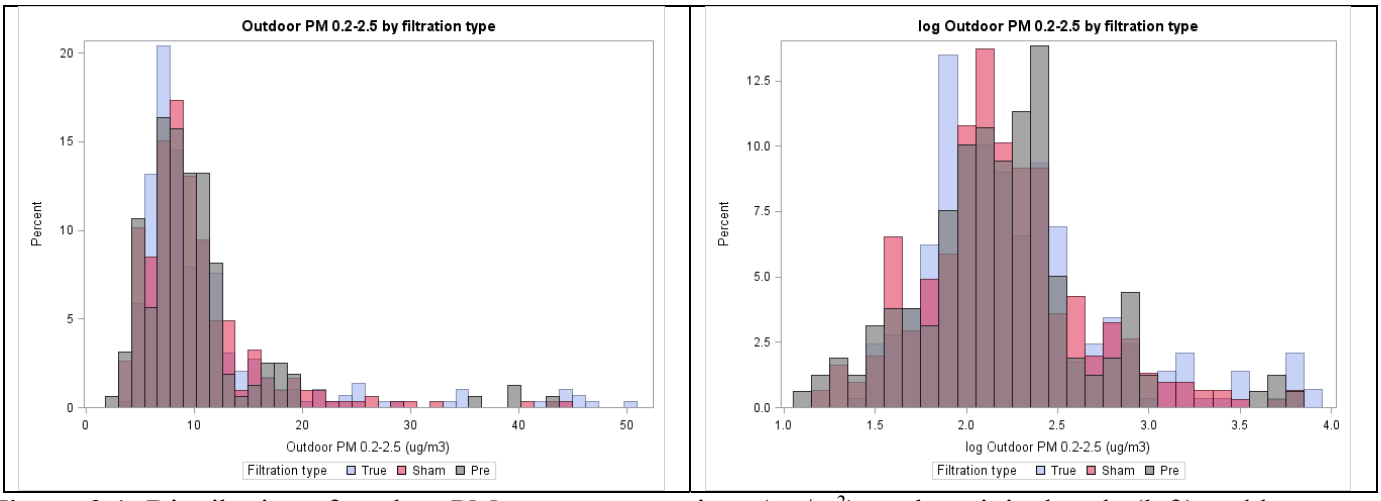


Figure 9.1: Distribution of outdoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 9.1: Descriptive statistics for outdoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Outdoor PM 0.2-2.5 concentrations																	
		Filtration type																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	44	2.6	0.47	2.6	2.2	2.9	48	2.9	0.54	2.8	2.4	3.2	27	2.7	0.54	2.7	2.2	2.9
	Spring	38	1.7	0.26	1.6	1.6	1.8	43	1.8	0.22	1.8	1.6	1.9	32	1.7	0.31	1.7	1.5	2
	Summer	40	2.2	0.37	2.2	2	2.4	52	2.2	0.33	2.1	2	2.5	29	2.1	0.25	2.1	1.9	2.3
	Fall	32	2.4	0.42	2.3	2.1	2.7	42	2.5	0.56	2.3	2.1	2.5	9	2.5	0.34	2.4	2.1	2.9
Riverside	Winter	24	2.1	0.23	2.1	2.1	2.1	25	2.1	0.27	2.1	1.9	2.2	1	2.1	.	2.1	2.1	2.1
	Spring	26	2	0.34	2	1.8	2.3	29	2	0.22	2	1.9	2.1	13	2	0.37	2.1	1.8	2.3
	Summer	22	2.3	0.19	2.3	2.2	2.4	23	2.3	0.18	2.3	2.2	2.4	30	2.4	0.13	2.4	2.3	2.4
	Fall	16	2.1	0.22	2	1.9	2.3	27	2.1	0.23	2	1.9	2.3	18	2.1	0.17	2.1	2	2.2

Stratified by city and season, the mean outdoor $PM_{0.2\text{-}2.5}$ concentrations did not differ between the pre-installation period compared with the sham and true filtration periods (Table 9.1).

Table 9.2: Log-normal mixed-effects model examining whether levels of outdoor $PM_{0.2\text{-}2.5}$ differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration type	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				1.7715	0.04632	168	38.25	<.0001	1.6801	1.863
true			Sham	-0.0252	0.03823	515	-0.66	0.5100	-0.1003	0.0499
true			True	0.03866	0.03387	515	1.14	0.2542	-0.02788	0.1052
true			Pre	0	.	.	.	.	.	.
season		Fall		0.4748	0.05281	515	8.99	<.0001	0.3711	0.5786
season		Summer		0.3925	0.04479	515	8.76	<.0001	0.3046	0.4805
season		Winter		0.7059	0.05542	515	12.74	<.0001	0.597	0.8147
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.09619	0.03292	515	2.92	0.0036	0.03151	0.1609
area	Riverside			0	.	.	.	.	.	.

Table 9.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	515	2.48	0.0845
season	3	515	67.16	<.0001
area	1	515	8.54	0.0036

Table 9.4: Contrasts in log geometric mean outdoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for filtration type in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.0252	0.03823	515	0.66	0.5100	-0.0499	0.1003
pre vs true	-0.03866	0.03387	515	-1.14	0.2542	-0.1052	0.02788
sham vs true	-0.06386	0.0296	515	-2.16	0.0314	-0.122	-0.00571

Table 9.5: Log Geometric Means (GM) of outdoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
Sham	2.1877	2.1404	2.2351	8.9147	8.5028	9.3474
True	2.2516	2.2060	2.2972	9.5029	9.0793	9.9463
Pre	2.2129	2.1550	2.2709	9.1422	8.6279	9.6881

Pre- vs Post-installation Outdoor Air Main Effects Model: The outdoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) at pre-installation did not differ significantly from those in sham (β=0.03 [95% CI: -0.05, 0.10], p=0.51) or compared with true filtration (0.03 [-0.11, 0.03], p=0.25) (Table 9.4). Outdoor $PM_{0.2\text{-}2.5}$ levels were significantly lower in sham than in true filtration (-0.06 [-0.12, -0.01], p=0.03). The geometric mean (GM) outdoor $PM_{0.2\text{-}2.5}$ concentrations at pre-installation, in sham, and in true filtration were 9.14 $\mu g/m^3$ [95% CI: 8.63, 9.69], 8.91 $\mu g/m^3$ [8.50, 9.35], and 9.50 $\mu g/m^3$ [9.08, 9.95], respectively (Table 9.5).

9b. Outdoor $PM_{0.2-2.5}$ concentrations, included only actual measured values

Table 9.6: Descriptive statistics for outdoor $PM_{0.2-2.5}$ concentrations (log-transformed from $\mu g/m^3$) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Outdoor PM 0.2-2.5 concentrations											
		Filtration status											
		SHAM						TRUE					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	36	2.6	0.5	2.6	2.2	2.9	35	2.9	0.5	2.9	2.4	3.2
	Spring	32	1.6	0.3	1.6	1.4	1.8	35	1.8	0.2	1.8	1.6	1.9
	Summer	35	2.1	0.4	2.1	1.9	2.3	43	2.2	0.3	2.2	1.9	2.4
	Fall	29	2.4	0.4	2.3	2.1	2.7	35	2.4	0.5	2.3	2.0	2.5
Riverside	Winter	10	2.1	0.4	2.1	1.8	2.4	18	2.1	0.3	2.0	1.9	2.3
	Spring	25	2.0	0.3	2.0	1.8	2.2	27	2.1	0.2	2.0	1.9	2.1
	Summer	18	2.3	0.2	2.3	2.1	2.4	19	2.3	0.2	2.3	2.2	2.5
	Fall	16	2.2	0.3	2.1	1.9	2.3	26	2.1	0.2	2.0	1.9	2.3

Stratified by city and season, the mean outdoor $PM_{0.2-2.5}$ concentrations did not differ between sham and true filtration periods (Table 9.6).

Table 9.7: Contrasts in log geometric mean of outdoor $PM_{0.2-2.5}$ concentrations ($\mu g/m^3$) for filtration status in the log- normal mixed-effects model

Filtration status	Estimate	SE	DF	t Value	Pr > |t|
Sham vs. True	-0.04212	0.0322	331	-1.31	0.1917

Table 9.8: Log geometric means (GM) of outdoor $PM_{0.2-2.5}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	2.1876	0.02777	8.9138	1.02816
TRUE	2.2298	0.02688	9.2980	1.02724

The outdoor $PM_{0.2-2.5}$ concentrations (log-transformed) are not significantly different between true, and sham periods (Table 9.7). The geometric means (GM) of outdoor $PM_{0.2-2.5}$ concentrations during sham and true filtration periods were 8.91 $\mu g/m^3$ [1.03], and 9.30 $\mu g/m^3$ [1.03], respectively (Table 9.8).

10a. Outdoor $PM_{2.5-10}$ concentrations, including estimated outdoor values

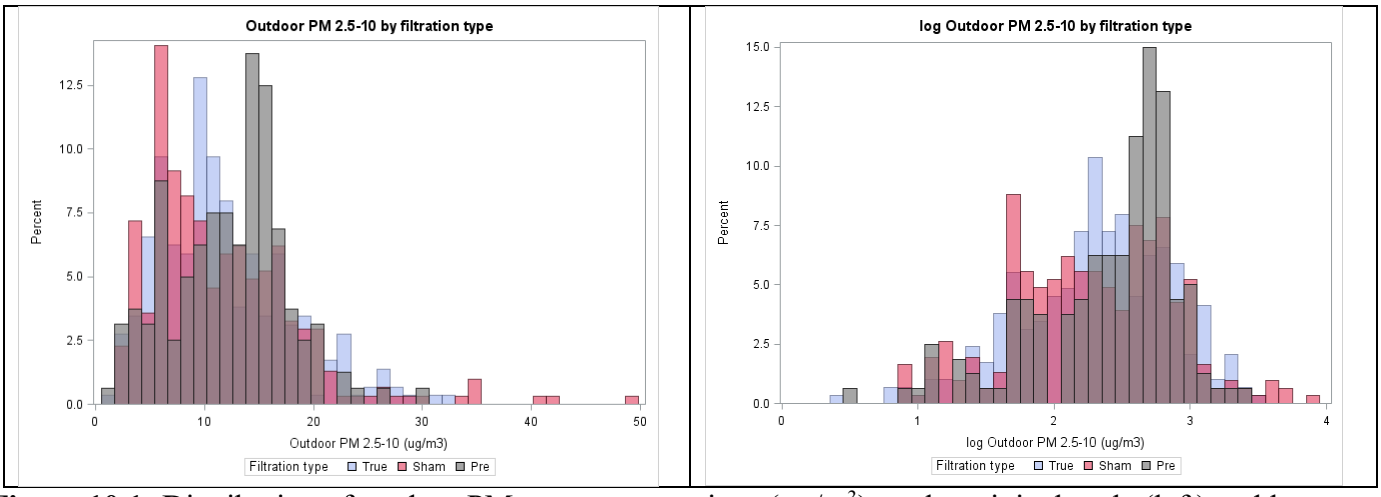


Figure 10.1: Distribution of outdoor $PM_{2.5-10}$ concentrations (µg/m^3) on the original scale (left) and log *e* scale (right)

The PM concentrations appear to be log-normally distributed.

Table 10.1: Descriptive statistics for outdoor $PM_{2.5-10}$ concentrations (log-transformed from µg/m^3) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Outdoor PM 2.5-10 concentrations																	
		Filtration type																	
		SHAM						TRUE						PRE-INSTALLATION					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	44	1.7	0.48	1.7	1.2	2	48	1.7	0.43	1.7	1.4	2	27	1.9	0.75	1.8	1.3	2.8
	Spring	38	2	0.27	2	1.8	2.2	43	2.2	0.35	2.2	1.9	2.4	32	2.1	0.38	2.2	1.7	2.4
	Summer	40	2.9	0.50	2.8	2.7	3	52	2.9	0.28	2.9	2.7	3.1	29	2.8	0.18	2.8	2.7	2.9
	Fall	32	2.4	0.64	2.4	1.9	2.9	42	2.3	0.64	2.3	1.8	2.8	9	2.4	0.6	2.3	1.9	2.9
Riverside	Winter	24	1.9	0.34	1.7	1.7	2	25	2.2	0.53	2.2	1.7	2.7	1	1.7	.	1.7	1.7	1.7
	Spring	26	2.3	0.38	2.2	2	2.6	29	2.4	0.22	2.3	2.3	2.5	14	2.4	0.38	2.5	2.2	2.6
	Summer	22	2.6	0.24	2.6	2.4	2.7	23	2.4	0.35	2.3	2.1	2.8	30	2.6	0.14	2.6	2.6	2.7
	Fall	16	2.6	0.28	2.6	2.5	2.8	27	2.5	0.29	2.5	2.3	2.7	18	2.7	0.23	2.7	2.5	2.8

Stratified by city and season, the mean outdoor $PM_{2.5-10}$ concentrations did not differ between the pre-installation period compared with the sham and true filtration periods (Table 10.1).

Table 10.2: Log-normal mixed-effects model examining whether levels of outdoor $PM_{2.5-10}$ differ at pre-installation, sham, and true periods

Effect	City	Season	Filtration type	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				2.2913	0.0514	168	44.58	<.0001	2.1899	2.3928
true			Sham	-0.07335	0.04164	516	-1.76	0.0787	-0.1552	0.008447
true			True	-0.01299	0.03922	516	-0.33	0.7405	-0.09004	0.06405
true			Pre	0	.	.	.	.	.	.
season		Fall		0.2313	0.05456	516	4.24	<.0001	0.1241	0.3385
season		Summer		0.5362	0.04997	516	10.73	<.0001	0.438	0.6344
season		Winter		-0.3788	0.05055	516	-7.49	<.0001	-0.4781	-0.2795
season		Spring		0	.	.	.	.	.	.
area	Fresno			-0.107	0.04109	516	-2.6	0.0095	-0.1877	-0.02628
area	Riverside			0	.	.	.	.	.	.

Table 10.3: Type III tests of fixed effects for log-normal mixed-effects main effects model

Effect	Num DF	Den DF	F Value	Pr > F
true	2	516	2.16	0.1162
season	3	516	86.36	<.0001
area	1	516	6.78	0.0095

Table 10.4: Contrasts in log geometric mean outdoor $PM_{2.5-10}$ concentrations ($\mu g/m^3$) for filtration type in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
pre vs sham	0.07335	0.04164	516	1.76	0.0787	-0.00845	0.1552
pre vs true	0.01299	0.03922	516	0.33	0.7405	-0.06405	0.09004
sham vs true	-0.06036	0.03344	516	-1.8	0.0717	-0.1261	0.005342

Table 10.5: Log Geometric Means (GM) of outdoor $PM_{2.5-10}$ concentrations ($\mu g/m^3$) by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
Sham	2.2617	2.2035	2.3199	9.5994	9.0567	10.1747
True	2.3220	2.2699	2.3742	10.1960	9.6784	10.7424
Pre	2.3350	2.2656	2.4045	10.3295	9.6369	11.0729

Pre- vs Post-installation Outdoor Air Main Effects Model: The outdoor $PM_{2.5-10}$ concentrations (log-transformed) at pre-installation did not differ significantly from those in true filtration (β=0.01 [95% CI: -0.06, 0.09], p=0.74) but were slightly higher compared with sham (0.01 [-0.01, 0.16], p=0.08) (Table 10.4). Outdoor $PM_{2.5-10}$ were slightly lower in sham than in true filtration (-0.06 [-0.13, 0.01], p=0.07). The geometric mean (GM) outdoor $PM_{2.5-10}$ levels at pre-installation, in sham, and in true filtration were 10.33 $\mu g/m^3$ [95% CI: 9.64, 11.07], 9.60 $\mu g/m^3$ [9.06, 10.17], and 10.20 $\mu g/m^3$ [9.68, 10.74], respectively (Table 10.4).

10b. Outdoor $PM_{2.5-10}$ concentrations

Table 10.6: Descriptive statistics for outdoor $PM_{2.5-10}$ concentrations (log-transformed) during pre-installation, sham and true filtration periods, stratified by city and season

		Log Outdoor PM 2.5-10 concentrations											
		Filtration status											
		SHAM						TRUE					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	36	1.6	0.48	1.4	1.2	1.8	35	1.7	0.46	1.7	1.6	1.9
	Spring	32	2.0	0.29	1.9	1.8	2.1	35	2.2	0.36	2.2	1.9	2.4
	Summer	35	2.8	0.49	2.8	2.6	3.0	43	2.9	0.30	2.8	2.6	3.1
	Fall	29	2.4	0.62	2.5	1.9	2.9	35	2.4	0.65	2.5	2.0	2.8
Riverside	Winter	10	2.1	0.45	2.0	1.9	2.3	18	2.2	0.57	2.2	1.7	2.7
	Spring	25	2.3	0.39	2.2	2.1	2.6	26	2.4	0.22	2.3	2.3	2.5
	Summer	18	2.5	0.27	2.5	2.4	2.7	19	2.3	0.35	2.3	2.1	2.5
	Fall	16	2.6	0.33	2.5	2.4	2.7	26	2.5	0.29	2.5	2.3	2.7

Stratified by city and season, the mean outdoor $PM_{2.5-10}$ concentrations did not differ between the pre-installation period compared with the sham and true filtration periods (Table 10.6).

Table 10.7: Mean differences of outdoor $PM_{2.5-10}$ concentrations ($\mu g/m^3$) for filtration status in the log-normal mixed-effects model

Filtration status	Estimate	SE	DF	t Value	Pr > |t|
Sham vs. True	-0.05664	0.03666	329	-1.54	0.1233

Table 10.8: Least squares means of outdoor $PM_{2.5-10}$ concentrations ($\mu g/m^3$) by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	2.2678	0.03374	9.6581	1.03432
TRUE	2.3245	0.03018	10.2216	1.03064

The outdoor $PM_{2.5-10}$ concentrations (log-transformed) are not significantly different between true and sham periods (β=-0.06 [SE=0.04], p=0.12) (Table 10.7). The geometric means (GM) of outdoor $PM_{2.5-10}$ concentrations during sham and true filtration periods were 9.66 $\mu g/m^3$ [1.03] and 10.22 $\mu g/m^3$ [1.03], respectively (Table 10.8).

11. Determine whether filtration type is associated with reflectance indoor/outdoor (I/O) ratios.

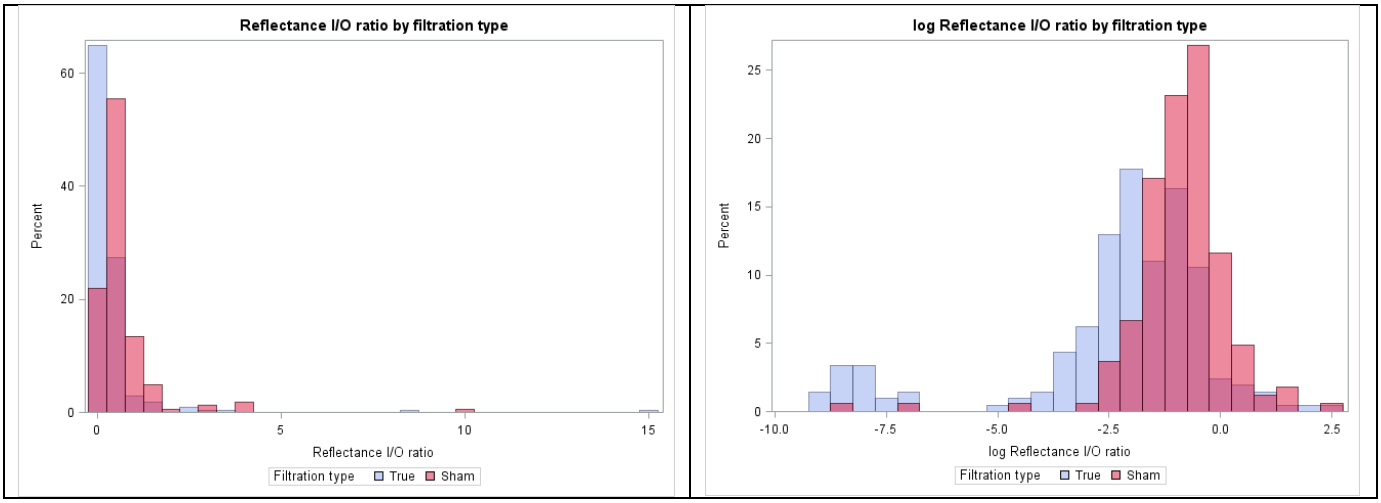


Figure 11.1: Distribution of Reflectance Indoor/Outdoor (I/O) ratios on the original scale (left) and log *e* scale (right)

The reflectance I/O ratios appear to be log-normally distributed; however, there is also evidence of a bimodal distribution.

Table 11.1: Descriptive statistics for reflectance indoor/outdoor ratios (log-transformed) in sham and true filtration, stratified by city and season

		Log Reflectance I/O Ratio											
		Filtration type											
		SHAM						TRUE					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	32	-0.9	0.91	-1.0	-1.4	-0.5	34	-3.0	2.68	-2.2	-3.5	-1.7
	Spring	30	-1.2	1.56	-1.0	-1.5	-0.4	29	-2.9	2.73	-1.8	-3.2	-1.2
	Summer	22	-1.5	1.72	-1.0	-2.0	-0.4	33	-2.6	2.38	-1.9	-2.7	-1.2
	Fall	20	-0.4	0.90	-0.4	-0.8	0.1	29	-1.8	2.57	-0.9	-2.3	-0.4
Riverside	Winter	10	-0.9	0.59	-0.9	-1.3	-0.4	17	-2.2	1.93	-1.9	-2.8	-1.1
	Spring	22	-0.6	0.83	-0.7	-1.2	-0.3	25	-1.7	1.78	-1.7	-2.1	-0.9
	Summer	15	-1.0	0.75	-1.0	-1.5	-0.4	19	-1.8	1.95	-1.1	-2.8	-0.8
	Fall	13	-0.6	0.71	-0.7	-1.1	-0.2	22	-2.0	0.97	-1.9	-2.5	-1.1

Stratified by city and season, the log mean reflectance indoor/outdoor (I/O) ratios appeared slightly higher in sham than in true filtration (Table 11.1).

Table 11.2: Parameter estimates for log-normal mixed-effects model examining whether reflectance indoor/outdoor (I/O) ratios differ by filtration type

Effect	City	Season	Filtration type	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Intercept				-2.1312	0.2396	136	-8.89	<.0001	-2.605	-1.6573
true			Sham	1.4789	0.1704	230	8.68	<.0001	1.1431	1.8147
true			True	0	.	.	.	.	.	.
season		Fall		0.4673	0.2355	230	1.98	0.0484	0.003327	0.9312
season		Summer		-0.07687	0.3001	230	-0.26	0.798	-0.6681	0.5143
season		Winter		-0.08324	0.2866	230	-0.29	0.7717	-0.6479	0.4814
season		Spring		0	.	.	.	.	.	.
area	Fresno			-0.4414	0.2218	230	-1.99	0.0478	-0.8785	-0.0044
area	Riverside			0	.	.	.	.	.	.

The reflectance I/O ratios were 4.39 times higher in sham than in true filtration (β=1.48 [95% CI: 1.14, 1.81], p<0.0001).

Table 11.3: Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
Sham	-0.7962	-0.9707	-0.6217	0.4510	0.3788	0.5370
True	-2.2751	-2.5979	-1.9523	0.1028	0.0744	0.1419

The reflectance I/O ratios were 4.39 times higher in sham than in true filtration (β=1.48 [95% CI: 1.14, 1.81], p<0.0001) (Table 11.2). The geometric mean (GM) reflectance I/O ratios in sham and true filtration were 0.45 [0.38, 0.54] and 0.10 [0.07, 0.14], respectively (Table 11.3).

Table 11.4: Filtration system by filtration type

	SHAM		TRUE	
Filtration system	n	%	n	%
Air cleaner	117	71.3	160	76.9
Central	47	28.7	48	23.1

The proportions of homes with air cleaners and central systems were similar by filtration type, as expected (Table 11.4). Approximately, 71% of households in sham and 77% in true filtration had air cleaners.

Table 11.5: Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x filtration system in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	1.5455	0.1872	228	8.25	<.0001	1.1766	1.9144
Central: Sham vs True	1.2500	0.3880	228	3.22	0.0015	0.4854	2.0145
Air Cleaner vs. Central diff in Sham vs. True diffs	0.2955	0.4294	228	0.69	0.4920	-0.5506	1.1417

The 2-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) was not statistically significant, indicating that the type of home filtration system did not modify the effect of sham versus true filtration on the reflectance I/O ratios (p=0.49). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes with air cleaners (β=1.55 [95% CI: 1.18, 1.91], p<0.0001) and homes with central systems (1.25 [0.49, 2.01], p=0.002) (Table 11.5). However, the difference between air cleaner and central system homes in sham vs. true log geometric mean differences in reflectance I/O ratios were not significantly different although slightly higher in air cleaner homes (0.30 [-0.55, 1.14],

p=0.49), indicating that improvements in air quality with true filtration did not vary much by the type of home filtration system.

Table 11.6: Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the filtration type x filtration system interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Log GM	95% CI		GM	95% CI	
Sham	Air Cleaner	-0.8271	-1.0137	-0.6404	0.4373	0.3629	0.5271
Sham	Central	-0.6877	-1.0909	-0.2845	0.5027	0.3359	0.7524
True	Air Cleaner	-2.3726	-2.7419	-2.0033	0.0932	0.0644	0.1349
True	Central	-1.9376	-2.6641	-1.2112	0.1440	0.0697	0.2978

The geometric means (GM) of reflectance I/O ratios are presented in Table 11.6. In homes with air cleaners, the GM reflectance I/O ratios in sham and true filtration were 0.44 [95% CI: 0.36, 0.53] and 0.09 [0.06, 0.13]. In homes with central systems, the GM reflectance I/O ratios in sham and true filtration were 0.50 [0.34, 0.75] and 0.14 [0.07, 0.30], respectively.

12. Determine whether filtration type is associated with indoor ozone concentrations (ppb) in homes with air cleaners only.

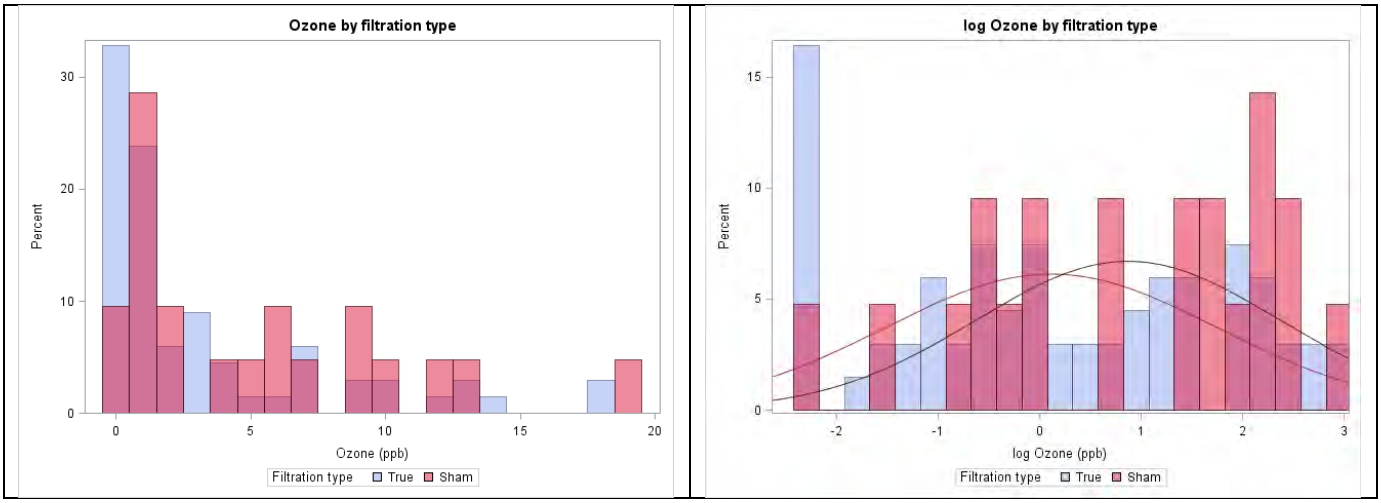


Figure 12.1: Distribution of indoor ozone concentrations (ppb) on the original scale (left) and log *e* scale (right)

Ozone concentrations appear to be log-normally distributed.

Table 12.1: Descriptive statistics for indoor ozone concentrations (log-transformed from ppb) in sham and true filtration, stratified by city and season

		Log indoor Ozone concentrations											
		Filtration type											
		SHAM						TRUE					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	.	.	.	.	.	.	.	.	.	.	.	.
	Spring	.	.	.	.	.	.	1	-0.2	.	-0.2	-0.2	-0.2
	Summer	5	1.3	1	1.8	0.6	1.9	35	0.2	1.61	0.4	-1.1	1.5
	Fall	8	0.2	1.42	-0.4	-0.6	1.5	6	0.4	1.61	0.6	-1.3	1.9
Riverside	Winter	.	.	.	.	.	.	.	.	.	.	.	.
	Spring	.	.	.	.	.	.	.	.	.	.	.	.
	Summer	.	.	.	.	.	.	.	.	.	.	.	.
	Fall	8	1.3	1.74	2	0.4	2.4	25	0	1.74	-0.2	-1.6	1.5

Stratified by city and season, the mean indoor ozone concentrations appeared slightly higher in sham than in true filtration (Table 12.1). Note that there were only 21 measurements taken in sham and 67 in true filtration.

Table 12.2: Parameter estimates for log-normal mixed-effects model examining whether indoor ozone concentrations (ppb) differ by filtration type

Effect	City	Filtration type	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept			-0.01709	0.3588	76	-0.05	0.9621	-0.7318	0.6976
True		Sham	0.4224	0.3355	9	1.26	0.2397	-0.3365	1.1813
True		True	0	.	.	.	.	.	.
Area	Fresno		0.2411	0.4178	9	0.58	0.578	-0.704	1.1863
Area	Riverside		0	.	.	.	.	.	.

The sham vs. true filtration differences in log geometric mean indoor ozone levels were not statistically significant (β=0.42 [95% CI: -0.34, 1.18], p=0.24).

Table 12.3: Log Geometric Means (GM) of ozone concentrations (ppb) by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
Sham	0.5259	-0.2509	1.3027	1.6920	0.7781	3.6792
True	0.1035	-0.3865	0.5935	1.1090	0.6794	1.8103

The sham vs. true filtration differences in log geometric mean indoor ozone levels were not statistically significant (β=0.42 [95% CI: -0.34, 1.18], p=0.24) (Table 12.2). The geometric mean (GM) indoor ozone concentrations (ppb) in sham and true filtration were 1.69 ppb [0.78, 3.68] and 1.11 ppb [0.68, 1.81], respectively (Table 12.3).

13. Determine whether filtration type is associated with ozone indoor/outdoor (I/O) ratios in homes with air cleaners only.

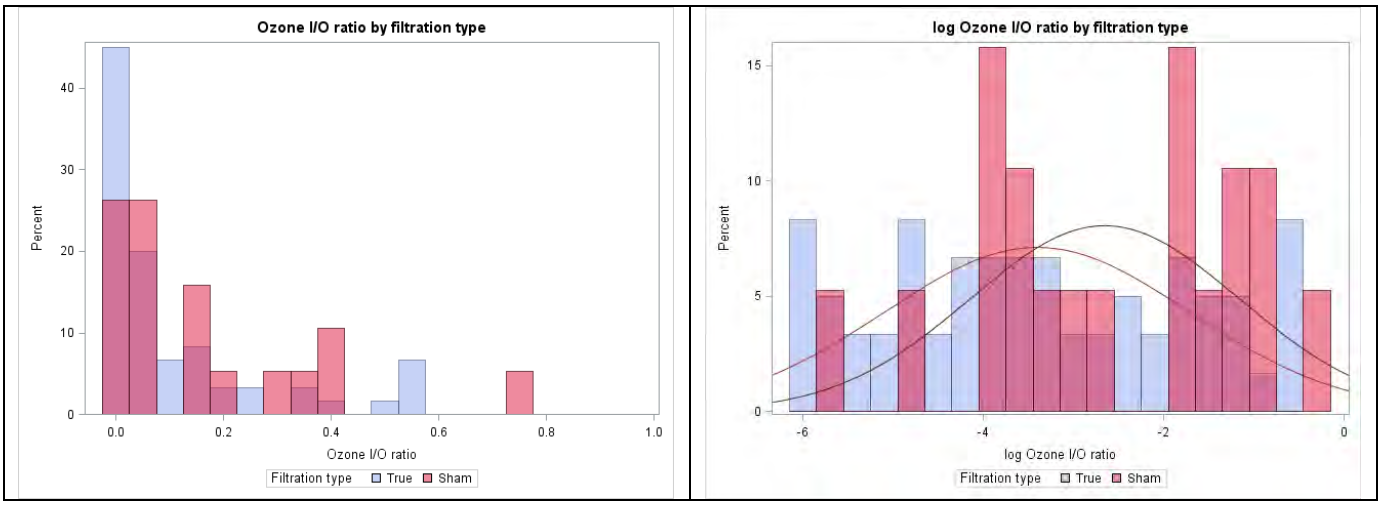


Figure 13.1: Distribution of ozone indoor/outdoor (I/O) ratios on the original scale (left) and log *e* scale (right)

Ozone I/O ratios appear to be log-normally distributed.

Table 13.1: Descriptive statistics for ozone indoor/outdoor (I/O) ratios (log-transformed) in sham and true filtration, stratified by city and season

		Log Ozone I/O ratio											
		Filtration type											
		SHAM						TRUE					
City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Fresno	Winter	.	.	.	.	.	.	.	.	.	.	.	.
	Spring	.	.	.	.	.	.	1	-4	.	-4	-4	-4
	Summer	4	-2.5	1.07	-2.5	-3.4	-1.6	28	-3.4	1.53	-3.3	-4.6	-2.3
	Fall	8	-3	1.36	-3.4	-3.9	-1.8	6	-2.9	1.83	-2.7	-4.9	-1.6
Riverside	Winter	.	.	.	.	.	.	.	.	.	.	.	.
	Spring	.	.	.	.	.	.	.	.	.	.	.	.
	Summer	.	.	.	.	.	.	.	.	.	.	.	.
	Fall	7	-2.4	1.91	-1.9	-3.8	-0.9	25	-3.5	1.89	-3.8	-5.3	-1.8

Stratified by city and season, the mean ozone I/O ratios appeared to be similar between sham and true filtration (Table 13.1). Note that there were only 19 measurements taken in sham and 60 in true filtration.

Table 13.2: Parameter estimates for log-normal mixed-effects model examining whether ozone indoor/outdoor (I/O) ratios differ by filtration type

Effect	City	Filtration type	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept			-3.5009	0.3862	68	-9.06	<.0001	-4.2715	-2.7302
True		Sham	0.4353	0.371	8	1.17	0.2744	-0.4202	1.2907
True		True	0	.	.	.	.	.	.
Area	Fresno		0.1998	0.4469	8	0.45	0.6667	-0.8308	1.2303
Area	Riverside		0	.	.	.	.	.	.

The sham vs. true filtration differences in log geometric mean ozone I/O ratios were not statistically significant (β=0.44 [95% CI: -0.42, 1.29], p=0.27).

Table 13.3: Log Geometric Means (GM) of ozone indoor/outdoor (I/O) ratios by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
Sham	-2.9657	-3.8070	-2.1244	0.0515	0.0222	0.1195
True	-3.4010	-3.9432	-2.8587	0.0333	0.0194	0.0573

The sham vs. true filtration differences in log geometric mean ozone I/O ratios were not statistically significant (β=0.44 [95% CI: -0.42, 1.29], p=0.27) (Table 13.2). The geometric mean (GM) ozone I/O ratios in sham and true filtration were 0.05 [0.02, 0.12] and 0.03 [0.02, 0.06] (Table 13.3).

F.3 Air Pollution Interaction Analyses

Interaction terms with *P* values less than 0.20 were considered broadly significant; and so, associations between the filtration status (or another exposure) and indoor air pollution measurements were further evaluated and described at the various levels of any moderating factors identified as broadly significant based on this definition. For pair-wise comparisons at a particular level of the moderating factor (or combination of factors), *P* values greater than 0.05 but less than 0.20 were described as approaching significance or marginally significant whereas *P* values less than 0.05 indicated statistical significance at the α=0.05 level. Given the likely possibility of low power in analyses with interaction terms (especially those containing 3-way interaction terms), the usual statistical significance thresholds were slackened. Despite this loosened definition of significance, all results with *P* values greater than 0.05 should be interpreted with caution.

Analyses to examine potential moderators:

- Days per week windows were open >2 hours: almost always [6-7 days], sometimes [2-5 days] vs. rarely [<2 days]
- Smoking indoors, frying/sautéing, and/or burning fire (wood, candles, incense) as sources of PM (presented as sum of days per week of each source, maximum 21 days): significant source [5+ days], moderate [3-4 days] vs. not significant [<3 days]
- Year the home was built: Before 1977 vs. 1977 or later
- Presence of gas stove in the home
- Proximity to roadway: <1 block (<360 ft), 1 block, 2-4 blocks, 5+ blocks
- Filtration utilization (proportion of volume normalized to what asked to use), continuous
- Outdoor PM concentrations, continuous (indoor $PM_{0.2}$ and $PM_{2.5}$ only)
- Filtration fraction (fraction of the volume of air in the home that is cleaned every hour) (indoor $PM_{0.2}$ and $PM_{2.5}$ only)

The base model includes the TRUE x INTERVENTION interaction term, as it was determined that type of intervention significantly modifies the relationship between filtration status and indoor PM measurements. Covariates included in all models are city and season and Household ID is specified as the random effect. The interaction analyses below explore whether additional factors further modify the filtration status and indoor air pollution relationship with 3-way interaction terms included in these models. The outcome variables used in these analyses are indoor $PM_{0.2}$, $PM_{2.5}$, and $PM_{0.2\text{-}2.5}$.

1. Compare whether the number of days windows were open >2 hours per week modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations
   c. Indoor $PM_{0.2\text{-}2.5}$ concentrations

2. Compare whether the number of days one or more of the following occurred: smoking indoors, frying/sautéing, or burning fire (wood, candles, incense) as a sum of days per week modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations

c. Indoor $PM_{0.2-2.5}$ concentrations

3. Compare whether the age of the home modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations
   c. Indoor $PM_{0.2-2.5}$ concentrations

4. Compare whether having a gas stove modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations
   c. Indoor $PM_{0.2-2.5}$ concentrations

5. Compare whether the proximity to a major roadway modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations
   c. Indoor $PM_{0.2-2.5}$ concentrations
   d. Indoor $PM_{0.2}$ concentrations, dichotomized at 5 blocks
   e. Indoor $PM_{2.5}$ concentrations, dichotomized at 5 blocks
   f. Indoor $PM_{0.2-2.5}$ concentrations, dichotomized at 5 blocks

6. Compare whether filtration utilization (proportion of volume normalized to what asked to use) modifies the association between indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations
   c. Indoor $PM_{0.2-2.5}$ concentrations

7. Compare whether outdoor PM concentrations modify the association between corresponding indoor PM concentrations in sham vs. true filtration periods
   a. Indoor $PM_{0.2}$ concentrations
   b. Indoor $PM_{2.5}$ concentrations

8. Compare whether the filtration fraction (fraction of the volume of air in the home that is cleaned every hour) modifies the association between indoor PM concentrations in sham vs. true filtration periods
    a. Indoor $PM_{0.2}$ concentrations
    b. Indoor $PM_{2.5}$ concentrations
    c. Indoor $PM_{0.2\text{-}2.5}$ concentrations (comparing pre-installation vs. true filtration at 12 months)
9. Compare whether the number of days windows were open >2 hours per week modifies the association between indoor/ outdoor reflectance ratios in sham vs. true filtration periods
10. Compare whether the proximity to a major roadway modifies the association indoor/ outdoor reflectance ratios in sham vs. true filtration periods
    a. Dichotomized at 5 blocks
11. Compare whether filtration utilization (proportion of volume normalized to what asked to use) modifies the association between indoor/ outdoor reflectance ratios in sham vs. true filtration periods

1. Compare whether the number of days windows were open >2 hours per week modifies the association between indoor PM concentrations in sham vs. true filtration periods

   Moderator: The number of days per week windows were open >2 hours was categorized as almost always [6-7 days], sometimes [2-5 days] vs. rarely [<2 days].

   The moderator was also modeled as a continuous variable, but the results did not differ notably (results not shown).

Table 1.1: Number of days per week had open windows for >2 hours by filtration type

	SHAM		TRUE	
Days/week had open windows >2 hours	**n**	**%**	**n**	**%**
Rarely open (<2 days)	130	55.1	139	49.5
Sometimes open (2-5 days)	44	18.6	62	22.1
Almost always open (6-7 days)	62	26.3	80	28.5

The number of days that windows were open for more than 2 hours was similar by filtration type, as expected.

1.a. Indoor $PM_{0.2}$ concentrations:

Table 1.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x window usage (TRUE × WINDOWS), filtration system x window usage (HVAC × WINDOWS), and filtration type x filtration system x window usage (TRUE × HVAC × WINDOWS)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	318	77.33	<.0001
hvac_ac	1	318	0.32	0.5748
sd_winopen_n	2	318	3.28	0.0388
true*hvac_ac	1	318	5.67	0.0178
true*sd_winopen_n	2	318	2.25	0.1067
hvac_ac*sd_winopen_n	2	318	0.02	0.9848
true*hvac_ac*sd_wino	2	318	0.07	0.9296
season	3	318	6.41	0.0003
area	1	318	4.41	0.0364

Table 1.3: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Always open, Air Cleaner: Sham vs True	0.5523	0.1095	318	5.04	<.0001	0.3368	0.7678
Always open, Central: Sham vs True	0.1941	0.2067	318	0.94	0.3483	-0.2125	0.6008
Always open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.3582**	**0.2315**	**318**	**1.55**	**0.1228**	**-0.09727**	**0.8136**
Sometimes open, Air Cleaner: Sham vs True	0.8167	0.1314	318	6.21	<.0001	0.5581	1.0753
Sometimes open, Central: Sham vs True	0.5334	0.2115	318	2.52	0.0122	0.1172	0.9496
Sometimes open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2833**	**0.2487**	**318**	**1.14**	**0.2556**	**-0.2061**	**0.7727**
Rarely open, Air Cleaner: Sham vs True	0.7580	0.07744	318	9.79	<.0001	0.6056	0.9103
Rarely open, Central: Sham vs True	0.5001	0.1033	318	4.84	<.0001	0.2968	0.7033
Rarely open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2579**	**0.1287**	**318**	**2**	**0.0459**	**0.004772**	**0.5110**
Always vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.1003**	**0.2631**	**318**	**0.38**	**0.7033**	**-0.4173**	**0.6179**
Sometimes vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.02542**	**0.2821**	**318**	**0.09**	**0.9283**	**-0.5296**	**0.5804**

Table 1.4: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Almost always open	0.8553	0.7034	1.0072	2.3521	2.0206	2.7379
Sham	Air cleaner	Sometimes open	0.9911	0.7876	1.1946	2.6942	2.1981	3.3022
Sham	Air cleaner	Rarely open	0.8120	0.6825	0.9414	2.2524	1.9788	2.5636
Sham	Central	Almost always open	0.7048	0.3950	1.0146	2.0234	1.4844	2.7583
Sham	Central	Sometimes open	0.9033	0.6568	1.1498	2.4677	1.9286	3.1576
Sham	Central	Rarely open	0.7342	0.5996	0.8689	2.0838	1.8214	2.3843
True	Air cleaner	Almost always open	0.3030	0.1295	0.4765	1.3539	1.1383	1.6104
True	Air cleaner	Sometimes open	0.1744	-0.0221	0.3708	1.1905	0.9782	1.4489
True	Air cleaner	Rarely open	0.0540	-0.1004	0.2084	1.0555	0.9045	1.2317
True	Central	Almost always open	0.5107	0.2482	0.7732	1.6665	1.2817	2.1667
True	Central	Sometimes open	0.3699	0.0177	0.7221	1.4476	1.0179	2.0588
True	Central	Rarely open	0.2341	0.0297	0.4386	1.2638	1.0301	1.5505

During both sham and true filtration periods, 26-29% of households reported almost always having windows open >2 hours (6-7 days per week), 19-22% of households sometimes opened windows (2-5 days per week), and 50-55% households rarely opened windows (0-1 days per week) (Table 1.1). The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x frequency of keeping windows open >2 hours (almost always, sometimes vs. rarely) was not statistically significant, indicating that the frequency of keeping windows open did not change the effect of sham versus true filtration or the effect of using an air cleaner versus central filtration on the indoor $PM_{0.2}$ concentrations (p=0.93) (Tables 1.2).

In homes with air cleaners that almost always kept their windows open for >2 hours, indoor $PM_{0.2}$ concentrations (log-transformed) were 1.74 times higher in sham than in true filtration (β=0.55 [95% CI: 0.34, 0.77], p<0.0001); while in homes with central systems and the same frequency of window usage, the sham-true differences in log geometric means of $PM_{0.2}$ concentrations were not significantly

different (0.19 [-0.21, 0.60], p=0.35) (Table 1.3). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.14 [-0.10, 0.81], p=0.12), showing that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In homes with air cleaners that sometimes kept their windows open, $PM_{0.2}$ concentrations were 2.26 times higher in sham than in true filtration (0.82 [0.56, 1.08], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{0.2}$ concentrations were 1.70 times higher in sham (0.53 [0.12, 0.95], p=0.01). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.28 [-0.21, 0.77], p=0.26), indicating minimal differences between air cleaner and central system interventions in the magnitude of air quality improvements with true filtration.

In homes with air cleaners that rarely kept their windows open, $PM_{0.2}$ concentrations were 2.13 times higher in sham than in true filtration (0.76 [0.61, 0.91], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{0.2}$ concentrations were 1.65 times higher in sham (0.50 [0.30, 0.70], p<0.0001). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was significant (0.26 [0.00, 0.51], p=0.05), showing that the improvements in air quality with true filtration were greater by 29% in homes with air cleaners than in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes that always vs. rarely opened windows were not significantly different (0.10 [-0.42, 0.62], p=0.70). Similarly, the differences in the sham-true log geometric mean differences between air cleaner and central system homes that sometimes vs. rarely opened windows were not significant (0.03[-0.53, 0.58], p=0.93). In other words, the effects of filtration system and filtration type on indoor $PM_{0.2}$ levels did not vary much by window usage frequency.

The geometric means (GM) of indoor $PM_{0.2}$ concentrations are presented in Table 1.4. During the sham period in homes with air cleaners, the GMs of $PM_{0.2}$ in households that always, sometimes or rarely opened windows were 2.35 $\mu g/m^3$ [2.02, 2.74], 2.69 $\mu g/m^3$ [2.19, 3.30], and 2.25 $\mu g/m^3$ [1.98, 2.56], respectively. During the sham period in homes with central systems, the GMs of $PM_{0.2}$ in households that always, sometimes or rarely opened windows were 2.02 $\mu g/m^3$ [1.48, 2.76], 2.47 $\mu g/m^3$ [1.93, 3.16], and 2.08 $\mu g/m^3$ [1.82, 2.38], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{0.2}$ in households that always, sometimes or rarely opened windows were 1.35 $\mu g/m^3$ [1.14, 1.61], 1.19 $\mu g/m^3$ [0.98, 1.45], and 1.06 $\mu g/m^3$ [0.90, 1.23], respectively. During the true filtration period in homes with central filtration, the GMs of $PM_{0.2}$ in households that always, sometimes or rarely opened windows were 1.67 $\mu g/m^3$ [1.28, 2.17], 1.45 $\mu g/m^3$ [1.02, 2.06], and 1.26 $\mu g/m^3$ [1.03, 1.55], respectively.

1.b. Indoor $PM_{2.5}$ concentrations:

Table 1.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x window usage (TRUE × WINDOWS), filtration system x window usage (HVAC × WINDOWS), and filtration type x filtration system x window usage (TRUE × HVAC × WINDOWS)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	310	65.93	<.0001
hvac_ac	1	310	0.03	0.8571
sd_winopen_n	2	310	1.67	0.1894
true*hvac_ac	1	310	3	0.0841
true*sd_winopen_n	2	310	0.8	0.4516
hvac_ac*sd_winopen_n	2	310	0.14	0.8703
true*hvac_ac*sd_wino	2	310	0.2	0.8212
season	3	310	9.15	<.0001
area	1	310	1.11	0.2935

Table 1.6: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Always open, Air Cleaner: Sham vs True	0.5433	0.1146	310	4.74	<.0001	0.3178	0.7688
Always open, Central: Sham vs True	0.3609	0.239	310	1.51	0.1320	-0.1093	0.8311
Always open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.1824**	**0.2632**	**310**	**0.69**	**0.4888**	**-0.3354**	**0.7002**
Sometimes open, Air Cleaner: Sham vs True	0.7471	0.1334	310	5.6	<.0001	0.4847	1.0096
Sometimes open, Central: Sham vs True	0.3847	0.2105	310	1.83	0.0686	-0.02947	0.7988
Sometimes open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.3625**	**0.2491**	**310**	**1.45**	**0.1467**	**-0.1277**	**0.8527**
Rarely open, Air Cleaner: Sham vs True	0.748	0.0788	310	9.49	<.0001	0.5929	0.9030
Rarely open, Central: Sham vs True	0.5719	0.167	310	3.43	0.0007	0.2434	0.9004
Rarely open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.1761**	**0.1863**	**310**	**0.95**	**0.3452**	**-0.1904**	**0.5426**
Always vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.006305**	**0.32**	**310**	**0.02**	**0.9843**	**-0.6233**	**0.6360**
Sometimes vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.1864**	**0.3269**	**310**	**0.57**	**0.5690**	**-0.4569**	**0.8296**

Table 1.7: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Almost always open	1.9252	1.7692	2.0812	6.8565	5.8662	8.0141
Sham	Air cleaner	Sometimes open	1.9903	1.7866	2.1940	7.3177	5.9691	8.9710
Sham	Air cleaner	Rarely open	1.8695	1.7379	2.0011	6.4851	5.6854	7.3972
Sham	Central	Almost always open	1.8483	1.4803	2.2164	6.3490	4.3943	9.1742
Sham	Central	Sometimes open	1.7880	1.5220	2.0541	5.9775	4.5814	7.7998
Sham	Central	Rarely open	1.8393	1.6636	2.0151	6.2921	5.2783	7.5015
True	Air cleaner	Almost always open	1.3819	1.1966	1.5672	3.9825	3.3088	4.7932
True	Air cleaner	Sometimes open	1.2432	1.0477	1.4386	3.4667	2.8511	4.2148
True	Air cleaner	Rarely open	1.1215	0.9551	1.2879	3.0695	2.5989	3.6252
True	Central	Almost always open	1.4874	1.1880	1.7869	4.4256	3.2805	5.9709
True	Central	Sometimes open	1.4034	1.0303	1.7765	4.0690	2.8019	5.9091
True	Central	Rarely open	1.2674	0.9562	1.5787	3.5516	2.6018	4.8486

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x frequency of keeping windows open >2 hours (almost always, sometimes vs. rarely) was not statistically significant, indicating that the frequency of keeping windows open did not change the effect of sham versus true filtration or the effect of using an air cleaner versus central filtration on the indoor $PM_{2.5}$ concentrations (p=0.82) (Tables 1.5).

In homes with air cleaners that almost always kept their windows open for >2 hours, indoor $PM_{2.5}$ concentrations (log-transformed) were 1.72 times higher in sham than in true filtration (β=0.54 [95% CI: 0.32, 0.77], p<0.0001); while in homes with central systems and the same frequency of window usage, the sham-true differences in log geometric means of $PM_{2.5}$ concentrations were not significantly different (0.36 [-0.11, 0.83], p=0.13) (Table 1.6). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.18 [-0.34, 0.70], p=0.49), showing that the improvements in air quality with true filtration were similar in homes with air cleaners and in homes with central filtration.

In homes with air cleaners that sometimes kept their windows open, $PM_{2.5}$ concentrations were 2.11 times higher in sham than in true filtration (0.75 [0.48, 1.01], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{2.5}$ concentrations were 1.47 times higher in sham (0.38 [-0.03, 0.80], p=0.07). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.36 [-0.13, 85], p=0.15), indicating minimal differences between air cleaner and central system interventions in the magnitude of air quality improvements with true filtration.

In homes with air cleaners that rarely kept their windows open, $PM_{0.2}$ concentrations were 2.11 times higher in sham than in true filtration (0.75 [0.59, 0.90], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{2.5}$ concentrations were 1.77 times higher in sham (0.57 [0.24, 0.90], p=0.001). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.18 [-0.19, 0.54], p=0.35), showing that the improvements in air quality with true filtration were similar in homes with air cleaners and in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes that always vs. rarely opened windows were not significantly different (0.01 [-0.62, 0.64], p=0.98).

Similarly, the differences in the sham-true log geometric mean differences between air cleaner and central system homes that sometimes vs. rarely opened windows were not significant 0.19 [-0.46, 0.83], p=0.57). In other words, the effects of filtration system and filtration type on indoor $PM_{2.5}$ levels did not vary by window usage frequency.

The geometric means (GM) of indoor $PM_{2.5}$ concentrations are presented in Table 1.7. During the sham period in homes with air cleaners, the GMs of $PM_{2.5}$ in households that always, sometimes or rarely opened windows were 6.86 $\mu g/m^3$ [5.87, 8.01], 7.32 $\mu g/m^3$ [5.97, 8.97], and 6.49 $\mu g/m^3$ [5.69, 7.40], respectively. During the sham period in homes with central systems, the GMs of $PM_{2.5}$ in households that always, sometimes or rarely opened windows were 6.35 $\mu g/m^3$ [4.39, 9.17], 5.98 $\mu g/m^3$ [4.58, 7.80], and 6.29 $\mu g/m^3$ [5.28, 7.50], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{2.5}$ in households that always, sometimes or rarely opened windows were 3.98 $\mu g/m^3$ [3.31, 4.79], 3.47 $\mu g/m^3$ [2.85, 4.21], and 3.07 $\mu g/m^3$ [2.60, 3.63], respectively. During the true filtration period in homes with central filtration, the GMs of $PM_{2.5}$ in households that always, sometimes or rarely opened windows were 4.43 $\mu g/m^3$ [3.28, 5.97], 4.07 $\mu g/m^3$ [2.80, 5.91], and 3.55 $\mu g/m^3$ [2.60, 4.85], respectively.

1.c. Indoor $PM_{0.2\text{-}2.5}$ concentrations:

Table 1.8: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x window usage (TRUE × WINDOWS), filtration system x window usage (HVAC × WINDOWS), and filtration type x filtration system x window usage (TRUE × HVAC × WINDOWS)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	342	63.62	<.0001
hvac_ac	1	342	0.11	0.7442
sd_winopen_n	2	342	1.43	0.2411
true*hvac_ac	1	342	4.3	0.0388
true*sd_winopen_n	2	342	0.33	0.7193
hvac_ac*sd_winopen_n	2	342	1.14	0.3225
true*hvac_ac*sd_wino	2	342	0.45	0.6372
season	3	342	17.91	<.0001
area	1	342	1.89	0.1698

Table 1.9: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Always open, Air Cleaner: Sham vs True	0.4276	0.09437	342	4.53	<.0001	0.2420	0.6132
Always open, Central: Sham vs True	0.3478	0.1884	342	1.85	0.0658	-0.02289	0.7184
Always open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.07984**	**0.2099**	**342**	**0.38**	**0.7038**	**-0.3329**	**0.4926**
Sometimes open, Air Cleaner: Sham vs True	0.5794	0.1089	342	5.32	<.0001	0.3652	0.7937
Sometimes open, Central: Sham vs True	0.2558	0.1722	342	1.49	0.1383	-0.08285	0.5944
Sometimes open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.3237**	**0.2041**	**342**	**1.59**	**0.1137**	**-0.07774**	**0.7251**
Rarely open, Air Cleaner: Sham vs True	0.6156	0.06229	342	9.88	<.0001	0.4930	0.7381
Rarely open, Central: Sham vs True	0.3492	0.1023	342	3.41	0.0007	0.1479	0.5505
Rarely open: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2663**	**0.1198**	**342**	**2.22**	**0.0268**	**0.03076**	**0.5019**
Always vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.1865**	**0.2356**	**342**	**-0.79**	**0.4292**	**-0.6500**	**0.2770**
Sometimes vs. Rarely open diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.05732**	**0.2490**	**342**	**0.23**	**0.8181**	**-0.4325**	**0.5471**

Table 1.10: Log Geometric Means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × WINDOWS interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Almost always open	1.7721	1.6355	1.9087	5.8832	5.1320	6.7443
Sham	Air cleaner	Sometimes open	1.7978	1.6000	1.9956	6.0364	4.9530	7.3566
Sham	Air cleaner	Rarely open	1.6694	1.5454	1.7934	5.3090	4.6898	6.0099
Sham	HVAC	Almost always open	1.6572	1.3177	1.9967	5.2446	3.7348	7.3647
Sham	HVAC	Sometimes open	1.5458	1.3108	1.7808	4.6917	3.7091	5.9346
Sham	HVAC	Rarely open	1.6157	1.4359	1.7955	5.0314	4.2034	6.0225
True	Air cleaner	Almost always open	1.3445	1.1897	1.4993	3.8363	3.2861	4.4786
True	Air cleaner	Sometimes open	1.2184	1.0750	1.3617	3.3818	2.9300	3.9028
True	Air cleaner	Rarely open	1.0538	0.9214	1.1863	2.8685	2.5128	3.2749
True	HVAC	Almost always open	1.3094	1.0480	1.5709	3.7040	2.8519	4.8110
True	HVAC	Sometimes open	1.2900	0.9826	1.5974	3.6328	2.6714	4.9402
True	HVAC	Rarely open	1.2665	1.0557	1.4772	3.5484	2.8740	4.3807

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x frequency of keeping windows open >2 hours (almost always, sometimes vs. rarely) was not statistically significant, indicating that the frequency of keeping windows open did not change the effect of sham versus true filtration or the effect of using an air cleaner versus central filtration on the indoor $PM_{0.2\text{-}2.5}$ concentrations (p=0.64) (Tables 1.8).

In homes with air cleaners that almost always kept their windows open for >2 hours, indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.53 times higher in sham than in true filtration (β=0.43 [95% CI: 0.24, 0.61], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{0.2\text{-}2.5}$ concentrations were 1.42 times higher in sham (0.35 [-0.02, 0.72], p=0.07) (Table 1.9). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.08 [-0.33, 0.49], p=0.70), showing that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In homes with air cleaners that sometimes kept their windows open, $PM_{0.2\text{-}2.5}$ concentrations were 1.78 times higher in sham than in true filtration (0.58 [0.37, 0.79], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{0.2\text{-}2.5}$ concentrations were not significantly different by filtration type (0.26 [-0.08, 0.59], p=0.14). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.32 [-0.08, 0.73], p=0.11), indicating little variation in the magnitude of air quality improvement between air cleaner and central system interventions; nevertheless, the sham-true log geometric mean differences were slightly greater in homes with air cleaners.

In homes with air cleaners that rarely kept their windows open, $PM_{0.2\text{-}2.5}$ concentrations were 1.85 times higher in sham than in true filtration (0.62 [0.49, 0.74], p<0.0001); while in homes with central systems and the same frequency of window usage, $PM_{0.2\text{-}2.5}$ concentrations were 1.42 times higher in sham (0.35 [0.15, 0.55], p=0.001). At this frequency of window usage, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was significant (0.27 [0.03, 0.50], p=0.03), showing that the improvements in air quality with true filtration were greater by 31% in homes with air cleaners than in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes that always vs. rarely opened windows were not significantly different (-0.19 [-0.65, 0.28], p=0.43). Similarly, the differences in the sham-true log geometric mean differences between air cleaner and central system homes that sometimes vs. rarely opened windows were not significant (0.06 [-0.43, 0.55], p=0.82). In other words, the effects of filtration system and filtration type on indoor $PM_{0.2\text{-}2.5}$ levels did not vary much by window usage frequency.

The geometric means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations are presented in Table 1.10. During the sham period in homes with air cleaners, the GMs of $PM_{0.2\text{-}2.5}$ in households that always, sometimes or rarely opened windows were 5.88 $\mu g/m^3$ [5.13, 6.74], 6.04 $\mu g/m^3$ [4.95, 7.36], and 5.31 $\mu g/m^3$ [4.69, 6.01], respectively. During the sham period in homes with central systems, the GMs of $PM_{0.2\text{-}2.5}$ in households that always, sometimes or rarely opened windows were 5.24 $\mu g/m^3$ [3.73, 7.36], 4.69 $\mu g/m^3$ [3.71, 5.93], and 5.03 $\mu g/m^3$ [4.20, 6.02], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{0.2\text{-}2.5}$ in households that always, sometimes or rarely opened windows were 3.84 $\mu g/m^3$ [3.29, 4.48], 3.38 $\mu g/m^3$ [2.93, 3.90], and 2.87 $\mu g/m^3$ [2.51, 3.27], respectively. During the true filtration period in homes with central filtration, the GMs of $PM_{0.2\text{-}2.5}$ in households that always, sometimes or rarely opened windows were 3.70 $\mu g/m^3$ [2.85, 4.81], 3.63 $\mu g/m^3$ [2.67, 4.94], and 3.55 $\mu g/m^3$ [2.87, 4.38], respectively.

2. Compare whether the number of days one or more of the following occurred: smoking indoors, frying/sautéing, or burning fire (wood, candles, incense) as a sum of days per week modifies the association between indoor PM concentrations in sham vs. true filtration periods

Table 2.1: Sum of days (max 21) that smoked inside, fried/sautéed food, or burned fire (wood, candles, incense) by filtration type

Sum of days/week that smoked, fried/sautéed, or burned fire	SHAM		TRUE	
	n	%	n	%
Not significant (<3 days)	134	56.78	149	53.2
Moderate (3-4 days)	46	19.49	58	20.7
Significant (5+ days)	56	23.73	73	26.1

The sum of days (max 21) that anyone smoked indoors, fried/sautéed food, or burned fire (wood, candles, incense) was similar by filtration type, as expected.

2.a. Indoor $PM_{0.2}$ concentrations:

Table 2.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x burning source (TRUE × BURN), filtration system x burning source (HVAC × BURN), and filtration type x filtration system x burning source (TRUE × HVAC × BURN)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	317	77.56	<.0001
hvac_ac	1	317	0.98	0.324
SUM_SMOKE_FRY_BURN_N	2	317	6.31	0.002
true*hvac_ac	1	317	2.23	0.1364
true*SUM_SMOKE_FRY_BURN_N	2	317	0.11	0.8993
hvac_ac*SUM_SMOKE_FRY_BURN_N	2	317	1.08	0.3413
true*hvac_ac*SUM_SMOKE_FRY_BURN_N	2	317	0.08	0.9273
season	3	317	5.52	0.0011
area	1	317	3.39	0.0664

Table 2.3: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Significant source, Air Cleaner: Sham vs True	0.6787	0.1716	317	3.95	<.0001	0.341	1.0164
Significant source, Central: Sham vs True	0.5240	0.1387	317	3.78	0.0002	0.2511	0.7969
Significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.1547**	**0.2207**	**317**	**0.7**	**0.4838**	**-0.2795**	**0.5890**
Moderate source, Air Cleaner: Sham vs True	0.6484	0.1092	317	5.94	<.0001	0.4337	0.8632
Moderate source, Central: Sham vs True	0.4455	0.2944	317	1.51	0.1311	-0.1336	1.0247
Moderate source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2029**	**0.3188**	**317**	**0.64**	**0.5249**	**-0.4243**	**0.8301**
Not significant source, Air Cleaner: Sham vs True	0.7473	0.07257	317	10.3	<.0001	0.6046	0.8901
Not significant source, Central: Sham vs True	0.4981	0.09249	317	5.39	<.0001	0.3162	0.6801
Not significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2492**	**0.1172**	**317**	**2.13**	**0.0342**	**0.01864**	**0.4797**
Significant vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.09445**	**0.2468**	**317**	**-0.38**	**0.7022**	**-0.5801**	**0.3911**
Moderate vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.04629**	**0.3431**	**317**	**-0.13**	**0.8928**	**-0.7213**	**0.6287**

Table 2.4: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Moderate	0.8602	0.6963	1.0242	2.3636	2.0063	2.7849
Sham	Air cleaner	Significant	0.9605	0.7281	1.1929	2.6130	2.0711	3.2966
Sham	Air cleaner	Not significant	0.8176	0.6919	0.9434	2.2651	1.9975	2.5687
Sham	Central	Moderate	0.8624	0.5283	1.1965	2.3688	1.6960	3.3085
Sham	Central	Significant	1.0829	0.8284	1.3374	2.9532	2.2897	3.8091
Sham	Central	Not significant	0.6466	0.4882	0.8049	1.9090	1.6294	2.2365
True	Air cleaner	Moderate	0.2118	0.0138	0.4098	1.2359	1.0138	1.5065
True	Air cleaner	Significant	0.2817	0.0453	0.5182	1.3254	1.0463	1.6790
True	Air cleaner	Not significant	0.0703	-0.0780	0.2185	1.0728	0.9250	1.2442
True	Central	Moderate	0.4169	-0.0712	0.9050	1.5173	0.9313	2.4719
True	Central	Significant	0.5589	0.2903	0.8276	1.7487	1.3368	2.2878
True	Central	Not significant	0.1484	-0.0286	0.3254	1.1600	0.9718	1.3846

During both sham and true filtration periods, 24-26% of households reported significant sources of indoor PM, defined as smoking indoors, frying/sautéing, or burning fire (wood, candles, or incense) (5 or more days, where maximum was 21 days), 19-21% of households had moderate sources of indoor PM (3-4 days out of 21), and 53-57% of households reported non-significant sources of indoor PM (0-1 days per week) (Table 2.1). The 3-way interaction term filtration type x filtration system x burning source (TRUE × HVAC × BURN) was not statistically significant, indicating that the frequency of indoor smoking, frying/sautéing, or burning fire (wood, candles, or incense) did not change the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2}$ concentrations (p=0.93) (Table 2.2).

In homes with air cleaners that had significant sources of burning (5+ days out of 21), indoor $PM_{0.2}$ concentrations (log-transformed) were 1.97 times higher in sham than in true filtration (β=0.68 [95%

CI: 0.34, 1.02], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2}$ concentrations were 1.69 times higher in sham (0.52 [0.25, 0.80], p=0.0002) (Table 2.3). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.15 [-0.28, 0.59], p=0.48), showing that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In homes with air cleaners and moderate sources of burning (3-4 days out of 21), $PM_{0.2}$ concentrations were 1.91 times higher in sham than in true filtration (0.65 [0.43, 0.86], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2}$ concentrations were not significantly different by filtration type (0.45 [-0.13, 1.02], p=0.13). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.20 [-0.42, 0.83], p=0.52), indicating little variation in the magnitude of air quality improvement between air cleaner and central system interventions.

In homes with air cleaners and no significant sources of burning (<3 days out of 21), $PM_{0.2}$ concentrations were 2.11 times higher in sham than in true filtration (0.75 [0.60, 0.89], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2}$ concentrations were 1.65 times higher in sham (0.50 [0.32, 0.68], p<0.0001). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was significant (0.25 [0.02, 0.48], p=0.03), showing that the improvements in air quality with true filtration were greater by 28% in homes with air cleaners than in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes with significant vs. not significant sources of burning were not significantly different (-0.09 [-0.58, 0.39], p=0.70). Similarly, the differences in the sham-true log geometric mean differences between air cleaner and central system homes with moderate vs. not significant sources of burning were not statistically significant (-0.05 [-0.72, 0.63], p=0.89). In other words, the effects of filtration system and filtration type on indoor $PM_{0.2}$ levels did not vary much by indoor smoking or burning frequency.

The geometric means (GM) of indoor $PM_{0.2}$ concentrations are presented in Table 2.4. During the sham period in homes with air cleaners, the GMs of $PM_{0.2}$ in households that had significant, moderate, or non-significant sources of burning were 2.61 $\mu g/m^3$ [95% CI: 2.07, 3.30], 2.36 $\mu g/m^3$ [2.01, 2.78], and 2.27 $\mu g/m^3$ [2.00, 2.57], respectively. During the sham period in homes with central systems, the GMs of $PM_{0.2}$ in households that had significant, moderate, or non-significant sources of burning were 2.95 $\mu g/m^3$ [2.29, 3.81], 2.37 $\mu g/m^3$ [1.70, 3.31], and 1.91 $\mu g/m^3$ [1.63, 2.24], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{0.2}$ in households that had significant, moderate, or non-significant sources of burning were 1.33 $\mu g/m^3$ [1.05, 1.68], 1.24 $\mu g/m^3$ [1.01, 1.51], and 1.07 $\mu g/m^3$ [0.93, 1.24], respectively. During true filtration in homes with central systems, the GMs of $PM_{0.2}$ in households that had significant, moderate, or non-significant sources of burning were 1.75 $\mu g/m^3$ [1.34, 2.29], 1.52 $\mu g/m^3$ [0.93, 2.47], and 1.16 $\mu g/m^3$ [0.97, 1.38], respectively.

2.b. Indoor $PM_{2.5}$ concentrations:

Table 2.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x burning source (TRUE × BURN), filtration system x burning source (HVAC × BURN), and filtration type x filtration system x burning source (TRUE × HVAC × BURN)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	309	93.3	<.0001
hvac_ac	1	309	0.5	0.4788
SUM_SMOKE_FRY_BURN_N	2	309	6.98	0.0011
true*hvac_ac	1	309	0.59	0.4441
true*SUM_SMOKE_FRY_B	2	309	0.03	0.9738
hvac_ac*SUM_SMOKE_FR	2	309	0.79	0.4569
true*hvac_ac*SUM_SMO	2	309	0.48	0.6187
season	3	309	7.18	0.0001
area	1	309	0.67	0.4139

Table 2.6: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Significant source, Air Cleaner: Sham vs True	0.6521	0.1819	309	3.58	0.0004	0.2942	1.0100
Significant source, Central: Sham vs True	0.5687	0.2009	309	2.83	0.0049	0.1735	0.9640
Significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.08334**	**0.271**	**309**	**0.31**	**0.7586**	**-0.4498**	**0.6165**
Moderate source, Air Cleaner: Sham vs True	0.5691	0.1049	309	5.43	<.0001	0.3627	0.7755
Moderate source, Central: Sham vs True	0.6134	0.257	309	2.39	0.0176	0.1077	1.1191
Moderate source: Air Cleaner vs. Central diff in Sham vs True diffs	**-0.04433**	**0.2822**	**309**	**-0.16**	**0.8753**	**-0.5997**	**0.5110**
Not significant source, Air Cleaner: Sham vs True	0.7561	0.07558	309	10	<.0001	0.6073	0.9048
Not significant source, Central: Sham vs True	0.4995	0.1167	309	4.28	<.0001	0.2699	0.7291
Not significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2566**	**0.1397**	**309**	**1.84**	**0.0672**	**-0.01829**	**0.5315**
Significant vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.1733**	**0.2998**	**309**	**-0.58**	**0.5638**	**-0.7632**	**0.4167**
Moderate vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.3009**	**0.3382**	**309**	**-0.89**	**0.3742**	**-0.9664**	**0.3645**

Table 2.7: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$)for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Moderate	1.9170	1.7338	2.1002	6.8005	5.6621	8.1678
Sham	Air cleaner	Significant	2.0065	1.7696	2.2433	7.4372	5.8685	9.4244
Sham	Air cleaner	Not significant	1.8668	1.7445	1.9891	6.4676	5.7230	7.3090
Sham	Central	Moderate	2.0263	1.8012	2.2514	7.5860	6.0569	9.5010
Sham	Central	Significant	2.1357	1.8753	2.3961	8.4630	6.5228	10.9803
Sham	Central	Not significant	1.6941	1.4967	1.8914	5.4417	4.4669	6.6286
True	Air cleaner	Moderate	1.3479	1.1567	1.5391	3.8493	3.1794	4.6604
True	Air cleaner	Significant	1.3544	1.1144	1.5943	3.8744	3.0477	4.9249
True	Air cleaner	Not significant	1.1108	0.9566	1.2650	3.0368	2.6028	3.5431
True	Central	Moderate	1.4129	0.9803	1.8454	4.1079	2.6653	6.3306
True	Central	Significant	1.5669	1.1417	1.9922	4.7918	3.1321	7.3316
True	Central	Not significant	1.1946	0.9857	1.4035	3.3022	2.6797	4.0694

The 3-way interaction term filtration type x filtration system x burning source (TRUE × HVAC × BURN) was not statistically significant, indicating that the frequency of indoor smoking, frying/sautéing, or burning fire (wood, candles, or incense) did not change the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{2.5}$ concentrations (p=0.62) (Table 2.5).

In homes with air cleaners that had significant sources of burning (5+ days out of 21), indoor $PM_{2.5}$ concentrations (log-transformed) were 1.92 times higher in sham than in true filtration (β=0.65 [95% CI: 0.29, 1.01], p=0.0004); while in homes with central systems and the same frequency of burning, $PM_{2.5}$ concentrations were 1.77 times higher in sham (0.57 [0.17, 0.96], p=0.005) (Table 2.6). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.08 [-0.45, 0.62], p=0.76), showing that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In homes with air cleaners and moderate sources of burning (3-4 days out of 21), $PM_{2.5}$ concentrations were 1.77 times higher in sham than in true filtration (0.57 [0.36, 0.78], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{2.5}$ concentrations were 1.85 times higher in sham (0.61 [0.11, 1.12], p=0.02). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (-0.04 [-0.60, 0.51], p=0.88), indicating little variation in the magnitude of air quality improvement between air cleaner and central system interventions.

In homes with air cleaners and no significant sources of burning (<3 days out of 21), $PM_{2.5}$ concentrations were 2.13 times higher in sham than in true filtration (0.76 [0.61, 0.90], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{2.5}$ concentrations were 1.65 times higher in sham (0.50 [0.27, 0.73], p<0.0001). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was marginally significant (0.26 [-0.02, 0.53], p=0.07), showing that the improvements in air quality with true filtration were greater by 29% in homes with air cleaners than in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes with significant vs. not significant sources of burning were not significantly different (-0.17 [-

0.76, 0.42], p=0.56). Likewise, the differences in the sham-true log geometric mean differences between air cleaner and central system homes with moderate vs. not significant sources of burning were not statistically significant (-0.30 [-0.97, 0.36], p=0.37). In other words, the effects of filtration system and filtration type on indoor $PM_{2.5}$ levels did not vary much by indoor smoking or burning frequency.

The geometric means (GM) of indoor $PM_{2.5}$ concentrations are presented in Table 2.7. During sham in homes with air cleaners, the GMs of $PM_{2.5}$ in households that had significant, moderate, or non-significant sources of burning were 7.44 $\mu g/m^3$ [95% CI: 5.87, 9.42], 6.80 $\mu g/m^3$ $\mu g/m^3$ [5.66, 8.17], and 6.47 $\mu g/m^3$ [5.72, 7.31], respectively. During sham in homes with central systems, the GMs of $PM_{2.5}$ in households that had significant, moderate, or non-significant sources of burning were 8.46 $\mu g/m^3$ [6.52, 10.98], 7.59 $\mu g/m^3$ [6.06, 9.50], and 5.44 $\mu g/m^3$ [4.47, 6.63], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{2.5}$ in households that had significant, moderate, or non-significant sources of burning were 3.87 $\mu g/m^3$ [3.05, 4.92], 3.85 $\mu g/m^3$ [3.18, 4.66], and 3.04 $\mu g/m^3$ [2.60, 3.54], respectively. During true filtration in homes with central systems, the GMs of $PM_{2.5}$ in households that had significant, moderate, or non-significant sources of burning were 4.79 $\mu g/m^3$ [3.13, 7.33], 4.11 $\mu g/m^3$ [2.67, 6.33], and 3.30 $\mu g/m^3$ [2.68, 4.07], respectively.

2.c. Indoor $PM_{0.2\text{-}2.5}$ concentrations:

Table 2.8: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x burning source (TRUE × BURN), filtration system x burning source (HVAC × BURN), and filtration type x filtration system x burning source (TRUE × HVAC × BURN)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	341	92.24	<.0001
hvac_ac	1	341	0.36	0.5515
SUM_SMOKE_FRY_BURN_N	2	341	10.59	<.0001
true*hvac_ac	1	341	2.6	0.1077
true*SUM_SMOKE_FRY_B	2	341	0.36	0.6992
hvac_ac*SUM_SMOKE_FR	2	341	2.99	0.0518
true*hvac_ac*SUM_SMO	2	341	0.07	0.9352
season	3	341	15.77	<.0001
area	1	341	1.34	0.2472

Table 2.9: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Significant source, Air Cleaner: Sham vs True	0.5136	0.1327	341	3.87	0.0001	0.2526	0.7746
Significant source, Central: Sham vs True	0.3020	0.1480	341	2.04	0.0420	0.01101	0.5931
Significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.2116**	**0.1976**	**341**	**1.07**	**0.2850**	**-0.1770**	**0.6002**
Moderate source, Air Cleaner: Sham vs True	0.5081	0.09423	341	5.39	<.0001	0.3228	0.6935
Moderate source, Central: Sham vs True	0.4096	0.1933	341	2.12	0.0348	0.0294	0.7897
Moderate source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.09856**	**0.2197**	**341**	**0.45**	**0.6540**	**-0.3336**	**0.5307**
Not significant source, Air Cleaner: Sham vs True	0.5792	0.05795	341	9.99	<.0001	0.4652	0.6932
Not significant source, Central: Sham vs True	0.4241	0.08514	341	4.98	<.0001	0.2567	0.5916
Not significant source: Air Cleaner vs. Central diff in Sham vs True diffs	**0.1550**	**0.1046**	**341**	**1.48**	**0.1391**	**-0.05063**	**0.3607**
Significant vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**0.05653**	**0.2279**	**341**	**0.25**	**0.8043**	**-0.3918**	**0.5049**
Moderate vs. Not significant source diff in Air Cleaner vs. Central diff in Sham vs True diffs	**-0.05648**	**0.2515**	**341**	**-0.22**	**0.8225**	**-0.5512**	**0.4383**

Table 2.10: Log Geometric Means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × BURN interaction term in the log-normal mixed-effects model

			Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Moderate	1.6864	1.5278	1.8449	5.4000	4.6080	6.3275
Sham	Air cleaner	Significant	1.8488	1.6531	2.0445	6.3522	5.2231	7.7253
Sham	Air cleaner	Not significant	1.6830	1.5668	1.7991	5.3817	4.7913	6.0442
Sham	Central	Moderate	1.7980	1.6229	1.9731	6.0376	5.0678	7.1929
Sham	Central	Significant	1.8319	1.5917	2.0721	6.2457	4.9121	7.9415
Sham	Central	Not significant	1.5116	1.3235	1.6997	4.5340	3.7565	5.4723
True	Air cleaner	Moderate	1.1782	1.0109	1.3456	3.2485	2.7481	3.8405
True	Air cleaner	Significant	1.3352	1.1572	1.5132	3.8008	3.1810	4.5412
True	Air cleaner	Not significant	1.1038	0.9852	1.2223	3.0156	2.6783	3.3950
True	Central	Moderate	1.3884	1.0473	1.7295	4.0084	2.8499	5.6378
True	Central	Significant	1.5299	1.2589	1.8008	4.6177	3.5215	6.0545
True	Central	Not significant	1.0875	0.9214	1.2536	2.9668	2.5128	3.5029

The 3-way interaction term filtration type x filtration system x burning source (TRUE × HVAC × BURN) was not statistically significant, indicating that the frequency of indoor smoking, frying/sautéing, or burning fire (wood, candles, or incense) did not change the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2\text{-}2.5}$ concentrations (p=0.94) (Table 2.8).

In homes with air cleaners that had significant sources of burning (5+ days out of 21), indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.67 times higher in sham than in true filtration (β=0.51 [95% CI: 0.25, 0.77], p=0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2\text{-}2.5}$ concentrations were 1.35 times higher in sham (0.30 [0.01, 0.59], p=0.04) (Table 2.9). At this frequency of burning, the difference in the sham-true log geometric mean differences between air

cleaner and central system homes was not significant (0.21 [-0.18, 0.60], p=0.29), showing that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In homes with air cleaners and moderate sources of burning (3-4 days out of 21), $PM_{0.2-2.5}$ concentrations were 1.66 times higher in sham than in true filtration (0.51 [0.32, 0.69], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2-2.5}$ concentrations were 1.51 times higher in sham (0.41 [0.03, 0.79], p=0.03). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.10 [-0.33, 0.53], p=0.65), indicating little variation in the magnitude of air quality improvement between air cleaner and central system interventions.

In homes with air cleaners and no significant sources of burning (<3 days out of 21), $PM_{0.2-2.5}$ concentrations were 1.78 times higher in sham than in true filtration (0.58 [0.47, 0.69], p<0.0001); while in homes with central systems and the same frequency of burning, $PM_{0.2-2.5}$ concentrations were 1.53 times higher in sham (0.42 [0.26, 0.59], p<0.0001). At this frequency of burning, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.16 [-0.05, 0.36], p=0.14), showing that the improvements in air quality with true filtration were not any greater in homes with air cleaners than in homes with central filtration.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes with significant vs. not significant sources of burning were not significantly different (0.06 [-0.39, 0.50], p=0.80). Likewise, the differences in the sham-true log geometric mean differences between air cleaner and central system homes with moderate vs. not significant sources of burning were not statistically significant (-0.06 [-0.55, 0.44], p=0.82). In other words, the effects of filtration system and filtration type on indoor $PM_{0.2-2.5}$ levels did not vary much by indoor smoking or burning frequency.

The geometric means (GM) of indoor $PM_{0.2-2.5}$ concentrations are presented in Table 2.10. During sham in homes with air cleaners, the GMs of $PM_{2.5}$ in households that had significant, moderate, or non-significant sources of burning were 6.35 $\mu g/m^3$ [95% CI: 5.22, 7.73], 5.40 $\mu g/m^3$ [4.61, 6.33], and 5.38 $\mu g/m^3$ [4.79, 6.04], respectively. During sham in homes with central systems, the GMs of $PM_{0.2-2.5}$ in households that had significant, moderate, or non-significant sources of burning were 6.25 $\mu g/m^3$ [4.91, 7.94], 6.04 $\mu g/m^3$ [5.07, 7.19], and 4.53 $\mu g/m^3$ [3.76, 5.47], respectively. During true filtration in homes with air cleaners, the GMs of $PM_{0.2-2.5}$ in households that had significant, moderate, or non-significant sources of burning were 3.80 $\mu g/m^3$ [3.18, 4.54], 3.25 $\mu g/m^3$ [2.75, 3.84], and 3.02 $\mu g/m^3$ [2.68, 3.40], respectively. During true filtration in homes with central systems, the GMs of $PM_{0.2-2.5}$ in households that had significant, moderate, or non-significant sources of burning were 4.62 $\mu g/m^3$ [3.52, 6.05], 4.01 $\mu g/m^3$ [2.85, 5.64], and 2.97 $\mu g/m^3$ [2.51, 3.50], respectively.

3. Compare whether the age of the home modifies the association between indoor PM concentrations in sham vs. true filtration periods

Table 3.1: Age of the home by filtration type

	SHAM		TRUE	
Year home was built	**n**	**%**	**n**	**%**
Before 1977	92	39.48	111	39.93
1977 or later	141	60.52	167	60.07

The proportion of homes built before 1977 was similar by filtration type, as expected.

3.a. Indoor $PM_{0.2}$ concentrations:

Table 3.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x age of home (TRUE × HOMEYR), filtration system x age of home (HVAC × HOMEYR), and filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	321	119.55	<.0001
hvac_ac	1	321	0	0.9604
home_yrbuilt	1	321	0.55	0.4582
true*hvac_ac	1	321	6.45	0.0116
true*home_yrbuilt	1	321	0.08	0.7756
hvac_ac*home_yrbuilt	1	321	3.5	0.0621
true*hvac_ac*home_yr	1	321	1.31	0.2530
season	3	321	5.42	0.0012
area	1	321	1.99	0.1593

Table 3.3: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Before 1977, Air Cleaner: Sham vs True	0.6733	0.09393	321	7.17	<.0001	0.4885	0.8581
Before 1977, Central: Sham vs True	0.5235	0.1239	321	4.22	<.0001	0.2797	0.7673
Before 1977: Air Cleaner vs. Central diff in Sham vs True diffs	0.1498	0.1554	321	0.96	0.3357	-0.1559	0.4555
1977 or later, Air Cleaner: Sham vs True	0.7645	0.07702	321	9.93	<.0001	0.6130	0.9160
1977 or later, Central: Sham vs True	0.3717	0.1235	321	3.01	0.0028	0.1287	0.6146
1977 or later: Air Cleaner vs. Central diff in Sham vs True diffs	0.3929	0.1457	321	2.7	0.0074	0.1063	0.6794
Air Cleaner: Before 1977 vs. 1977 or later diff in Sham vs True diffs	-0.09119	0.1206	321	-0.76	0.4499	-0.3284	0.1460
Central: Before 1977 vs. 1977 or later diff in Sham vs True diffs	0.1519	0.1749	321	0.87	0.3859	-0.1922	0.4959
Before 1977 vs. 1977 or later diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.243	0.2123	321	-1.15	0.2530	-0.6606	0.1745

During both sham and true filtration periods, 39-40% of homes were built before 1977 and 60-61% of homes were built in 1977 or later (Table 3.1). The 3-way interaction term filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR) was not statistically significant, indicating the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2}$ concentrations did not vary based on the age of the home (built before 1977 vs. in 1977 or later) (p=0.25) (Table 3.2).

In older homes (built before 1977) with air cleaners, indoor $PM_{0.2}$ concentrations (log-transformed) were 1.96 times higher in sham than in true filtration (β=0.67 [95% CI: 0.49, 0.86], p<0.0001); while in older homes with central systems, indoor $PM_{0.2}$ concentrations were 1.69 times higher in sham (0.52 [0.28, 0.77], p<0.0001) (Table 3.3). In older homes, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (0.15 [-0.16, 0.46], p=0.34), indicating

that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In newer homes (built in 1977 or later) with air cleaners, $PM_{0.2}$ concentrations were 2.15 times higher in sham than in true filtration (0.76 [0.61, 0.92], p<0.0001); while in newer homes with central systems, $PM_{0.2}$ concentrations were 1.45 times higher in sham (0.37 [0.13, 0.61], p=0.003). In newer homes, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was significant (0.39 [0.11, 0.68], p=0.01), showing greater improvements in air quality with true filtration in air cleaner homes than in homes with central systems.

No significant differences in the sham-true log geometric mean differences were detected between newer and older homes in households with air cleaners, or separately, in homes with central systems. As expected, the differences in the sham-true log geometric mean differences between air cleaner and central system homes built before 1977 vs. in 1977 or later were also not significantly different. In other words, the combined effects of filtration system and filtration type on indoor $PM_{0.2}$ levels did not vary much by the age of the home.

Table 3.4: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Year home built	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Before 1977	0.974	0.825	1.123	2.649	2.282	3.073
Sham	Air cleaner	1977 or later	0.801	0.660	0.942	2.227	1.934	2.565
Sham	HVAC	Before 1977	0.747	0.549	0.945	2.111	1.731	2.574
Sham	HVAC	1977 or later	0.765	0.624	0.906	2.149	1.866	2.474
True	Air cleaner	Before 1977	0.301	0.112	0.489	1.351	1.119	1.631
True	Air cleaner	1977 or later	0.036	-0.105	0.178	1.037	0.900	1.195
True	HVAC	Before 1977	0.224	-0.095	0.542	1.250	0.910	1.719
True	HVAC	1977 or later	0.393	0.172	0.614	1.482	1.188	1.848

The geometric means (GM) of indoor $PM_{0.2}$ concentrations are presented in Table 3.4. In older homes (built before 1977) with air cleaners, the GM $PM_{0.2}$ levels in sham and true filtration were 2.65 $\mu g/m^3$ [95% CI: 2.28, 3.07] and 1.35 $\mu g/m^3$ [1.12, 1.63], respectively. In newer homes (built in 1977 or later) with air cleaners, the GM $PM_{0.2}$ levels in sham and true filtration were 2.23 $\mu g/m^3$ [1.93, 2.57] and 1.04 $\mu g/m^3$ [0.90, 1.20]. In older homes with central systems, the GM $PM_{0.2}$ levels in sham and true filtration were 2.11 [1.73, 2.57] and 1.25 $\mu g/m^3$ [0.91, 1.72]. In newer homes with central systems, the GM $PM_{0.2}$ levels in sham and true filtration were 2.15 $\mu g/m^3$ [1.87, 2.47] and 1.48 $\mu g/m^3$ [1.19, 1.85].

3.b. Indoor $PM_{2.5}$ concentrations:

Table 3.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x age of home (TRUE × HOMEYR), filtration system x age of home (HVAC × HOMEYR), and filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	313	104.67	<.0001
hvac_ac	1	313	0	0.9929
home_yrbuilt	1	313	0.62	0.4334
true*hvac_ac	1	313	0.96	0.3272
true*home_yrbuilt	1	313	1.26	0.2617
hvac_ac*home_yrbuilt	1	313	1.66	0.1980
true*hvac_ac*home_yr	1	313	6.9	0.0090
season	3	313	7.12	0.0001
area	1	313	0.19	0.6610

Table 3.6: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Before 1977, Air Cleaner: Sham vs True	0.6011	0.08737	313	6.88	<.0001	0.4292	0.773
Before 1977, Central: Sham vs True	0.8077	0.1804	313	4.48	<.0001	0.4527	1.1626
Before 1977: Air Cleaner vs. Central diff in Sham vs True diffs	-0.2066	0.2013	313	-1.03	0.3055	-0.6027	0.1895
1977 or later, Air Cleaner: Sham vs True	0.7910	0.08384	313	9.43	<.0001	0.6260	0.9559
1977 or later, Central: Sham vs True	0.3351	0.1263	313	2.65	0.0084	0.08651	0.5836
1977 or later: Air Cleaner vs. Central diff in Sham vs True diffs	0.4559	0.1534	313	2.97	0.0032	0.1541	0.7577
Air Cleaner: Before 1977 vs. 1977 or later diff in Sham vs True diffs	-0.1899	0.1209	313	-1.57	0.1173	-0.4278	0.04803
Central: Before 1977 vs. 1977 or later diff in Sham vs True diffs	0.4726	0.2208	313	2.14	0.0331	0.0381	0.9071
Before 1977 vs. 1977 or later diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.6625	0.2521	313	-2.63	0.0090	-1.1586	-0.1664

The 3-way interaction term filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR) was statistically significant, indicating the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{2.5}$ concentrations were different depending on the age of the home (built before 1977 vs. in 1977 or later) (p=0.01) (Table 3.5).

In older homes (built before 1977) with air cleaners, indoor $PM_{2.5}$ concentrations (log-transformed) were 1.82 times higher in sham than in true filtration (β=0.60 [95% CI: 0.43, 0.77], p<0.0001); while in homes with central systems, $PM_{2.5}$ concentrations were 2.24 times higher in sham (0.81 [0.45, 1.16], p<0.0001) (Table 3.6). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was not significant (-0.21 [-0.60, 0.19], p=0.31) in older homes, indicating that the improvements in air quality with true filtration did not vary much between homes with air cleaners and homes with central filtration.

In newer homes (built in 1977 or later) with air cleaners, $PM_{2.5}$ concentrations were 2.21 times higher in sham than in true filtration (0.79 [0.63, 0.96], p<0.0001); while in homes with central systems, $PM_{2.5}$ levels were 1.40 times higher in sham (0.34 [0.09, 0.58], p=0.01). The difference in the sham-true log geometric mean differences between air cleaner and central system homes was significant (0.46 [0.15, 0.76], p=0.003) in newer homes, showing greater improvements in air quality with true filtration in air cleaner homes than in homes with central systems.

In homes with central systems, the sham-true log geometric mean difference was also greater older homes compared with newer homes (0.47 [0.04, 0.91], p=0.03); however, in homes with air cleaners, no significant difference in the sham-true log geometric mean differences was detected between newer and older homes. Accordingly, the difference in the sham-true log geometric mean differences between air

cleaner and central system homes built before 1977 vs. in 1977 or later was also statistically significant (-0.66 [-1.16, -0.17], p=0.01), showing that the combined effects of filtration system and filtration type on indoor $PM_{2.5}$ levels varied depending on the age of the home.

Table 3.7: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Year home built	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Before 1977	2.020	1.874	2.166	7.537	6.514	8.719
Sham	Air cleaner	1977 or later	1.861	1.707	2.016	6.433	5.511	7.508
Sham	Central	Before 1977	1.964	1.620	2.308	7.128	5.053	10.053
Sham	Central	1977 or later	1.790	1.629	1.952	5.992	5.097	7.044
True	Air cleaner	Before 1977	1.419	1.221	1.616	4.132	3.391	5.034
True	Air cleaner	1977 or later	1.070	0.916	1.225	2.917	2.500	3.402
True	Central	Before 1977	1.156	0.654	1.659	3.178	1.923	5.253
True	Central	1977 or later	1.455	1.190	1.721	4.286	3.287	5.589

The geometric means (GM) of indoor $PM_{2.5}$ concentrations are presented in Table 3.7. In older homes (built before 1977) with air cleaners, the GM $PM_{2.5}$ levels in sham and true filtration were 7.54 $\mu g/m^3$ [95% CI: 6.51, 8.72] and 4.13 $\mu g/m^3$ [3.39, 5.03], respectively. In newer homes (built in 1977 or later) with air cleaners, the GM $PM_{2.5}$ levels in sham and true filtration were 6.43 $\mu g/m^3$ [5.51, 7.51] and 2.92 $\mu g/m^3$ [2.50, 3.40]. In older homes with central systems, the GM $PM_{2.5}$ levels in sham and true filtration were 7.13 $\mu g/m^3$ [5.05, 10.05] and 3.18 $\mu g/m^3$ [1.92, 5.25]. In newer homes with central systems, the GM $PM_{2.5}$ levels in sham and true filtration were 5.99 $\mu g/m^3$ [5.10, 7.04] and 4.29 $\mu g/m^3$ [3.29, 5.59].

3.c. Indoor $PM_{0.2\text{-}2.5}$ concentrations:

Table 3.8: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x age of home (TRUE × HOMEYR), filtration system x age of home (HVAC × HOMEYR), and filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	343	109.44	<.0001
hvac_ac	1	343	0.01	0.9219
home_yrbuilt	1	343	2.41	0.1215
true*hvac_ac	1	343	5.06	0.0251
true*home_yrbuilt	1	343	0.06	0.7994
hvac_ac*home_yrbuilt	1	343	0.83	0.3631
true*hvac_ac*home_yr	1	343	5.16	0.0238
season	3	343	15.27	<.0001
area	1	343	0.48	0.4892

Table 3.9: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Before 1977, Air Cleaner: Sham vs True	0.4686	0.06348	343	7.38	<.0001	0.3437	0.5934
Before 1977, Central: Sham vs True	0.4736	0.1113	343	4.26	<.0001	0.2548	0.6925
Before 1977: Air Cleaner vs. Central diff in Sham vs True diffs	-0.00505	0.1277	343	-0.04	0.9685	-0.2563	0.2462
1977 or later, Air Cleaner: Sham vs True	0.6494	0.06674	343	9.73	<.0001	0.5181	0.7806
1977 or later, Central: Sham vs True	0.2486	0.1008	343	2.47	0.0141	0.0504	0.4469
1977 or later: Air Cleaner vs. Central diff in Sham vs True diffs	0.4007	0.123	343	3.26	0.0012	0.1588	0.6426
Air Cleaner: Before 1977 vs. 1977 or later diff in Sham vs True diffs	-0.1808	0.09179	343	-1.97	0.0497	-0.3613	-0.00022
Central: Before 1977 vs. 1977 or later diff in Sham vs True diffs	0.2250	0.1506	343	1.49	0.1360	-0.07114	0.5211
Before 1977 vs. 1977 or later diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.4058	0.1787	343	-2.27	0.0238	-0.7572	-0.0543

The 3-way interaction term filtration type x filtration system x age of home (TRUE × HVAC × HOMEYR) was statistically significant, indicating the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2\text{-}2.5}$ concentrations were different depending on the age of the home (built before 1977 vs. in 1977 or later) (p=0.02) (Table 3.8).

In older homes (built before 1977) with air cleaners, indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.60 times higher in sham than in true filtration (β=0.47 [95% CI: 0.34, 0.59], p<0.0001); in older homes with central systems, $PM_{0.2\text{-}2.5}$ levels were also 1.60 times higher in sham (0.47 [0.25, 0.69], p<0.0001) (Table 3.9). The difference in the sham-true log geometric mean differences between older homes with air cleaners and those with central systems was not significant (0.00 [-0.26, 0.25], p=0.97), indicating minimal differences in air quality improvements with true filtration by filtration system intervention.

In newer homes (built in 1977 or later) with air cleaners, $PM_{0.2\text{-}2.5}$ concentrations were 1.91 times higher in sham than in true filtration (0.65 [0.52, 0.78], p<0.0001); while in newer homes with central systems, $PM_{0.2\text{-}2.5}$ levels were 1.28 times higher in sham (0.25 [0.05, 0.45], p=0.01). The difference in the sham-true log geometric mean differences between newer homes with air cleaners and those with central systems was significant (0.40 [0.16, 0.64], p=0.001), showing greater improvements in air quality with true filtration in air cleaner homes than in homes with central systems.

In homes with air cleaners, the sham-true log geometric mean difference was smaller in older homes compared with newer homes (-0.18 [-0.36, 0.00], p=0.05); meanwhile, in homes with central systems, no significant difference in the sham-true log geometric mean differences was detected between newer and older homes. (This finding is in contrast with results for $PM_{2.5}$.) As such, the difference in the sham-true log geometric mean differences between air cleaner and central system homes built before 1977 vs. in 1977 or later was also statistically significant (-0.41 [-0.76, -0.05], p=0.02), showing that the combined effects of filtration system and filtration type on indoor $PM_{0.2\text{-}2.5}$ levels varied depending on the age of the home.

Table 3.10: Log Geometric Means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × HOMEYR interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Year home built	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Before 1977	1.835	1.710	1.960	6.265	5.527	7.101
Sham	Air cleaner	1977 or later	1.675	1.527	1.823	5.339	4.606	6.189
Sham	Central	Before 1977	1.735	1.386	2.084	5.669	3.998	8.040
Sham	Central	1977 or later	1.557	1.383	1.732	4.746	3.987	5.649
True	Air cleaner	Before 1977	1.366	1.214	1.519	3.921	3.367	4.567
True	Air cleaner	1977 or later	1.026	0.904	1.147	2.789	2.470	3.149
True	Central	Before 1977	1.262	0.964	1.559	3.531	2.622	4.755
True	Central	1977 or later	1.309	1.068	1.549	3.701	2.910	4.708

The geometric means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations are presented in Table 3.10. In older homes (built before 1977) with air cleaners, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 6.27 $\mu g/m^3$ [95% CI: 5.53, 7.10] and 3.92 $\mu g/m^3$ [3.37, 4.57], respectively. In newer homes (built in 1977 or later) with air cleaners, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 5.34 $\mu g/m^3$ [4.61, 6.19] and 2.79 $\mu g/m^3$ [2.47, 3.15]. In older homes with central systems, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 5.67 $\mu g/m^3$ [4.00, 8.04] and 3.53 $\mu g/m^3$ [2.62, 4.76]. In newer homes with central systems, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 4.75 $\mu g/m^3$ [3.99, 5.65] and 3.70 $\mu g/m^3$ [2.91, 4.71].

4. Compare whether having a gas stove modifies the association between indoor PM concentrations in sham vs. true filtration

Table 4.1: Stove type by filtration type

	SHAM		TRUE	
Stove type	**n**	**%**	**n**	**%**
Gas	175	71.72	205	70.69
Electric	69	28.28	85	29.31

During both sham and true filtration periods, 71-72% of homes used gas stoves (vs. electric) (Table 4.1).

4.a. Indoor $PM_{0.2}$ concentrations:

Table 4.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x stove type (TRUE × STOVE), filtration system x stove type (HVAC × STOVE), and filtration type x filtration system x stove type(TRUE × HVAC × STOVE)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	334	103.53	<.0001
hvac_ac	1	334	0.15	0.6983
BSL_STOVE_TYPE	1	334	0.32	0.5713
true*hvac_ac	1	334	8.22	0.0044
true*BSL_STOVE_TYPE	1	334	0.09	0.7618
hvac_ac*BSL_STOVE_TY	1	334	0.02	0.8954
true*hvac_ac*BSL_STO	1	334	0.18	0.6722
season	3	334	5.24	0.0015
area	1	334	4.37	0.0373

Table 4.3: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Gas, Air Cleaner: Sham vs True	0.7050	0.06181	334	11.41	<.0001	0.5834	0.8266
Gas, Central: Sham vs True	0.4227	0.1208	334	3.5	0.0005	0.1851	0.6602
Gas: Air Cleaner vs. Central diff in Sham vs True diffs	0.2823	0.1357	334	2.08	0.0383	0.01534	0.5494
Electric, Air Cleaner: Sham vs True	0.7884	0.127	334	6.21	<.0001	0.5387	1.0382
Electric, Central: Sham vs True	0.4085	0.1347	334	3.03	0.0026	0.1435	0.6735
Electric: Air Cleaner vs. Central diff in Sham vs True diffs	0.3799	0.1865	334	2.04	0.0424	0.01305	0.7468
Air Cleaner: Gas vs Electric diff in Sham vs True diffs	-0.08342	0.1402	334	-0.59	0.5524	-0.3593	0.1925
Central: Gas vs Electric diff in Sham vs True diffs	0.01417	0.1814	334	0.08	0.9378	-0.3427	0.3711
Gas vs. Electric diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.09759	0.2304	334	-0.42	0.6722	-0.5508	0.3557

The 3-way interaction term filtration type x filtration system x stove type (TRUE × HVAC × STOVE) was not statistically significant, indicating the effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2}$ concentrations did not vary based on the type of stove in the home (gas vs. electric) (p=0.67) (Table 4.2).

In homes with gas stoves, indoor $PM_{0.2}$ concentrations were higher in sham than true filtration in both air cleaner homes (β=0.71 [0.58, 0.83], p<0.0001) and homes with central systems (0.42 [0.19, 0.66], p=0.001) (Table 4.3). Additionally, the difference in the sham vs. true log mean differences was significantly greater in homes with air cleaners than homes with central systems (0.28 [0.02, 0.55], p=0.04). Similarly, in homes with electric stoves, indoor $PM_{0.2}$ levels were higher in sham than true filtration in homes with air cleaners (0.79 [0.54, 1.04], p<0.0001) and central systems (0.41 [0.14, 0.67], p=0.003). Likewise, the difference in the sham vs. true log mean differences was also significantly greater

in homes with air cleaners than homes with central systems (0.38 [0.01, 0.75], p=0.04). No differences were observed in the sham vs. true log mean $PM_{0.2}$ differences between households with gas and electric stoves in homes that used air cleaners as well as in homes that had central systems, indicating that the magnitude of improvements in air quality with true filtration did not vary by the type of stove in the home irrespective of the type of filtration system.

Table 4.4: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Stove type	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Gas	0.887	0.768	1.007	2.429	2.155	2.738
Sham	Air cleaner	Electric	0.863	0.674	1.051	2.369	1.963	2.861
Sham	Central	Gas	0.770	0.633	0.907	2.160	1.882	2.478
Sham	Central	Electric	0.721	0.464	0.977	2.056	1.591	2.657
True	Air cleaner	Gas	0.182	0.067	0.298	1.200	1.069	1.347
True	Air cleaner	Electric	0.074	-0.201	0.350	1.077	0.818	1.419
True	Central	Gas	0.347	0.134	0.561	1.415	1.143	1.753
True	Central	Electric	0.312	-0.015	0.639	1.366	0.985	1.895

The geometric means (GM) of indoor $PM_{0.2}$ concentrations are presented in Table 4.4. In homes with air cleaners and gas stoves, the GM $PM_{0.2}$ levels in sham and true filtration were 2.43 $\mu g/m^3$ [95% CI: 2.16, 2.74] and 1.20 $\mu g/m^3$ [1.07, 1.35], respectively. In homes with air cleaners and electric stoves, the GM $PM_{0.2}$ levels in sham and true filtration were 2.37 $\mu g/m^3$ [1.96, 2.86] and 1.08 $\mu g/m^3$ [0.82, 1.42]. In homes with central systems and gas stoves, the GM $PM_{0.2}$ levels in sham and true filtration were 2.16 $\mu g/m^3$ [1.88, 2.48] and 1.42 $\mu g/m^3$ [1.14, 1.75]. Lastly, in homes with central systems and electric stoves, the GM $PM_{0.2}$ levels in sham and true filtration were 2.06 $\mu g/m^3$ [1.59, 2.66] and 1.37 $\mu g/m^3$ [0.99, 1.90].

4.b. Indoor $PM_{2.5}$ concentrations:

Table 4.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x stove type (TRUE × STOVE), filtration system x stove type (HVAC × STOVE), and filtration type x filtration system x stove type(TRUE × HVAC × STOVE)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	325	50.89	<.0001
hvac_ac	1	325	0.04	0.8384
BSL_STOVE_TYPE	1	325	0.02	0.8928
true*hvac_ac	1	325	1.27	0.2612
true*BSL_STOVE_TYPE	1	325	0.53	0.4651
hvac_ac*BSL_STOVE_TY	1	325	0.02	0.8822
true*hvac_ac*BSL_STO	1	325	0.19	0.6635
season	3	325	7.83	<.0001
area	1	325	0.67	0.4151

Table 4.6: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Gas, Air Cleaner: Sham vs True	0.7063	0.06375	325	11.08	<.0001	0.5809	0.8317
Gas, Central: Sham vs True	0.4200	0.1181	325	3.56	0.0004	0.1876	0.6524
Gas: Air Cleaner vs. Central diff in Sham vs True diffs	0.2863	0.134	325	2.14	0.0333	0.02278	0.5498
Electric, Air Cleaner: Sham vs True	0.7571	0.1295	325	5.85	<.0001	0.5023	1.0118
Electric, Central: Sham vs True	0.6301	0.3086	325	2.04	0.0420	0.02299	1.2373
Electric: Air Cleaner vs. Central diff in Sham vs True diffs	0.1269	0.3412	325	0.37	0.7101	-0.5442	0.7981
Air Cleaner: Gas vs Electric diff in Sham vs True diffs	-0.05079	0.1453	325	-0.35	0.7269	-0.3366	0.2351
Central: Gas vs Electric diff in Sham vs True diffs	-0.2101	0.3309	325	-0.64	0.5258	-0.8611	0.4408
Gas vs. Electric diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.1594	0.3659	325	0.44	0.6635	-0.5605	0.8792

The 3-way interaction term filtration type x filtration system x stove type (TRUE × HVAC × STOVE) was not statistically significant, indicating the combined effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{2.5}$ concentrations did not vary based on the type of stove in the home (gas vs. electric) (p=0.66) (Table 4.5).

In homes with gas stoves, indoor $PM_{2.5}$ concentrations were higher in sham than true filtration in both air cleaner homes (β=0.71 [0.58, 0.83], p<0.0001) and homes with central systems (0.42 [0.19, 0.65], p=0.0004) (Table 4.6). Additionally, the difference in the sham vs. true log mean differences was significantly greater in homes with air cleaners than homes with central systems (0.29 [0.02, 0.55], p=0.03). Similarly, in homes with electric stoves, indoor $PM_{2.5}$ levels were higher in sham than true filtration in homes with air cleaners (0.76 [0.50, 1.01], p<0.0001) and central systems (0.63 [0.02, 1.24], p=0.04). However, the difference in the sham vs. true log mean differences was not significant between homes with air cleaners and central systems. No differences were observed in the sham vs. true log mean $PM_{2.5}$ differences between households with gas and electric stoves in homes that used air cleaners as well as in homes that had central systems, indicating that the magnitude of improvements in air quality with true filtration did not vary by the type of stove in the home regardless of the type of filtration system.

Table 4.7: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Stove type	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Gas	1.935	1.811	2.058	6.922	6.117	7.833
Sham	Air cleaner	Electric	1.959	1.741	2.178	7.093	5.701	8.825
Sham	Central	Gas	1.798	1.630	1.967	6.040	5.105	7.147
Sham	Central	Electric	1.942	1.601	2.283	6.970	4.957	9.801
True	Air cleaner	Gas	1.228	1.095	1.362	3.416	2.989	3.904
True	Air cleaner	Electric	1.202	0.929	1.475	3.327	2.532	4.371
True	Central	Gas	1.378	1.135	1.622	3.969	3.112	5.061
True	Central	Electric	1.312	0.645	1.978	3.712	1.906	7.228

The geometric means (GM) of indoor $PM_{2.5}$ concentrations are presented in Table 4.7. In homes with air cleaners and gas stoves, the GM $PM_{2.5}$ levels in sham and true filtration were 6.92 $\mu g/m^3$ [95% CI: 6.12, 7.83] and 3.42 $\mu g/m^3$ [2.99, 3.90], respectively. In homes with air cleaners and electric stoves, the GM $PM_{2.5}$ levels in sham and true filtration were 7.09 $\mu g/m^3$ [5.70, 8.83] and 3.33 $\mu g/m^3$ [2.53, 4.37]. In homes with central systems and gas stoves, the GM $PM_{2.5}$ levels in sham and true filtration were 6.04 $\mu g/m^3$ [5.11, 7.15] and 3.97 $\mu g/m^3$ [3.11, 5.06]. Lastly, in homes with central systems and electric stoves, the GM $PM_{0.2}$ levels in sham and true filtration were 6.97 $\mu g/m^3$ [4.96, 9.80] and 3.71 $\mu g/m^3$ [1.91, 7.23].

4.c. Indoor $PM_{0.2\text{-}2.5}$ concentrations:

Table 4.8: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x stove type (TRUE × STOVE), filtration system x stove type (HVAC × STOVE), and filtration type x filtration system x stove type(TRUE × HVAC × STOVE)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	357	96.86	<.0001
hvac_ac	1	357	0.07	0.798
BSL_STOVE_TYPE	1	357	0.66	0.4181
true*hvac_ac	1	357	8.14	0.0046
true*BSL_STOVE_TYPE	1	357	0	0.9719
hvac_ac*BSL_STOVE_TY	1	357	0.64	0.424
true*hvac_ac*BSL_STO	1	357	0	0.9997
season	3	357	16.78	<.0001
area	1	357	0.8	0.3704

Table 4.9: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Gas, Air Cleaner: Sham vs True	0.5862	0.05098	357	11.5	<.0001	0.4860	0.6865
Gas, Central: Sham vs True	0.3100	0.1012	357	3.06	0.0024	0.1109	0.5091
Gas: Air Cleaner vs. Central diff in Sham vs True diffs	0.2762	0.113	357	2.45	0.0150	0.05407	0.4984
Electric, Air Cleaner: Sham vs True	0.5830	0.09238	357	6.31	<.0001	0.4014	0.7647
Electric, Central: Sham vs True	0.3067	0.1188	357	2.58	0.0102	0.07319	0.5403
Electric: Air Cleaner vs. Central diff in Sham vs True diffs	0.2763	0.1578	357	1.75	0.0809	-0.03409	0.5867
Air Cleaner: Gas vs Electric diff in Sham vs True diffs	0.003192	0.1062	357	0.03	0.9760	-0.2056	0.2120
Central: Gas vs Electric diff in Sham vs True diffs	0.003276	0.1564	357	0.02	0.9833	-0.3043	0.3109
Gas vs. Electric diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.00008	0.1945	357	0	0.9997	-0.3826	0.3824

The 3-way interaction term filtration type x filtration system x stove type (TRUE × HVAC × STOVE) was not statistically significant, indicating the combined effects of filtration type (sham vs. true) and filtration system (air cleaner vs. central) on the indoor $PM_{0.2\text{-}2.5}$ concentrations did not vary based on the type of stove in the home (gas vs. electric) (p=1.00) (Table 4.8).

In homes with gas stoves, indoor $PM_{0.2\text{-}2.5}$ concentrations were higher in sham than true filtration in both air cleaner homes (β=0.59 [0.49, 0.69], p<0.0001) and homes with central systems (0.31 [0.11, 0.51], p=0.002) (Table 4.9). Additionally, the difference in the sham vs. true log mean differences was significantly greater in homes with air cleaners than homes with central systems (0.28 [0.05, 0.50], p=0.02). Similarly, in homes with electric stoves, indoor $PM_{0.2\text{-}2.5}$ levels were higher in sham than true filtration in homes with air cleaners (0.58 [0.40, 0.76], p<0.0001) and central systems (0.31 [0.07, 0.54], p=0.01). However, the difference in the sham vs. true log mean differences was not significant between homes with air cleaners and central systems. No differences were observed in the sham vs. true log mean $PM_{0.2\text{-}2.5}$ differences between households with gas and electric stoves in homes that used air cleaners as well as in homes that had central systems, indicating that the magnitude of improvements in air quality with true filtration did not vary by the type of stove in the home regardless of the type of filtration system.

Table 4.10: Log Geometric Means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × STOVE interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Stove type	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	Gas	1.751	1.639	1.863	5.762	5.152	6.444
Sham	Air cleaner	Electric	1.753	1.568	1.937	5.771	4.798	6.941
Sham	Central	Gas	1.560	1.381	1.739	4.760	3.980	5.694
Sham	Central	Electric	1.716	1.392	2.041	5.564	4.022	7.697
True	Air cleaner	Gas	1.165	1.057	1.273	3.206	2.879	3.570
True	Air cleaner	Electric	1.170	0.973	1.367	3.221	2.646	3.922
True	Central	Gas	1.250	1.019	1.481	3.491	2.771	4.399
True	Central	Electric	1.410	1.140	1.679	4.094	3.128	5.360

The geometric means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations are presented in Table 4.10. In homes with air cleaners and gas stoves, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 5.76 $\mu g/m^3$ [95% CI: 5.15, 6.44] and 3.21 $\mu g/m^3$ [2.88, 3.57], respectively. In homes with air cleaners and electric stoves, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 5.77 $\mu g/m^3$ [4.80, 6.94] and 3.22 $\mu g/m^3$ [2.65, 3.92]. In homes with central systems and gas stoves, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 4.76 $\mu g/m^3$ [3.98, 5.69] and 3.49 $\mu g/m^3$ [2.77, 4.40]. Lastly, in homes with central systems and electric stoves, the GM $PM_{0.2\text{-}2.5}$ levels in sham and true filtration were 5.56 $\mu g/m^3$ [4.02, 7.70] and 4.09 $\mu g/m^3$ [3.13, 5.36].

5. Compare whether the proximity to a major roadway modifies the association between indoor PM concentrations in sham vs. true filtration periods

Table 5.1: Proximity to a major roadway by filtration type

	SHAM		TRUE	
Proximity to major roadway	**n**	**%**	**n**	**%**
<1 block (<360 ft)	32	13.11	33	11.46
1 block	53	21.72	66	22.92
2-4 blocks	70	28.69	84	29.17
5+ blocks	89	36.48	105	36.46

The proximity of a home to a major roadway was similar by filtration type, as expected. For analyses, <1 block and 1 block categories were combined. In both sham and true filtration, approximately 35% of homes were <2 blocks away from a major roadway (1 block = 360 ft), 29% of homes were 2-4 blocks away, and 36% of homes were 5 or more blocks away (Table 5.1).

5.a. Indoor $PM_{0.2}$ concentrations:

Table 5.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	331	109.33	<.0001
hvac_ac	1	331	1.25	0.2636
BSL_DISTTOTRAFF	2	331	5.41	0.0049
true*hvac_ac	1	331	8.29	0.0042
true*BSL_DISTTOTRAFF	2	331	1.79	0.1679
hvac_ac*BSL_DISTTOTR	2	331	3.23	0.0407
true*hvac_ac*BSL_DIS	2	331	0.46	0.6340
season	3	331	4.95	0.0022
area	1	331	2.04	0.1542

Table 5.3: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<2 blocks, Air Cleaner: Sham vs True	0.7651	0.1051	331	7.28	<.0001	0.5583	0.9719
<2 blocks, Central: Sham vs True	0.5358	0.1232	331	4.35	<.0001	0.2935	0.7780
<2 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2294	0.1638	331	1.4	0.1624	-0.09287	0.5516
2-4 blocks, Air Cleaner: Sham vs True	0.6451	0.09954	331	6.48	<.0001	0.4493	0.8409
2-4 blocks, Central: Sham vs True	0.1641	0.2132	331	0.77	0.4421	-0.2554	0.5836
2-4 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.4810	0.2361	331	2.04	0.0424	0.01664	0.9453
5+ blocks, Air Cleaner: Sham vs True	0.7649	0.09105	331	8.4	<.0001	0.5858	0.9440
5+ blocks, Central: Sham vs True	0.5333	0.1273	331	4.19	<.0001	0.2829	0.7837
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2316	0.1564	331	1.48	0.1396	-0.07607	0.5392
Air Cleaner: <2 vs 5+ blocks diff in Sham vs True diffs	0.000256	0.1387	331	0	0.9985	-0.2727	0.2732
Air Cleaner: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.1198	0.1354	331	-0.88	0.3772	-0.3862	0.1467
Central: <2 vs 5+ blocks diff in Sham vs True diffs	0.00248	0.177	331	0.01	0.9888	-0.3457	0.3507
Central: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.3692	0.2484	331	-1.49	0.1381	-0.8578	0.1194
<2 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.00222	0.2258	331	-0.01	0.9921	-0.4463	0.4419
2-4 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.2494	0.2836	331	0.88	0.3799	-0.3086	0.8074

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<2, 2-4 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically

significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{0.2}$ concentrations (p=0.63) (Tables 5.2).

In homes with air cleaners, indoor $PM_{0.2}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<2 blocks: β=0.77 [95% CI: 0.56, 0.97], p<0.0001; 2-4 blocks: 0.65 [0.45, 0.84], p<0.0001; 5+ blocks: 0.76 [0.59, 0.94], p<0.0001) (Table 5.3). Similarly, in homes with central systems, $PM_{0.2}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway (<2 blocks: 0.54 [0.29, 0.78], p<0.0001; 5+ blocks: 0.53 [0.28, 0.78], p<0.0001), with the exception of homes located 2-4 blocks away where the differences between sham and true filtration were not significant, though trending in the same direction. Additionally, the difference in sham vs. true log mean $PM_{0.2}$ levels was significantly greater in homes with air cleaners located 2-4 blocks from a major roadway than in homes with central systems located within the same distance to a roadway (0.48 [0.02, 0.95], p=0.04). No differences in the sham vs. true log mean $PM_{0.2}$ differences were observed between homes located <2 and 2-4 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{0.2}$ differences between air cleaner and central system homes located <2 vs. 5+ blocks from a major roadway were not significantly different. Likewise, the differences in the sham vs. true differences between air cleaner and central system homes located 2-4 vs. 5+ blocks from a major roadway were not statistically significant. This lack of significance indicates that the combined effects of filtration system and filtration type on indoor $PM_{0.2}$ levels did not vary much by distance to a major roadway.

Table 5.4: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<2 blocks (1 block = 360 ft)	0.960	0.793	1.127	2.611	2.209	3.086
Sham	Air cleaner	2-4 blocks	0.837	0.675	0.999	2.309	1.964	2.716
Sham	Air cleaner	5+ blocks	0.844	0.661	1.027	2.324	1.936	2.791
Sham	Central	<2 blocks (1 block = 360 ft)	0.907	0.670	1.145	2.477	1.953	3.142
Sham	Central	2-4 blocks	0.887	0.643	1.131	2.428	1.902	3.100
Sham	Central	5+ blocks	0.621	0.477	0.765	1.860	1.611	2.149
True	Air cleaner	<2 blocks (1 block = 360 ft)	0.195	0.001	0.389	1.215	1.001	1.475
True	Air cleaner	2-4 blocks	0.192	-0.010	0.394	1.212	0.990	1.483
True	Air cleaner	5+ blocks	0.079	-0.113	0.270	1.082	0.893	1.310
True	Central	<2 blocks (1 block = 360 ft)	0.371	0.066	0.677	1.450	1.068	1.968
True	Central	2-4 blocks	0.723	0.447	0.999	2.060	1.563	2.715
True	Central	5+ blocks	0.087	-0.143	0.318	1.091	0.866	1.375

The geometric means (GM) of indoor $PM_{0.2}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.4.

5.b. Indoor $PM_{2.5}$ concentrations:

Table 5.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	322	83.61	<.0001
hvac_ac	1	322	0.68	0.4091
BSL_DISTTOTRAFF	2	322	7.16	0.0009
true*hvac_ac	1	322	2.9	0.0898
true*BSL_DISTTOTRAFF	2	322	1.2	0.3037
hvac_ac*BSL_DISTTOTR	2	322	4.8	0.0088
true*hvac_ac*BSL_DIS	2	322	0.77	0.4649
season	3	322	7.5	<.0001
area	1	322	0.13	0.7182

Table 5.6: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<2 blocks, Air Cleaner: Sham vs True	0.7076	0.1057	322	6.69	<.0001	0.4996	0.9156
<2 blocks, Central: Sham vs True	0.7324	0.2447	322	2.99	0.0030	0.2509	1.2138
<2 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	-0.02479	0.2733	322	-0.09	0.9278	-0.5625	0.5129
2-4 blocks, Air Cleaner: Sham vs True	0.6616	0.09537	322	6.94	<.0001	0.4739	0.8492
2-4 blocks, Central: Sham vs True	0.2448	0.2289	322	1.07	0.2856	-0.2054	0.6951
2-4 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.4167	0.2487	322	1.68	0.0948	-0.07254	0.9060
5+ blocks, Air Cleaner: Sham vs True	0.7834	0.1013	322	7.73	<.0001	0.5841	0.9826
5+ blocks, Central: Sham vs True	0.4826	0.1401	322	3.45	0.0006	0.2071	0.7582
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.3007	0.1728	322	1.74	0.0828	-0.03932	0.6408
Air Cleaner: <2 vs 5+ blocks diff in Sham vs True diffs	-0.0758	0.1467	322	-0.52	0.6058	-0.3644	0.2128
Air Cleaner: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.1218	0.1406	322	-0.87	0.3870	-0.3984	0.1548
Central: <2 vs 5+ blocks diff in Sham vs True diffs	0.2497	0.2825	322	0.88	0.3774	-0.3061	0.8055
Central: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.2378	0.2683	322	-0.89	0.3761	-0.7657	0.2900
<2 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.3255	0.3222	322	-1.01	0.3131	-0.9594	0.3083
2-4 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.1160	0.3038	322	0.38	0.7028	-0.4816	0.7136

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<2, 2-4 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{2.5}$ concentrations (p=0.46) (Tables 5.5).

In homes with air cleaners, indoor $PM_{2.5}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<2 blocks: β=0.71 [95% CI: 0.50, 0.92], p<0.0001; 2-4 blocks: 0.66 [0.47, 0.85], p<0.0001; 5+ blocks: 0.78 [0.58, 0.98], p<0.0001) (Table 5.6). Similarly, in homes with central systems, $PM_{2.5}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway (<2 blocks: 0.73 [0.25, 1.21], p=0.003; 5+ blocks: 0.48 [0.21, 0.76], p=0.001), with the exception of homes located 2-4 blocks away where the differences between sham and true filtration were not significant, though trending in the same direction. No differences in the sham vs. true log mean $PM_{2.5}$ differences were observed between homes located <2 and 2-4 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{2.5}$ differences between air cleaner and central system homes located <2 vs. 5+ blocks from a major roadway were not significantly different. Likewise, the differences in the sham vs. true differences between air cleaner and central system homes located 2-4 vs. 5+ blocks from a major roadway were not statistically significant. This lack of significance indicates that the combined effects of

filtration system and filtration type on indoor $PM_{2.5}$ levels did not vary much by distance to a major roadway.

Table 5.7: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<2 blocks (1 block = 360 ft)	2.011	1.829	2.193	7.473	6.229	8.965
Sham	Air cleaner	2-4 blocks	1.904	1.725	2.082	6.709	5.615	8.017
Sham	Air cleaner	5+ blocks	1.901	1.715	2.088	6.695	5.556	8.068
Sham	Central	<2 blocks (1 block = 360 ft)	2.096	1.747	2.445	8.134	5.738	11.532
Sham	Central	2-4 blocks	2.038	1.823	2.253	7.672	6.188	9.512
Sham	Central	5+ blocks	1.574	1.408	1.740	4.827	4.089	5.698
True	Air cleaner	<2 blocks (1 block = 360 ft)	1.304	1.103	1.505	3.683	3.012	4.504
True	Air cleaner	2-4 blocks	1.242	1.022	1.462	3.462	2.779	4.314
True	Air cleaner	5+ blocks	1.118	0.905	1.331	3.059	2.473	3.783
True	Central	<2 blocks (1 block = 360 ft)	1.364	0.758	1.969	3.911	2.135	7.164
True	Central	2-4 blocks	1.793	1.495	2.090	6.006	4.461	8.088
True	Central	5+ blocks	1.092	0.813	1.370	2.979	2.255	3.936

The geometric means (GM) of indoor $PM_{2.5}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.7.

5.c. Indoor $PM_{0.2\text{-}2.5}$ concentrations:

Table 5.8: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	353	86.26	<.0001
hvac_ac	1	353	0.52	0.4711
BSL_DISTTOTRAFF	2	353	10.33	<.0001
true*hvac_ac	1	353	8.3	0.0042
true*BSL_DISTTOTRAFF	2	353	0.73	0.4846
hvac_ac*BSL_DISTTOTR	2	353	6.94	0.0011
true*hvac_ac*BSL_DIS	2	353	0.07	0.9342
season	3	353	16.6	<.0001
area	1	353	0.15	0.7036

Table 5.9: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<2 blocks, Air Cleaner: Sham vs True	0.5899	0.07979	353	7.39	<.0001	0.4330	0.7468
<2 blocks, Central: Sham vs True	0.3526	0.1455	353	2.42	0.0159	0.0664	0.6389
<2 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2373	0.1725	353	1.38	0.1700	-0.1021	0.5766
2-4 blocks, Air Cleaner: Sham vs True	0.5260	0.08235	353	6.39	<.0001	0.3641	0.6880
2-4 blocks, Central: Sham vs True	0.1927	0.1787	353	1.08	0.2818	-0.1588	0.5442
2-4 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.3333	0.1974	353	1.69	0.0921	-0.05482	0.7215
5+ blocks, Air Cleaner: Sham vs True	0.6356	0.07358	353	8.64	<.0001	0.4909	0.7803
5+ blocks, Central: Sham vs True	0.3670	0.1112	353	3.30	0.0011	0.1483	0.5858
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2686	0.1332	353	2.02	0.0445	0.006646	0.5305
Air Cleaner: <2 vs 5+ blocks diff in Sham vs True diffs	-0.04573	0.109	353	-0.42	0.6751	-0.2601	0.1686
Air Cleaner: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.1096	0.1111	353	-0.99	0.3247	-0.3281	0.1089
Central: <2 vs 5+ blocks diff in Sham vs True diffs	-0.01441	0.1829	353	-0.08	0.9372	-0.3741	0.3453
Central: 2-4 vs 5+ blocks diff in Sham vs True diffs	-0.1744	0.2107	353	-0.83	0.4084	-0.5887	0.2400
<2 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.03132	0.2192	353	-0.14	0.8865	-0.4624	0.3997
2-4 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.06478	0.2389	353	0.27	0.7864	-0.4050	0.5345

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<2, 2-4 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{0.2\text{-}2.5}$ concentrations (p=0.93) (Tables 5.8).

In homes with air cleaners, indoor $PM_{0.2\text{-}2.5}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<2 blocks: β=0.59 [95% CI: 0.43, 0.75], p<0.0001; 2-4 blocks: 0.53 [0.36, 0.69], p<0.0001; 5+ blocks: 0.64 [0.49, 0.78], p<0.0001) (Table 5.9). Similarly, in homes with central systems, $PM_{0.2\text{-}2.5}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway (<2 blocks: 0.35 [0.07, 0.64], p=0.02; 5+ blocks: 0.37 [0.15, 0.59], p=0.001), with the exception of homes located 2-4 blocks away where the differences between sham and true filtration were not significant, though trending in the same direction. Additionally, the difference in sham vs. true log mean $PM_{0.2\text{-}2.5}$ levels was significantly greater in homes with air cleaners located 5+ blocks from a major roadway than in homes with central systems located within the same distance to a roadway (0.27 [0.01, 0.53], p=0.04). No differences in the sham vs. true log mean $PM_{0.2\text{-}2.5}$ differences were observed between homes located <2 and 2-4 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{0.2\text{-}2.5}$ differences between air cleaner and central system homes located <2 vs. 5+ blocks from a major roadway were not significantly different. Likewise, the differences in the sham vs. true differences between air cleaner and central system homes located 2-4 vs. 5+ blocks from a major roadway were not statistically significant. This lack of significance indicates that the combined effects of filtration system and filtration type on indoor $PM_{0.2\text{-}2.5}$ levels did not vary much by distance to a major roadway.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes located <2 vs. 5+ blocks from a major roadway were not significantly different (0.08 [-0.33, 0.48], p=0.70). Similarly, the differences in the sham-true log geometric mean differences between air cleaner and central system homes located 2-4 vs. 5+ blocks from a major roadway were not statistically significant (0.22 [-0.24, 0.67], p=0.35). In other words, the effects of filtration system and filtration type on indoor $PM_{0.2\text{-}2.5}$ levels did not vary much by distance to a major roadway.

Table 5.10: Log Geometric Means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations (μg/m^3) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<2 blocks (1 block = 360 ft)	1.840	1.684	1.996	6.297	5.386	7.361
Sham	Air cleaner	2-4 blocks	1.698	1.532	1.864	5.464	4.627	6.451
Sham	Air cleaner	5+ blocks	1.711	1.547	1.875	5.532	4.695	6.518
Sham	Central	<2 blocks (1 block = 360 ft)	1.862	1.508	2.215	6.435	4.519	9.164
Sham	Central	2-4 blocks	1.833	1.638	2.028	6.251	5.143	7.600
Sham	Central	5+ blocks	1.306	1.131	1.482	3.691	3.097	4.400
True	Air cleaner	<2 blocks (1 block = 360 ft)	1.250	1.092	1.408	3.491	2.981	4.087
True	Air cleaner	2-4 blocks	1.172	0.980	1.364	3.229	2.665	3.911
True	Air cleaner	5+ blocks	1.075	0.925	1.225	2.930	2.521	3.405
True	Central	<2 blocks (1 block = 360 ft)	1.509	1.173	1.846	4.523	3.230	6.333
True	Central	2-4 blocks	1.640	1.390	1.890	5.156	4.015	6.621
True	Central	5+ blocks	0.939	0.709	1.169	2.557	2.031	3.220

The geometric means (GM) of indoor $PM_{0.2\text{-}2.5}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.10.

5.d. Indoor $PM_{0.2}$ concentrations, dichotomized at 5 blocks:

As an additional analysis, we compare whether the proximity to a major roadway modifies the association between indoor PM concentrations in sham vs. true filtration periods dichotomized at 5 blocks.

Table 5.11: Proximity to a major roadway by filtration type

	SHAM		TRUE	
Proximity to major roadway	**n**	**%**	**n**	**%**
<5 block (<360 ft)	155	63.5	183	63.5
5+ blocks	89	36.5	105	36.5

The proximity of a home to a major roadway was similar by filtration type, as expected. In both sham and true filtration, approximately 64% of homes were <5 blocks away from a major roadway (1 block = 360 ft), and 36% of homes were 5 or more blocks away (Table 5.11).

Table 5.12: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	335	111.09	<.0001
hvac_ac	1	335	0.23	0.6339
BSL_DISTTOTRAFF	1	335	10.61	0.0012
true*hvac_ac	1	335	7.96	0.0051
true*BSL_DISTTOTRAFF	1	335	1.44	0.2305
hvac_ac*BSL_DISTTOTR	1	335	3.99	0.0467
true*hvac_ac*BSL_DIS	1	335	0.55	0.4594
season	3	335	5.04	0.0020
area	1	335	2.13	0.1458

Table 5.13: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<5 blocks, Air Cleaner: Sham vs True	0.7129	0.0740	335	9.63	<.0001	0.5672	0.8585
<5 blocks, Central: Sham vs True	0.3185	0.1377	335	2.31	0.0213	0.0477	0.5893
<5 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.3944	0.1567	335	2.52	0.0123	0.0861	0.7027
5+ blocks, Air Cleaner: Sham vs True	0.7637	0.0910	335	8.39	<.0001	0.5847	0.9427
5+ blocks, Central: Sham vs True	0.5332	0.1273	335	4.19	<.0001	0.2829	0.7836
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2304	0.1564	335	1.47	0.1414	-0.0771	0.5380
Air Cleaner: <5 vs 5+ blocks diff in Sham vs True diffs	-0.0508	0.1174	335	-0.43	0.6655	-0.2817	0.1801
Central: <5 vs 5+ blocks diff in Sham vs True diffs	-0.2147	0.1875	335	-1.15	0.2529	-0.5835	0.1540
<5 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.1639	0.2213	335	0.74	0.4594	-0.2714	0.5993

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<5 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{0.2}$ concentrations (p=0.46) (Tables 5.12).

In homes with air cleaners, indoor $PM_{0.2}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<5 blocks: β=0.71 [95% CI: 0.57, 0.86], p<0.0001; 5+ blocks: 0.76 [0.58, 0.94], p<0.0001) (Table 5.3). Similarly, in homes with central systems, $PM_{0.2}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway

(<5 blocks: 0.32 [0.05, 0.59], p=0.02; 5+ blocks: 0.53 [0.28, 0.78], p<0.0001). No differences in the sham vs. true log mean $PM_{0.2}$ differences were observed between homes located <5 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{0.2}$ differences between air cleaner and central system homes located <5 vs. 5+ blocks from a major roadway were not significantly different. This lack of significance indicates that the combined effects of filtration system and filtration type on indoor $PM_{0.2}$ levels did not vary much by distance to a major roadway.

Table 5.14: Log Geometric Means (GM) of indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<5 blocks (1 block = 360 ft)	0.9075	0.7882	1.0269	2.4781	2.1994	2.7924
Sham	Air cleaner	5+ blocks	0.8416	0.6589	1.0243	2.3201	1.9327	2.7851
Sham	Central	<5 blocks (1 block = 360 ft)	0.8846	0.7209	1.0484	2.4220	2.0563	2.8531
Sham	Central	5+ blocks	0.6206	0.4766	0.7646	1.8600	1.6106	2.1481
True	Air cleaner	<5 blocks (1 block = 360 ft)	0.1947	0.0542	0.3351	1.2149	1.0557	1.3981
True	Air cleaner	5+ blocks	0.0779	-0.1137	0.2696	1.0810	0.8925	1.3094
True	Central	<5 blocks (1 block = 360 ft)	0.5661	0.3530	0.7792	1.7614	1.4233	2.1797
True	Central	5+ blocks	0.0874	-0.1434	0.3181	1.0913	0.8664	1.3745

The geometric means (GM) of indoor $PM_{0.2}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.14.

5.e. Indoor $PM_{2.5}$ concentrations, dichotomized at 5 blocks:

Table 5.15: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	326	92.43	<.0001
hvac_ac	1	326	0.02	0.8750
BSL_DISTTOTRAFF	1	326	11.64	0.0007
true*hvac_ac	1	326	4.50	0.0347
true*BSL_DISTTOTRAFF	1	326	0.24	0.6211
hvac_ac*BSL_DISTTOTR	1	326	4.88	0.0279
true*hvac_ac*BSL_DIS	1	326	0.05	0.8156
season	3	326	7.59	<.0001
area	1	326	0.15	0.7021

Table 5.16: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<5 blocks, Air Cleaner: Sham vs True	0.6902	0.0717	326	9.63	<.0001	0.5492	0.8313
<5 blocks, Central: Sham vs True	0.4497	0.1706	326	2.64	0.0088	0.1141	0.7854
<5 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2405	0.1872	326	1.28	0.1999	-0.1278	0.6088
5+ blocks, Air Cleaner: Sham vs True	0.7826	0.1012	326	7.73	<.0001	0.5834	0.9817
5+ blocks, Central: Sham vs True	0.4826	0.1400	326	3.45	0.0006	0.2072	0.7581
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2999	0.1728	326	1.74	0.0835	-0.0400	0.6398
Air Cleaner: <5 vs 5+ blocks diff in Sham vs True diffs	-0.0923	0.1249	326	-0.74	0.4605	-0.3381	0.1535
Central: <5 vs 5+ blocks diff in Sham vs True diffs	-0.0329	0.2210	326	-0.15	0.8818	-0.4676	0.4019
<5 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.0594	0.2547	326	-0.23	0.8156	-0.5605	0.4416

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<5 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{2.5}$ concentrations (p=0.82) (Table 5.15).

In homes with air cleaners, indoor $PM_{2.5}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<5 blocks: β=0.69 [95% CI: 0.55, 0.83], p<0.0001; 5+ blocks: 0.78 [0.58, 0.98], p<0.0001) (Table 5.6). Similarly, in homes with central systems, $PM_{2.5}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway (<5 blocks: 0.45 [0.11, 0.79], p=0.01; 5+ blocks: 0.48 [0.21, 0.76], p=0.001). No differences in the sham vs. true log mean $PM_{2.5}$ differences were observed between homes located <5 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{2.5}$ differences between air cleaner and central system homes located <5 vs. 5+ blocks from a major roadway were not significantly different. This lack of significance indicates that the combined effects of filtration system and filtration type on indoor $PM_{2.5}$ levels did not vary much by distance to a major roadway.

Table 5.17: Log Geometric Means (GM) of indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<5 blocks (1 block = 360 ft)	1.9680	1.8410	2.0950	7.1563	6.3028	8.1254
Sham	Air cleaner	5+ blocks	1.9001	1.7140	2.0862	6.6866	5.5511	8.0543
Sham	Central	<5 blocks (1 block = 360 ft)	2.0515	1.8651	2.2380	7.7796	6.4566	9.3746
Sham	Central	5+ blocks	1.5739	1.4079	1.7399	4.8254	4.0874	5.6968
True	Air cleaner	<5 blocks (1 block = 360 ft)	1.2777	1.1275	1.4280	3.5884	3.0879	4.1704
True	Air cleaner	5+ blocks	1.1176	0.9050	1.3301	3.0575	2.4719	3.7814
True	Central	<5 blocks (1 block = 360 ft)	1.6018	1.2846	1.9191	4.9620	3.6132	6.8148
True	Central	5+ blocks	1.0912	0.8127	1.3698	2.9778	2.2540	3.9346

The geometric means (GM) of indoor $PM_{2.5}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.17.

5.f. Indoor $PM_{0.2\text{-}2.5}$ concentrations, dichotomized at 5 blocks:

Table 5.18: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2\text{-}2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x distance to major roadway (TRUE × ROADWAY), filtration system x distance to major roadway (HVAC × ROADWAY), and filtration type x filtration system x distance to major roadway (TRUE × HVAC × ROADWAY)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	357	97.75	<.0001
hvac_ac	1	357	0.17	0.6810
BSL_DISTTOTRAFF	1	357	21.15	<.0001
true*hvac_ac	1	357	9.59	0.0021
true*BSL_DISTTOTRAFF	1	357	0.94	0.3328
hvac_ac*BSL_DISTTOTR	1	357	10.85	0.0011
true*hvac_ac*BSL_DIS	1	357	0.04	0.8453
season	3	357	16.86	<.0001
area	1	357	0.28	0.5944

Table 5.19: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
<5 blocks, Air Cleaner: Sham vs True	0.5648	0.0571	357	9.89	<.0001	0.4524	0.6771
<5 blocks, Central: Sham vs True	0.2596	0.1152	357	2.25	0.0248	0.0331	0.4862
<5 blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.3051	0.1304	357	2.34	0.0198	0.0487	0.5616
5+ blocks, Air Cleaner: Sham vs True	0.6354	0.0736	357	8.64	<.0001	0.4908	0.7800
5+ blocks, Central: Sham vs True	0.3669	0.1113	357	3.30	0.0011	0.1481	0.5857
5+ blocks: Air Cleaner vs. Central diff in Sham vs True diffs	0.2685	0.1332	357	2.02	0.0445	0.0066	0.5304
Air Cleaner: <5 vs 5+ blocks diff in Sham vs True diffs	-0.0706	0.0936	357	-0.75	0.4510	-0.2547	0.1135
Central: <5 vs 5+ blocks diff in Sham vs True diffs	-0.1073	0.1601	357	-0.67	0.5034	-0.4222	0.2077
<5 vs. 5+ blocks diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.0366	0.1875	357	0.20	0.8453	-0.3322	0.4054

The 3-way interaction term filtration type (sham vs. true) x filtration system (air cleaner vs. central) x distance to major roadway (<5 vs. 5+ blocks) (TRUE x HVAC x ROADWAY) was not statistically significant, indicating that proximity to a major roadway did not change the combined effects of filtration type and filtration system on the indoor $PM_{0.2\text{-}2.5}$ concentrations (p=0.85) (Tables 5.18).

In homes with air cleaners, indoor $PM_{0.2\text{-}2.5}$ concentrations were significantly higher in sham compared with true filtration irrespective of distance to a major roadway (<5 blocks: β=0.56 [95% CI: 0.45, 0.68], p<0.0001; 5+ blocks: 0.64 [0.49, 0.78], p<0.0001) (Table 5.9). Also, the difference in sham vs. true log mean $PM_{0.2\text{-}2.5}$ levels was significantly greater in homes with air cleaners located <5 blocks from a major roadway than in homes with central systems located within the same distance to a roadway (0.31 [0.05, 0.56], p=0.02). Similarly, in homes with central systems, $PM_{0.2\text{-}2.5}$ levels were significantly higher in sham than true filtration regardless of distance to a major roadway (<5 blocks: 0.26 [0.03, 0.49], p=0.02; 5+ blocks: 0.37 [0.15, 0.59], p=0.001). Additionally, the difference in sham vs. true log mean $PM_{0.2\text{-}2.5}$ levels was significantly greater in homes with air cleaners located 5+ blocks from a major roadway than in homes with central systems located within the same distance to a roadway (0.27 [0.01, 0.53], p=0.04). No differences in the sham vs. true log mean $PM_{0.2\text{-}2.5}$ differences were observed between homes located <5 blocks compared to 5+ blocks away from a major roadway irrespective of the home filtration system. The differences in the sham vs. true log geometric mean $PM_{0.2\text{-}2.5}$ differences between air cleaner and central system homes located <5 vs. 5+ blocks from a major roadway were not significantly different. This lack of significance indicates that the combined effects of filtration system and filtration type on indoor $PM_{0.2\text{-}2.5}$ levels did not vary much by distance to a major roadway.

In homes with air cleaners and <5 blocks from a major roadway, indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.76 times higher in sham than in true filtration (β=0.56 [95% CI: 0.45, 0.68], p<0.0001); while in homes with central systems and the same distance to roadway, $PM_{0.2\text{-}2.5}$ concentrations were 1.30 times higher in sham (0.26 [0.03, 0.49], p=0.02) (Table 5.9). At this distance to roadway, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.31 [0.05, 0.56], p=0.02), showing a 36% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

In homes with air cleaners and 5+ blocks from a major roadway, $PM_{0.2\text{-}2.5}$ concentrations were 1.88 times higher in sham than in true filtration (0.64 [0.49, 0.78], p<0.0001); while in homes with central systems and the same distance to roadway, $PM_{0.2\text{-}2.5}$ concentrations were 1.44 times higher in sham (0.37 [0.15, 0.59], p=0.001). At this distance to a major roadway, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.27 [0.01, 0.53], p=0.04), showing a 31% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

The differences in the sham-true log geometric mean differences between air cleaner and central system homes located <5 vs. 5+ blocks from a major roadway were not significantly different (0.04 [-0.33, 0.41], p=0.85). In other words, the combined effects of filtration system and filtration type on indoor $PM_{0.2-2.5}$ levels did not vary much by distance to a major roadway.

Table 5.20: Log Geometric Means (GM) of indoor $PM_{0.2-2.5}$ concentrations ($\mu g/m^3$) for each level of the TRUE × HVAC × ROADWAY interaction term in the log-normal mixed-effects model

Filtration type	Filtration system	Distance to major roadway	Log GM	95% CI		GM	95% CI	
Sham	Air cleaner	<5 blocks (1 block = 360 ft)	1.7804	1.6631	1.8976	5.9322	5.2756	6.6699
Sham	Air cleaner	5+ blocks	1.7098	1.5458	1.8739	5.5279	4.6917	6.5137
Sham	Central	<5 blocks (1 block = 360 ft)	1.8366	1.6541	2.0190	6.2752	5.2284	7.5308
Sham	Central	5+ blocks	1.3048	1.1291	1.4806	3.6870	3.0929	4.3956
True	Air cleaner	<5 blocks (1 block = 360 ft)	1.2156	1.0889	1.3423	3.3723	2.9710	3.8278
True	Air cleaner	5+ blocks	1.0744	0.9241	1.2247	2.9282	2.5196	3.4031
True	Central	<5 blocks (1 block = 360 ft)	1.5769	1.3762	1.7777	4.8399	3.9598	5.9162
True	Central	5+ blocks	0.9379	0.7066	1.1693	2.5546	2.0271	3.2197

The geometric means (GM) of indoor $PM_{0.2-2.5}$ concentrations for each combination of the interaction term filtration type x filtration system x distance to roadway are presented in Table 5.2

6. Compare whether filtration utilization (proportion of volume normalized to what asked to use) modifies the association between indoor PM concentrations in sham vs. true filtration periods

Table 6.1: Filtration use ratio by filtration type

Filtration use	N	Mean	Std Dev	Median	Minimum	Maximum
Sham	233	0.98	0.325	1.00	0	3.03
True	281	0.98	0.309	1.00	0	3.03

The mean filtration use ratios were the same by filtration type, as expected.

6.a. Indoor $PM_{0.2}$ concentrations:

Table 6.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	316	0.46	0.4978
hvac_ac	1	316	3.55	0.0603
USERATIO_SW	1	316	14.74	0.0001
true*hvac_ac	1	316	0.12	0.7299
USERATIO_SW*true	1	316	3.8	0.0522
USERATIO_SW*hvac_ac	1	316	4.73	0.0304
USERATI*true*hvac_ac	1	316	0.27	0.6012
season	3	316	4.37	0.0049
area	1	316	2.35	0.1260

Table 6.3: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	City	Season	Filtration type	Air cleaner or HVAC	Estimate	SE	DF	t Value	Pr > |t|
Intercept					0.5425	0.2219	152	2.44	0.0156
true			Sham		0.07302	0.2599	316	0.28	0.7789
true			true		0	.	.	.	.
hvac_ac				Air cleaner	0.3593	0.3578	316	1	0.3160
hvac_ac				HVAC	0	.	.	.	.
USERATIO_SW					-0.3428	0.1653	316	-2.07	0.0389
true*hvac_ac			Sham	Air cleaner	0.1521	0.4403	316	0.35	0.7299
true*hvac_ac			Sham	HVAC	0	.	.	.	.
true*hvac_ac			true	Air cleaner	0	.	.	.	.
true*hvac_ac			true	HVAC	0	.	.	.	.
USERATIO_SW*true			Sham		0.2956	0.2087	316	1.42	0.1577
USERATIO_SW*true			true		0	.	.	.	.
USERATIO_SW*hvac_ac				Air cleaner	-0.6042	0.3439	316	-1.76	0.0799
USERATIO_SW*hvac_ac				HVAC	0	.	.	.	.
USERATI*true*hvac_ac			Sham	Air cleaner	0.2178	0.4163	316	0.52	0.6012
USERATI*true*hvac_ac			Sham	HVAC	0	.	.	.	.
USERATI*true*hvac_ac			true	Air cleaner	0	.	.	.	.
USERATI*true*hvac_ac			true	HVAC	0	.	.	.	.
season		Fall			0.2135	0.06788	316	3.15	0.0018
season		Summer			0.06756	0.09287	316	0.73	0.4675
season		Winter			0.164	0.084	316	1.95	0.0518
season		Spring			0	.	.	.	.
area	Fresno				0.1202	0.07835	316	1.53	0.126
area	Riverside				0	.	.	.	.

Table 6.4: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for *selected values* of the filtration use ratio (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × USERATIO

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Use ratio = 0.75, Air Cleaner: Sham vs True	0.6102	0.09817	316	6.22	<.0001	0.4171	0.8034
Use ratio = 0.75, Central: Sham vs True	0.2947	0.1287	316	2.29	0.0227	0.04156	0.5479
Use ratio = 0.75: Air Cleaner vs. Central diff in Sham vs True diffs	0.3155	0.1619	316	1.95	0.0521	-0.00295	0.6340
Use ratio = 1.00, Air Cleaner: Sham vs True	0.7386	0.05667	316	13.03	<.0001	0.6271	0.8501
Use ratio = 1.00, Central: Sham vs True	0.3686	0.1023	316	3.60	0.0004	0.1674	0.5698
Use ratio = 1.00: Air Cleaner vs. Central diff in Sham vs True diffs	0.3700	0.1168	316	3.17	0.0017	0.1401	0.5998
Air Cleaner: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.1284	0.08989	316	-1.43	0.1543	-0.3052	0.0485
Central: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.0739	0.05218	316	-1.42	0.1577	-0.1766	0.02876
Use ratio = 0.75 vs. 1.00 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.05446	0.1041	316	-0.52	0.6012	-0.2592	0.1503

The mean filtration use ratio (proportion of volume normalized to what asked to use) was the same (Mean = 0.98; Median = 1) in both sham and true filtration, as expected (Table 6.1). The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × filtration use ratio (TRUE × HVAC × USERATIO) was not statistically significant, indicating that the proportion of time the filtration systems were used to the amount asked did not change the combined effects of filtration type and filtration system intervention on the indoor $PM_{0.2}$ concentrations (p=0.60) (Table 6.2).

Use ratios of 1 (mean levels) and 0.75 were used to illustrate the moderating effect of use ratio on the relationship between filtration type and indoor PM.

The difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2}$ levels between hypothetical homes that use their filtration systems 75% of the time asked vs. 100% was marginally significant in homes with air cleaners (-0.13 [-0.31, 0.05], p=0.15) and in homes with central systems (-0.07 [-0.18, 0.03], p=0.16).

In a hypothetical scenario where homes with air cleaners used their filtration systems 75% of the time asked (use ratio = 0.75), indoor $PM_{0.2}$ concentrations (log-transformed) were 1.84 times higher in sham than in true filtration (β=0.61 [95% CI: 0.42, 0.80], p<0.0001); while in homes with central systems and the same use ratio, $PM_{0.2}$ levels were 1.34 times higher in sham (0.29 [0.04, 0.55], p=0.02) (Tables 6.3-6.4). At this use ratio, the difference in the sham vs. true differences in log geometric mean $PM_{0.2}$ levels between air cleaner and central system homes was marginally significant (0.32 [-0.003, 0.63], p=0.052), showing a 37% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

As a comparison, in another scenario where homes with air cleaners used their filtration systems 100% of the time asked (use ratio = 1.00), $PM_{0.2}$ concentrations were 2.09 times higher in sham than in true filtration (β=0.74 [0.63, 0.85], p<0.0001); while in homes with central systems and the same use ratio, $PM_{0.2}$ levels were 1.45 times higher in sham (0.37 [0.17, 0.57], p=0.0004). At this use ratio, the difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2}$ levels between air cleaner and central system homes was statistically significant (0.37 [0.14, 0.60], p=0.002), showing a 45% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

The majority of homes had a filtration use ratio between 0.95 and 1.05; therefore, evaluating the relationship between filtration type and indoor PM0.2 levels at lower filtration use ratios was thought to be potentially underpowered. See the scatter plots in Figures 6.1-6.4 and Table 6.5 of average values of indoor concentration for different use ratios.

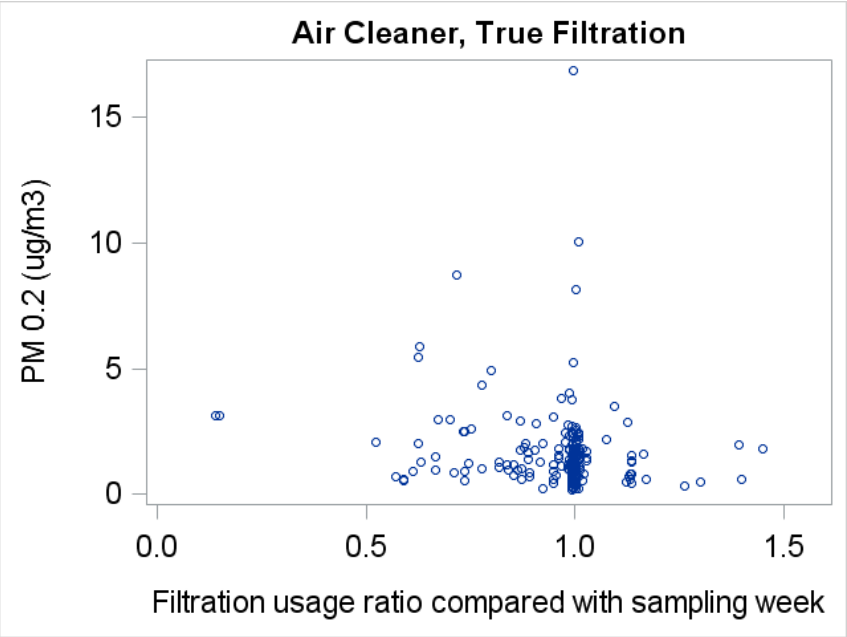


Figure 6.1 Indoor $PM_{0.2}$ concentration vs. percent time air cleaner run during sampling week with true filtration

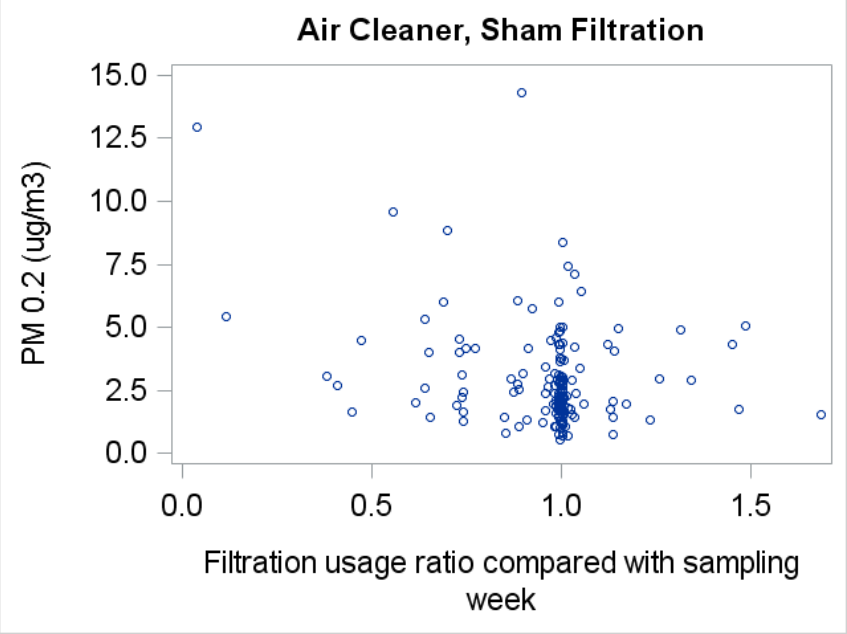


Figure 6.2 Indoor $PM_{0.2}$ concentration vs. percent time air cleaner run during sampling week with sham filtration

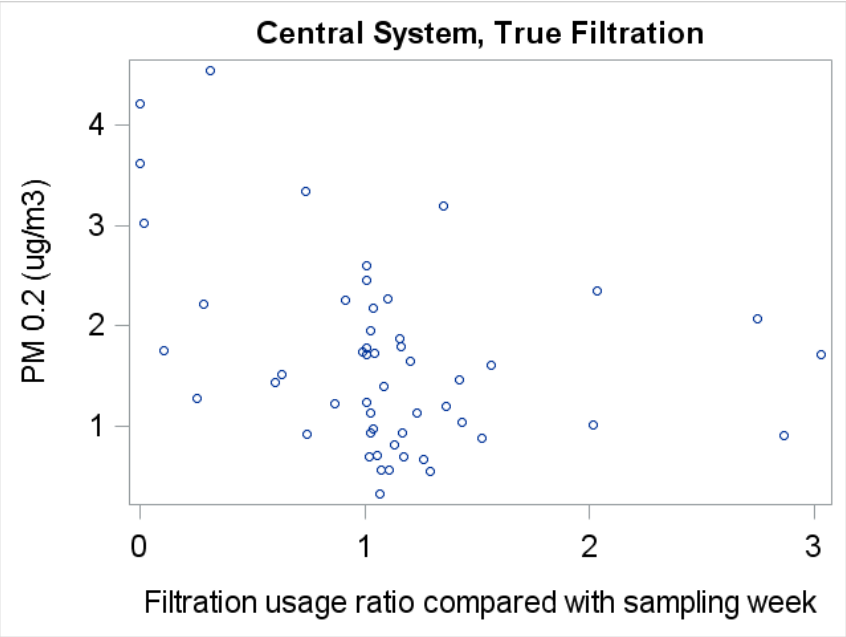


Figure 6.3 Indoor $PM_{0.2}$ concentration vs. percent time central system run during sampling week with sham filtration

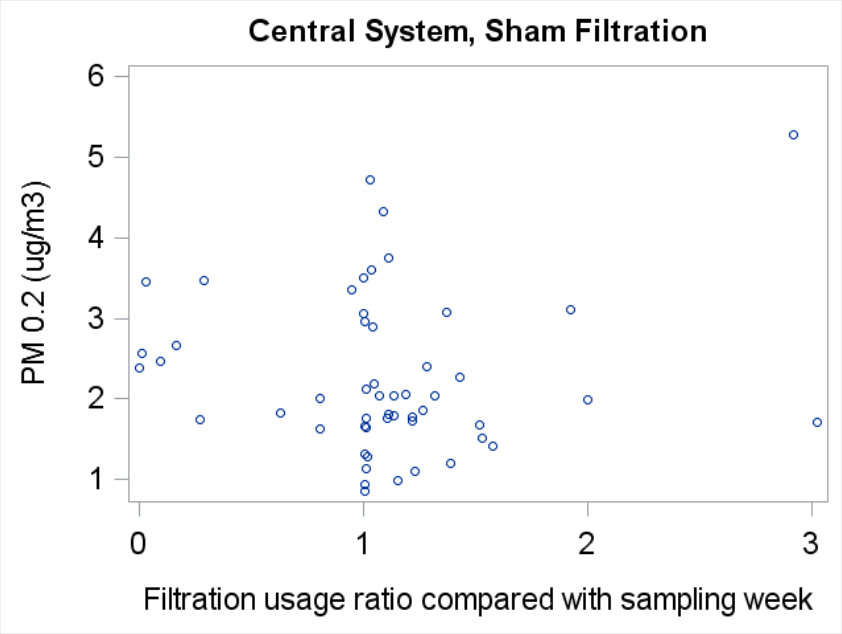


Figure 6.4 Indoor $PM_{0.2}$ concentration vs. percent time central system run during sampling week with sham filtration

Table 6.5: Average Values of Indoor Concentration of $PM_{0.2}$ (ug/m^3) of Air Cleaner Homes during True Filtration Period for Different Use Ratios

Filtration usage ratio compared with sampling week	N	Mean	Std Dev	Minimum	Maximum
<0.5	2	3.120	0.006	3.116	3.124
0.501-0.75	20	2.244	2.144	0.519	8.706
0.7501-0.95	32	1.635	1.109	0.221	4.929
0.9501-1.05	136	1.509	1.816	0.181	16.859
More than 1.0501	19	1.252	0.886	0.322	3.475

6.b. Indoor $PM_{2.5}$ concentrations:

Table 6.6: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	308	0.15	0.7005
hvac_ac	1	308	6.23	0.0131
USERATIO_SW	1	308	19.57	<.0001
true*hvac_ac	1	308	0.01	0.9327
USERATIO_SW*true	1	308	4.96	0.0266
USERATIO_SW*hvac_ac	1	308	7.96	0.0051
USERATI*true*hvac_ac	1	308	0.5	0.4783
season	3	308	5.98	0.0006
area	1	308	0.33	0.5633

Table 6.7: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	City	Season	Filtration type	Air cleaner or HVAC	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.5655	0.2342	152	6.69	<.0001
true			Sham		0.06824	0.2456	308	0.28	0.7813
true			true		0	.	.	.	.
hvac_ac				Air cleaner	0.5681	0.3582	308	1.59	0.1138
hvac_ac				HVAC	0	.	.	.	.
USERATIO_SW					-0.3398	0.1703	308	-2	0.0469
true*hvac_ac			Sham	Air cleaner	0.03841	0.4544	308	0.08	0.9327
true*hvac_ac			Sham	HVAC	0	.	.	.	.
true*hvac_ac			true	Air cleaner	0	.	.	.	.
true*hvac_ac			true	HVAC	0	.	.	.	.
USERATIO_SW*true			Sham		0.3258	0.1944	308	1.68	0.0948
USERATIO_SW*true			true		0	.	.	.	.
USERATIO_SW*hvac_ac				Air cleaner	-0.7671	0.3379	308	-2.27	0.0239
USERATIO_SW*hvac_ac				HVAC	0	.	.	.	.
USERATI*true*hvac_ac			Sham	Air cleaner	0.3046	0.429	308	0.71	0.4783
USERATI*true*hvac_ac			Sham	HVAC	0	.	.	.	.
USERATI*true*hvac_ac			true	Air cleaner	0	.	.	.	.
USERATI*true*hvac_ac			true	HVAC	0	.	.	.	.
season		Fall			0.1514	0.06726	308	2.25	0.0251
season		Summer			0.09038	0.09007	308	1	0.3164
season		Winter			0.2758	0.08837	308	3.12	0.0020
season		Spring			0	.	.	.	.
area	Fresno				0.04947	0.0855	308	0.58	0.5633
area	Riverside				0	.	.	.	.

Table 6.8: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for *selected values* of the filtration use ratio (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × USERATIO

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Use ratio = 0.75, Air Cleaner: Sham vs True	0.5794	0.1064	308	5.45	<.0001	0.3701	0.7887
Use ratio = 0.75, Central: Sham vs True	0.3126	0.1296	308	2.41	0.0165	0.05747	0.5677
Use ratio = 0.75: Air Cleaner vs. Central diff in Sham vs True diffs	0.2668	0.1682	308	1.59	0.1137	-0.06411	0.5978
Use ratio = 1.00, Air Cleaner: Sham vs True	0.7370	0.05439	308	13.55	<.0001	0.6300	0.8440
Use ratio = 1.00, Central: Sham vs True	0.3940	0.1084	308	3.64	0.0003	0.1808	0.6073
Use ratio = 1.00: Air Cleaner vs. Central diff in Sham vs True diffs	0.3430	0.1221	308	2.81	0.0053	0.1028	0.5832
Air Cleaner: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.1576	0.09562	308	-1.65	0.1004	-0.3457	0.03057
Central: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.08144	0.0486	308	-1.68	0.0948	-0.1771	0.01418
Use ratio = 0.75 vs. 1.00 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.07614	0.1073	308	-0.71	0.4783	-0.2872	0.1349

The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × filtration use ratio (TRUE × HVAC × USERATIO) was not statistically significant, indicating that the proportion of time the filtration systems were used to the amount asked did not change the combined effects of filtration type and filtration system intervention on the indoor $PM_{2.5}$ concentrations (p=0.48) (Table 6.5).

The difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{2.5}$ levels between hypothetical homes that use their filtration systems 75% of the time asked vs. 100% was statistically significant in homes with air cleaners (-0.16 [-0.35, 0.03], p=0.10) and in homes with central systems (-0.08 [-0.18, 0.01], p=0.09).

In a hypothetical scenario where homes with air cleaners used their filtration systems 75% of the time asked (use ratio = 0.75), indoor $PM_{2.5}$ concentrations (log-transformed) were 1.78 times higher in sham than in true filtration (β=0.58 [95% CI: 0.37, 0.79], p<0.0001); while in homes with central systems and the same use ratio, $PM_{2.5}$ levels were 1.37 times higher in sham (0.31 [0.06, 0.57], p=0.02) (Tables 6.6-6.7). At this use ratio, the difference in the sham vs. true differences in log geometric mean $PM_{2.5}$ levels between air cleaner and central system homes was not statistically significant (0.27 [-0.06, 0.60], p=0.11), showing little variation in air quality improvements with true filtration between homes with air cleaners and homes with central systems.

As a comparison, in another scenario where homes with air cleaners used their filtration systems 100% of the time asked (use ratio = 1.00), $PM_{2.5}$ concentrations were 2.09 times higher in sham than in true filtration (β=0.74 [0.63, 0.84], p<0.0001); while in homes with central systems and the same use ratio, $PM_{2.5}$ levels were 1.48 times higher in sham (0.39 [0.18, 0.61], p=0.0003). At this use ratio, the difference in the sham vs. true differences in log geometric mean $PM_{2.5}$ levels between air cleaner and central system homes was statistically significant (0.34 [0.10, 0.58], p=0.01), showing a 41% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

6.c. Indoor $PM_{0.2-2.5}$ concentrations:

Table 6.9: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2-2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	339	0.29	0.5922
hvac_ac	1	339	6.06	0.0143
USERATIO_SW	1	339	15.6	<.0001
true*hvac_ac	1	339	0.15	0.7003
USERATIO_SW*true	1	339	3.33	0.069
USERATIO_SW*hvac_ac	1	339	7.07	0.0082
USERATI*true*hvac_ac	1	339	0.32	0.5739
season	3	339	13.98	<.0001
area	1	339	0.68	0.4106

Table 6.10: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2-2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration use ratio (TRUE × USERATIO), filtration system x filtration use ratio (HVAC × USERATIO), and filtration type x filtration system x filtration use ratio (TRUE × HVAC × USERATIO)

Effect	City	Season	Filtration type	Air cleaner or HVAC	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.2992	0.2045	156	6.35	<.0001
true			Sham		0.02826	0.215	339	0.13	0.8955
true			true		0	.	.	.	.
hvac_ac				Air cleaner	0.4651	0.3035	339	1.53	0.1263
hvac_ac				HVAC	0	.	.	.	.
USERATIO_SW					-0.2389	0.1353	339	-1.77	0.0783
true*hvac_ac			Sham	Air cleaner	0.1464	0.3799	339	0.39	0.7003
true*hvac_ac			Sham	HVAC	0	.	.	.	.
true*hvac_ac			true	Air cleaner	0	.	.	.	.
true*hvac_ac			true	HVAC	0	.	.	.	.
USERATIO_SW*true			Sham		0.2223	0.1635	339	1.36	0.1748
USERATIO_SW*true			true		0	.	.	.	.
USERATIO_SW*hvac_ac				Air cleaner	-0.6256	0.2787	339	-2.24	0.0254
USERATIO_SW*hvac_ac				HVAC	0	.	.	.	.
USERATI*true*hvac_ac			Sham	Air cleaner	0.1998	0.355	339	0.56	0.5739
USERATI*true*hvac_ac			Sham	HVAC	0	.	.	.	.
USERATI*true*hvac_ac			true	Air cleaner	0	.	.	.	.
USERATI*true*hvac_ac			true	HVAC	0	.	.	.	.
season		Fall			0.2746	0.06108	339	4.5	<.0001
season		Summer			0.1519	0.08414	339	1.8	0.072
season		Winter			0.3861	0.08549	339	4.52	<.0001
season		Spring			0	.	.	.	.
area	Fresno				0.06287	0.07631	339	0.82	0.4106
area	Riverside				0	.	.	.	.

Table 6.11: Contrasts in log geometric mean indoor $PM_{0.2\text{-}2.5}$ concentrations ($\mu g/m^3$) for *selected values* of the filtration use ratio (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × USERATIO

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Use ratio = 0.75, Air Cleaner: Sham vs True	0.4912	0.08524	339	5.76	<.0001	0.3236	0.6589
Use ratio = 0.75, Central: Sham vs True	0.1950	0.1079	339	1.81	0.0717	-0.01727	0.4072
Use ratio = 0.75: Air Cleaner vs. Central diff in Sham vs True diffs	0.2962	0.1375	339	2.15	0.0319	0.02572	0.5668
Use ratio = 1.00, Air Cleaner: Sham vs True	0.5968	0.04288	339	13.92	<.0001	0.5124	0.6811
Use ratio = 1.00, Central: Sham vs True	0.2506	0.08243	339	3.04	0.0026	0.08844	0.4127
Use ratio = 1.00: Air Cleaner vs. Central diff in Sham vs True diffs	0.3462	0.09278	339	3.73	0.0002	0.1637	0.5287
Air Cleaner: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.1055	0.07853	339	-1.34	0.1799	-0.2600	0.04893
Central: Use ratio = 0.75 vs 1.00 diff in Sham vs True diffs	-0.05558	0.04087	339	-1.36	0.1748	-0.1360	0.02482
Use ratio = 0.75 vs. 1.00 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.04995	0.08875	339	-0.56	0.5739	-0.2245	0.1246

The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × filtration use ratio (TRUE × HVAC × USERATIO) was not statistically significant, indicating that the proportion of time the filtration systems were used to the amount asked did not change the combined effects of filtration type and filtration system intervention on the indoor $PM_{0.2\text{-}2.5}$ concentrations (p=0.57) (Table 6.9).

The difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2\text{-}2.5}$ levels between hypothetical homes that use their filtration systems 75% of the time asked vs. 100% was marginally statistically significant in homes with air cleaners (-0.11 [-0.26, 0.05], p=0.18) and in homes with central systems (-0.06 [-0.14, 0.02], p=0.17) (Table 6.11)

In a hypothetical scenario where homes with air cleaners used their filtration systems 75% of the time asked (use ratio = 0.75), indoor $PM_{0.2\text{-}2.5}$ concentrations (log-transformed) were 1.63 times higher in sham than in true filtration (β=0.49 [95% CI: 0.32, 0.66], p<0.0001); while in homes with central systems and the same use ratio, $PM_{0.2\text{-}2.5}$ levels were 1.22 times higher in sham (0.20 [-0.02, 0.41], p=0.07) (Tables 6.11). At this use ratio, the difference in the sham vs. true differences in log geometric mean $PM_{0.2\text{-}2.5}$ levels between air cleaner and central system homes was statistically significant (0.30 [0.03, 0.57], p=0.03), showing a 34% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

As a comparison, in another scenario where homes with air cleaners used their filtration systems 100% of the time asked (use ratio = 1.00), $PM_{0.2\text{-}2.5}$ concentrations were 1.82 times higher in sham than in true filtration (β=0.60 [0.51, 0.68], p<0.0001); while in homes with central systems and the same use ratio, $PM_{0.2\text{-}2.5}$ levels were 1.28 times higher in sham (0.25 [0.09, 0.41], p=0.003). At this use ratio, the difference in the sham vs. true differences in log geometric mean $PM_{0.2\text{-}2.5}$ levels between air cleaner and central system homes was statistically significant (0.35 [0.16, 0.53], p=0.0002), showing a 42% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

7. Compare whether outdoor PM concentrations modify the association between corresponding indoor PM concentrations in sham vs. true filtration periods

7.a. Indoor $PM_{0.2}$ concentrations:

Table 7.1: Outdoor $PM_{0.2}$ concentrations ($\mu g/m^3$) by filtration type

Filtration use	N	GM	Std Dev	Median	95th %ile	Minimum	Maximum
Sham	235	3.05	1.59	2.87	7.82	0.95	11.17
True	276	3.31	1.56	3.12	8.47	1.00	13.13

GM = Geometric Mean

The mean outdoor $PM_{0.2}$ concentrations were slightly higher in true filtration compared with sham.

Table 7.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x outdoor $PM_{0.2}$ (TRUE × PM02_OUT), filtration system x outdoor $PM_{0.2}$ (HVAC × PM02_OUT), and filtration type x filtration system x outdoor $PM_{0.2}$ (TRUE × HVAC × PM02_OUT)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	327	21.26	<.0001
hvac_ac	1	327	1.31	0.2524
PM02_out	1	327	10.27	0.0015
true*hvac_ac	1	327	15.96	<.0001
PM02_out*true	1	327	0.27	0.6032
PM02_out*hvac_ac	1	327	0.62	0.4302
PM02_ou*true*hvac_ac	1	327	10.11	0.0016
season	3	327	6.8	0.0002
area	1	327	0.87	0.3504

Table 7.3: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type × filtration system (TRUE × HVAC), filtration type × outdoor $PM_{0.2}$ (TRUE × PM02_OUT), filtration system × outdoor $PM_{0.2}$ (HVAC × PM02_OUT), and filtration type × filtration system × outdoor $PM_{0.2}$ (TRUE × HVAC × PM02_OUT)

Effect	City	Season	Filtration type	Filtration system	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					0.28	0.185	152	1.51	0.1322	-0.0855	0.6455
true			Sham		0.08283	0.1927	327	0.43	0.6676	-0.2963	0.462
true			True		0	.	.	.	.	.	.
hvac_ac				Air cleaner	-0.6045	0.209	327	-2.89	0.0041	-1.0156	-0.1933
hvac_ac				Central	0	.	.	.	.	.	.
PM02_out					-0.0006	0.03866	327	-0.02	0.9875	-0.07665	0.07544
true*hvac_ac			Sham	Air cleaner	0.8871	0.2221	327	3.99	<.0001	0.4502	1.324
true*hvac_ac			Sham	Central	0	.	.	.	.	.	.
true*hvac_ac			True	Air cleaner	0	.	.	.	.	.	.
true*hvac_ac			True	Central	0	.	.	.	.	.	.
PM02_out*true			Sham		0.1014	0.0454	327	2.23	0.0262	0.01211	0.1907
PM02_out*true			True		0	.	.	.	.	.	.
PM02_out*hvac_ac				Air cleaner	0.1136	0.04884	327	2.33	0.0206	0.01757	0.2097
PM02_out*hvac_ac				Central	0	.	.	.	.	.	.
PM02_ou*true*hvac_ac			Sham	Air cleaner	-0.1733	0.05451	327	-3.18	0.0016	-0.2806	-0.0661
PM02_ou*true*hvac_ac			Sham	Central	0	.	.	.	.	.	.
PM02_ou*true*hvac_ac			True	Air cleaner	0	.	.	.	.	.	.
PM02_ou*true*hvac_ac			True	Central	0	.	.	.	.	.	.
season		Fall			0.1404	0.07275	327	1.93	0.0546	-0.00277	0.2835
season		Summer			-0.1002	0.1027	327	-0.98	0.3298	-0.3023	0.1018
season		Winter			0.1565	0.08031	327	1.95	0.0522	-0.0015	0.3145
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.07288	0.07793	327	0.94	0.3504	-0.08043	0.2262
area	Riverside				0	.	.	.	.	.	.

Table 7.4: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for *selected values* of outdoor $PM_{0.2}$ (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × PM02_OUT

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Outdoor PM02 = 8.0 (95th perc), Air Cleaner: Sham vs True	0.3947	0.1633	327	2.42	0.0162	0.07341	0.7159
Outdoor PM02 = 8.0 (95th perc), Central: Sham vs True	0.8942	0.2168	327	4.12	<.0001	0.4676	1.3208
Outdoor PM02 = 8.0 (95th perc): Air Cleaner vs. Central diff in Sham vs True diffs	-0.4995	0.2666	327	-1.87	0.0619	-1.024	0.02501
Outdoor PM02 = 3.0 (50th perc), Air Cleaner: Sham vs True	0.7542	0.05482	327	13.76	<.0001	0.6464	0.8621
Outdoor PM02 = 3.0 (50th perc), Central: Sham vs True	0.3871	0.09966	327	3.88	0.0001	0.191	0.5831
Outdoor PM02 = 3.0 (50th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.3671	0.1137	327	3.23	0.0014	0.1435	0.5908
Air Cleaner: Outdoor PM02 = 8.0 vs 3.0 diff in Sham vs True diffs	-0.3596	0.1607	327	-2.24	0.0259	-0.6756	-0.04352
Central: Outdoor PM02 = 8.0 vs 3.0 diff in Sham vs True diffs	0.5071	0.227	327	2.23	0.0262	0.06055	0.9537
Outdoor PM02 = 8.0 vs. 3.0 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.8667	0.2725	327	-3.18	0.0016	-1.4028	-0.3305

The mean outdoor $PM_{0.2}$ concentrations were slightly higher in true filtration (Geometric Mean [GM] = 3.31 [SD=1.56]; Median = 3.12; 95th percentile = 8.47) than in sham (3.05 [1.59]; Median = 2.87; 95th percentile = 7.82) (Table 7.1). The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × outdoor $PM_{0.2}$ (TRUE × HVAC × PM02_OUT) was statistically significant, indicating that the combined effects of filtration type and filtration system intervention on the indoor $PM_{0.2}$ concentrations varied depending on the levels of outdoor $PM_{0.2}$ (p=0.002) (Table 7.2).

In a hypothetical scenario where homes with air cleaners had outdoor $PM_{0.2}$ levels of 8.0 $\mu g/m^3$, the indoor $PM_{0.2}$ concentrations (log-transformed) were 1.48 times higher in sham than in true filtration (β=0.39 [95% CI: 0.07, 0.72], p=0.02); while in homes with central systems and the same outdoor $PM_{0.2}$ levels, the indoor

$PM_{0.2}$ concentrations were 2.45 times higher in sham (0.89 [0.47, 1.32], p<0.0001) (Tables 7.3-7.4). At outdoor $PM_{0.2}$ levels of 8.0 μg/m^3, the difference in the sham-true log geometric mean differences between air cleaner and central system homes did not reach statistical significance, indicating that air quality improvements did not differ by home filtration system where outdoor $PM_{0.2}$ levels were in approximately the 95th percentile.

As a comparison, in another scenario where homes with air cleaners had outdoor $PM_{0.2}$ levels of 3.0 μg/m^3, $PM_{0.2}$ concentrations were 2.13 times higher in sham than in true filtration (0.75 [0.65, 0.86], p<0.0001); while in homes with central systems and the same outdoor $PM_{0.2}$ levels, indoor $PM_{0.2}$ concentrations were 1.47 times higher in sham (0.39 [0.19, 0.58], p=0.0001). At outdoor $PM_{0.2}$ levels of 3.0 μg/m^3, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.37 [0.14, 0.59], p=0.001), showing a 44% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems where outdoor $PM_{0.2}$ levels were in approximately the 50th percentile.

In air cleaner homes, the sham vs. true log mean differences were greater at lower outdoor $PM_{0.2}$ levels (e.g. 50th percentile compared with 95th) (-0.36 [-0.68, -0.04), p=0.03). Conversely, in homes with central systems, the sham vs. true differences were greater at higher outdoor $PM_{0.2}$ levels (0.51 [0.06, 0.95], p=0.03). Accordingly, the difference in the sham-true log geometric mean differences between air cleaner and central system homes comparing the two hypothetical levels of outdoor $PM_{0.2}$ (8.0 vs. 3.0) was statistically significant (-0.87 [-1.40, -0.33], p=0.002). In other words, the combined effects of filtration system and filtration type on indoor $PM_{0.2}$ concentrations varied substantially depending on the levels of outdoor $PM_{0.2}$.

7.b. Indoor $PM_{2.5}$ concentrations:

Table 7.5: Outdoor $PM_{2.5}$ concentrations (μg/m^3) by filtration type

Filtration use	N	GM	Std Dev	Median	95th %ile	Minimum	Maximum
Sham	234	9.21	1.75	8.85	21.54	1.21	232.76
True	268	10.28	1.75	8.94	40.45	3.86	73.70

GM = Geometric Mean

The mean outdoor $PM_{2.5}$ concentrations were slightly higher during the true filtration period compared with the sham period.

Table 7.6: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type × filtration system (TRUE × HVAC), filtration type × outdoor $PM_{2.5}$ (TRUE × PM25_OUT), filtration system × outdoor $PM_{2.5}$ (HVAC × PM25_OUT), and filtration type × filtration system × outdoor $PM_{2.5}$ (TRUE × HVAC × PM25_OUT)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	318	8.52	0.0038
hvac_ac	1	318	2.19	0.1398
PM25_out	1	318	5.11	0.0245
true*hvac_ac	1	318	0.69	0.4071
PM25_out*true	1	318	1.26	0.2619
PM25_out*hvac_ac	1	318	2.32	0.1290
PM25_ou*true*hvac_ac	1	318	0.14	0.7120
season	3	318	1.29	0.2769
area	1	318	0.01	0.9164

Table 7.7: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x outdoor $PM_{2.5}$ (TRUE × PM25_OUT), filtration system x outdoor $PM_{2.5}$ (HVAC × PM25_OUT), and filtration type x filtration system x outdoor $PM_{2.5}$ (TRUE × HVAC × PM25_OUT)

Effect	City	Season	Filtration type	Filtration system	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					1.3531	0.161	152	8.4	<.0001	1.035	1.6713
true			Sham		0.3045	0.2667	318	1.14	0.2545	-0.2203	0.8293
true			True		0	.	.	.	.	.	.
hvac_ac				Air cleaner	-0.3847	0.1791	318	-2.15	0.0325	-0.737	-0.03227
hvac_ac				Central	0	.	.	.	.	.	.
PM25_out					0.001333	0.005996	318	0.22	0.8242	-0.01046	0.01313
true*hvac_ac			Sham	Air cleaner	0.234	0.2819	318	0.83	0.4071	-0.3206	0.7887
true*hvac_ac			Sham	Central	0	.	.	.	.	.	.
true*hvac_ac			True	Air cleaner	0	.	.	.	.	.	.
true*hvac_ac			True	Central	0	.	.	.	.	.	.
PM25_out*true			Sham		0.01041	0.02566	318	0.41	0.6852	-0.04007	0.0609
PM25_out*true			True		0	.	.	.	.	.	.
PM25_out*hvac_ac				Air cleaner	0.0171	0.008774	318	1.95	0.0522	-0.00016	0.03436
PM25_out*hvac_ac				Central	0	.	.	.	.	.	.
PM25_ou*true*hvac_ac			Sham	Air cleaner	0.009761	0.02642	318	0.37	0.7120	-0.04221	0.06173
PM25_ou*true*hvac_ac			Sham	Central	0	.	.	.	.	.	.
PM25_ou*true*hvac_ac			True	Air cleaner	0	.	.	.	.	.	.
PM25_ou*true*hvac_ac			True	Central	0	.	.	.	.	.	.
season		Fall			0.03693	0.07042	318	0.52	0.6003	-0.1016	0.1755
season		Summer			0.00285	0.09202	318	0.03	0.9753	-0.1782	0.1839
season		Winter			0.1244	0.09527	318	1.31	0.1926	-0.06306	0.3118
season		Spring			0	.	.	.	.	.	.
area	Fresno				-0.00901	0.08584	318	-0.1	0.9164	-0.1779	0.1599
area	Riverside				0	.	.	.	.	.	.

Table 7.8: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for *selected values* of outdoor $PM_{2.5}$ (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × PM25_OUT

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Outdoor PM25 = 27 (95th perc), Air Cleaner: Sham vs True	1.0832	0.1345	318	8.05	<.0001	0.8185	1.3479
Outdoor PM25 = 27 (95th perc), Central: Sham vs True	0.5857	0.4664	318	1.26	0.2101	-0.3319	1.5032
Outdoor PM25 = 27 (95th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.4976	0.4803	318	1.04	0.3010	-0.4474	1.4425
Outdoor PM25 = 9 (50th perc), Air Cleaner: Sham vs True	0.7201	0.05522	318	13.04	<.0001	0.6114	0.8287
Outdoor PM25 = 9 (50th perc), Central: Sham vs True	0.3982	0.1152	318	3.46	0.0006	0.1716	0.6248
Outdoor PM25 = 9 (50th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.3219	0.1297	318	2.48	0.0136	0.06664	0.5771
Air Cleaner: Outdoor PM25 = 27 vs 9 diff in Sham vs True diffs	0.3631	0.1403	318	2.59	0.0101	0.08715	0.6391
Central: Outdoor PM25 = 27 vs 9 diff in Sham vs True diffs	0.1874	0.4619	318	0.41	0.6852	-0.7213	1.0962
Outdoor PM25 = 27 vs. 9 diff in Air Cleaner vs. Central diff in Sham vs True diffs	0.1757	0.4755	318	0.37	0.7120	-0.7598	1.1112

The mean outdoor $PM_{2.5}$ concentrations were slightly higher in true filtration (Geometric Mean [GM] = 10.28 [SD=1.1.75]; Median = 8.94; 95th percentile = 40.45) than in sham (9.21 [1.75]; Median = 8.85; 95th percentile = 21.54) (Table 7.5). The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × outdoor $PM_{2.5}$ (TRUE × HVAC × PM25_OUT) was not statistically significant, indicating that the combined effects of filtration type and filtration system intervention on the indoor $PM_{2.5}$ concentrations did not vary much based on the levels of outdoor $PM_{2.5}$ (p=0.71) (Table 7.2).

In a hypothetical scenario where homes with air cleaners had outdoor $PM_{2.5}$ levels of 27 $\mu g/m^3$, the indoor $PM_{2.5}$ concentrations (log-transformed) were 2.95 times higher in sham than in true filtration (β=1.08 [95%

CI: 0.82, 1.35], p<0.0001); while in homes with central systems and the same outdoor $PM_{2.5}$ levels, the indoor $PM_{2.5}$ concentrations did not differ significantly between sham and true filtration (Tables 7.6-7.7). At outdoor $PM_{2.5}$ levels of 27 $\mu g/m^3$, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was also not statistically significant, indicating negligible differences in air quality improvements with true filtration between homes with air cleaners and homes with central systems, where the outdoor $PM_{2.5}$ were in approximately the 95th percentile.

As a comparison, in another scenario where homes with air cleaners had outdoor $PM_{2.5}$ levels of 9 $\mu g/m^3$, $PM_{2.5}$ concentrations were 2.05 times higher in sham than in true filtration (β=0.72 [0.61, 0.83], p<0.0001); while in homes with central systems and the same outdoor $PM_{2.5}$ levels, indoor $PM_{2.5}$ concentrations were 1.49 times higher in sham (0.40 [0.17, 0.62], p=0.001). At outdoor $PM_{2.5}$ levels of 9 $\mu g/m^3$, the difference in the sham-true log geometric mean differences between air cleaner and central system homes was statistically significant (0.36 [0.09, 0.64], p=0.01), indicating a 38% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems, where the outdoor $PM_{2.5}$ levels were in approximately the 50th percentile.

In air cleaner homes, the sham vs. true log mean differences were greater at higher outdoor $PM_{2.5}$ levels (e.g. 95th percentile compared with 50th) (0.36 [0.09, 0.64), p=0.01). However, in homes with central systems, the sham vs. true differences did not vary significantly by levels of outdoor $PM_{2.5}$. The difference in the sham-true log geometric mean differences between air cleaner and central system homes comparing the two hypothetical levels of outdoor $PM_{2.5}$ (27 vs. 9 $\mu g/m^3$) was also not statistically significant. In other words, the combined effects of filtration system and filtration type on indoor $PM_{2.5}$ concentrations did not vary much based on the levels of outdoor $PM_{2.5}$.

8. Compare whether the filtration fraction (fraction of the volume of air in the home that is cleaned every hour) modifies the association between indoor PM concentrations in sham vs. true filtration periods

Table 8.1: Filtration fraction by filtration type

Filtration fraction	N	Mean	Std Dev	Median	95th %ile	Minimum	Maximum
Sham	203	2.40	1.38	2.24	5.08	0	7.36
True	245	2.40	1.44	2.13	5.10	0	10.63

The mean filtration fractions were similar by filtration type, as expected.

8.a. Indoor $PM_{0.2}$ concentrations:

Table 8.2: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration fraction (TRUE × FILT_FRACTION), filtration system x filtration fraction (HVAC × FILT_FRACTION), and filtration type x filtration system x filtration fraction (TRUE × HVAC × FILT_FRACTION)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	278	8.02	0.005
hvac_ac	1	278	1.03	0.3119
filt_fraction	1	278	1.61	0.2062
true*hvac_ac	1	278	1.86	0.174
filt_fraction*true	1	278	0.48	0.4882
filt_fractio*hvac_ac	1	278	0.63	0.4292
filt_fr*true*hvac_ac	1	278	0.29	0.5922
season	3	278	3.6	0.0141
area	1	278	1.67	0.1973

Table 8.3: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{0.2}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration fraction (TRUE × FILT_FRACTION), filtration system x filtration fraction (HVAC × FILT_FRACTION), and filtration type x filtration system x filtration fraction (TRUE × HVAC × FILT_FRACTION)

Effect	City	Season	Filtration type	Air cleaner or HVAC	Estimate	SE	DF	t Value	Pr > |t|
Intercept					0.4919	0.3485	132	1.41	0.1605
true			Sham		0.2434	0.3096	278	0.79	0.4326
true			True		0	.	.	.	.
hvac_ac				Air cleaner	-0.4434	0.3516	278	-1.26	0.2084
hvac_ac				HVAC	0	.	.	.	.
filt_fraction					-0.1142	0.1158	278	-0.99	0.3249
true*hvac_ac			Sham	Air cleaner	0.4518	0.3315	278	1.36	0.174
true*hvac_ac			Sham	HVAC	0	.	.	.	.
true*hvac_ac			True	Air cleaner	0	.	.	.	.
true*hvac_ac			True	HVAC	0	.	.	.	.
filt_fraction*true			Sham		0.06583	0.09943	278	0.66	0.5084
filt_fraction*true			True		0	.	.	.	.
filt_fractio*hvac_ac				Air cleaner	0.0916	0.1234	278	0.74	0.4585
filt_fractio*hvac_ac				HVAC	0	.	.	.	.
filt_fr*true*hvac_ac			Sham	Air cleaner	-0.05765	0.1075	278	-0.54	0.5922
filt_fr*true*hvac_ac			Sham	HVAC	0	.	.	.	.
filt_fr*true*hvac_ac			True	Air cleaner	0	.	.	.	.
filt_fr*true*hvac_ac			True	HVAC	0	.	.	.	.
season		Fall			0.1927	0.07119	278	2.71	0.0072
season		Summer			0.006536	0.1041	278	0.06	0.95
season		Winter			0.129	0.09246	278	1.39	0.1642
season		Spring			0	.	.	.	.
area	Fresno				0.1153	0.08919	278	1.29	0.1973
area	Riverside				0	.	.	.	.

Table 8.4: Contrasts in log geometric mean indoor $PM_{0.2}$ concentrations ($\mu g/m^3$) for *selected values* of filtration fraction (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × FILT_FRACTION

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Filt fraction = 5 (95th perc), Air Cleaner: Sham vs True	0.7361	0.1141	278	6.45	<.0001	0.5116	0.9607
Filt fraction = 5 (95th perc), Central: Sham vs True	0.5725	0.2448	278	2.34	0.0201	0.09057	1.0545
Filt fraction = 5 (95th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.1636	0.2721	278	0.60	0.5482	-0.3720	0.6992
Filt fraction = 2 (50th perc), Air Cleaner: Sham vs True	0.7116	0.06422	278	11.08	<.0001	0.5851	0.8380
Filt fraction = 2 (50th perc), Central: Sham vs True	0.3750	0.1490	278	2.52	0.0124	0.08181	0.6682
Filt fraction = 2 (50th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.3365	0.1619	278	2.08	0.0386	0.01783	0.6552
Air Cleaner: Filt fraction = 5 (95th perc) vs 2 (50th perc) diff in Sham vs True diffs	0.02455	0.1192	278	0.21	0.8370	-0.2102	0.2593
Central: Filt fraction 5 (95th perc) vs 2 (50th perc) diff in Sham vs True diffs	0.1975	0.2983	278	0.66	0.5084	-0.3897	0.7847
Filt fraction = 5 vs. 2 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.1729	0.3225	278	-0.54	0.5922	-0.8079	0.4620

The mean filtration fraction (fraction of the volume of air in the home that is cleaned every hour) was similar during both sham (Mean = 2.40 [1.38]; Median = 2.24; 95th percentile = 5.08) and true filtration periods (Mean = 2.40 [1.44]; Median = 2.13; 95th percentile = 5.10), as expected (Table 8.1). The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × filtration fraction (TRUE × HVAC × FILT_FRACTION) was not statistically significant, indicating that the combined effects of filtration type and filtration system intervention on the indoor $PM_{0.2}$ concentrations did not vary much based on the fraction of volume of air in the homes that was cleaned every hour (p=0.59) (Table 8.2).

A filtration fraction value of 2 (median levels) and 5 (95th percentile) were used to illustrate the moderating effect of filtration fraction on the relationship between filtration type and indoor $PM_{0.2}$ concentrations in homes with central systems and separately in homes with air cleaners.

The difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2}$ levels between hypothetical homes that had an air filtration fraction of 5 vs. 2 was not significant in homes with air cleaners (0.02 [-0.21, 0.26], p=0.84) or in homes with central systems (0.20 [-0.39, 0.78], p=0.51).

In a hypothetical scenario where homes with air cleaners had air filtration fraction of 5, the indoor $PM_{0.2}$ concentrations (log-transformed) were 2.09 times higher in sham than in true filtration (β=0.74 [95% CI: 0.51, 0.96], p<0.0001); while in homes with central systems and the same filtration fraction, the indoor $PM_{0.2}$ concentrations were 1.77 times higher in sham (0.57 [0.09, 1.05], p=0.02) (Tables 8.3-8.4). At this filtration fraction, the difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2}$ levels between air cleaner and central system homes was not statistically significant (0.16 [-0.37, 0.70], p=0.55), indicating negligible differences in air quality improvements with true filtration between homes with air cleaners and homes with central systems.

As a comparison, in another scenario where homes with air cleaners had air filtration fraction of 2, $PM_{0.2}$ concentrations were 2.04 times higher in sham than in true filtration (β=0.71 [0.59, 0.84], p<0.0001); while in homes with central systems and the same filtration fraction, $PM_{0.2}$ concentrations were 1.45 times higher in sham (0.38 [0.08, 0.67], p=0.01). At this filtration fraction, the difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{0.2}$ levels between air cleaner and central system homes was statistically significant (0.34 [0.02, 0.66], p=0.04), indicating a 40% greater improvement in air quality with true filtration in homes with air cleaners than in homes with central systems.

8.b. Indoor $PM_{2.5}$ concentrations:

Table 8.5: Type III tests of fixed effects for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration fraction (TRUE × FILT_FRACTION), filtration system x filtration fraction (HVAC × FILT_FRACTION), and filtration type x filtration system x filtration fraction (TRUE × HVAC × FILT_FRACTION)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	272	7.49	0.0066
hvac_ac	1	272	0.76	0.3838
filt_fraction	1	272	1.19	0.2767
true*hvac_ac	1	272	0.58	0.4480
filt_fraction*true	1	272	0.25	0.6179
filt_fractio*hvac_ac	1	272	0.67	0.4127
filt_fr*true*hvac_ac	1	272	0.00	0.9986
season	3	272	4.51	0.0041
area	1	272	0.12	0.7250

Table 8.6: Parameter estimates for log-normal mixed-effects model examining sham vs. true filtration differences in indoor $PM_{2.5}$ concentrations, with interaction terms: filtration type x filtration system (TRUE × HVAC), filtration type x filtration fraction (TRUE × FILT_FRACTION), filtration system x filtration fraction (HVAC × FILT_FRACTION), and filtration type x filtration system x filtration fraction (TRUE × HVAC × FILT_FRACTION)

Effect	City	Season	Filtration type	Air cleaner or HVAC	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.4957	0.3962	132	3.78	0.0002
true			Sham		0.3573	0.34	272	1.05	0.2941
true			True		0	.	.	.	.
hvac_ac				Air cleaner	-0.3603	0.4026	272	-0.89	0.3717
hvac_ac				HVAC	0	.	.	.	.
filt_fraction					-0.09443	0.1225	272	-0.77	0.4413
true*hvac_ac			Sham	Air cleaner	0.2763	0.3636	272	0.76	0.4480
true*hvac_ac			Sham	HVAC	0	.	.	.	.
true*hvac_ac			True	Air cleaner	0	.	.	.	.
true*hvac_ac			True	HVAC	0	.	.	.	.
filt_fraction*true			Sham		0.02743	0.1025	272	0.27	0.7892
filt_fraction*true			True		0	.	.	.	.
filt_fractio*hvac_ac				Air cleaner	0.06925	0.1291	272	0.54	0.5922
filt_fractio*hvac_ac				HVAC	0	.	.	.	.
filt_fr*true*hvac_ac			Sham	Air cleaner	-0.0002	0.1109	272	0	0.9986
filt_fr*true*hvac_ac			Sham	HVAC	0	.	.	.	.
filt_fr*true*hvac_ac			True	Air cleaner	0	.	.	.	.
filt_fr*true*hvac_ac			True	HVAC	0	.	.	.	.
season		Fall			0.1221	0.06897	272	1.77	0.0779
season		Summer			0.05296	0.1028	272	0.52	0.6068
season		Winter			0.2511	0.09758	272	2.57	0.0106
season		Spring			0	.	.	.	.
area	Fresno				0.03455	0.09812	272	0.35	0.7250
area	Riverside				0	.	.	.	.

Table 8.7: Contrasts in log geometric mean indoor $PM_{2.5}$ concentrations ($\mu g/m^3$) for *selected values* of filtration fraction (a continuous variable) in the log-normal mixed-effects model with interaction term TRUE × HVAC × FILT_FRACTION

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Filt fraction = 5 (95th perc), Air Cleaner: Sham vs True	0.7698	0.1053	272	7.31	<.0001	0.5625	0.9771
Filt fraction = 5 (95th perc), Central: Sham vs True	0.4945	0.2426	272	2.04	0.0425	0.01691	0.9720
Filt fraction = 5 (95th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.2753	0.2682	272	1.03	0.3055	-0.2526	0.8032
Filt fraction = 2 (50th perc), Air Cleaner: Sham vs True	0.6881	0.0654	272	10.52	<.0001	0.5593	0.8168
Filt fraction = 2 (50th perc), Central: Sham vs True	0.4122	0.1728	272	2.38	0.0178	0.07194	0.7524
Filt fraction = 2 (50th perc): Air Cleaner vs. Central diff in Sham vs True diffs	0.2759	0.1852	272	1.49	0.1375	-0.08874	0.6405
Air Cleaner: Filt fraction = 5 (95th perc) vs 2 (50th perc) diff in Sham vs True diffs	0.08168	0.1214	272	0.67	0.5016	-0.1573	0.3207
Central: Filt fraction 5 (95th perc) vs 2 (50th perc) diff in Sham vs True diffs	0.08228	0.3074	272	0.27	0.7892	-0.5230	0.6875
Filt fraction = 5 vs. 2 diff in Air Cleaner vs. Central diff in Sham vs True diffs	-0.0006	0.3327	272	0.00	0.9986	-0.6556	0.6544

The 3-way interaction term filtration type (sham vs. true) × filtration system (air cleaner vs. central) × filtration fraction (TRUE × HVAC × FILT_FRACTION) was not statistically significant, indicating that the combined effects of filtration type and filtration system intervention on the indoor $PM_{2.5}$ concentrations did not vary much based on the fraction of volume of air in the homes that was cleaned every hour (p=0.999) (Table 8.5).

The difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{2.5}$ levels between hypothetical homes that had an air filtration fraction of 5 vs. 2 was not significant in homes with air cleaners (0.08 [-0.16, 0.32], p=0.50) or in homes with central systems (0.08 [-0.52, 0.69], p=0.79).

In a hypothetical scenario where homes with air cleaners had air filtration fraction of 5, the indoor $PM_{2.5}$ concentrations (log-transformed) were 2.16 times higher in sham than in true filtration (β=0.77 [95% CI: 0.56, 0.98], p<0.0001); while in homes with central systems and the same filtration fraction, the indoor $PM_{2.5}$ concentrations were 1.64 times higher in sham (0.49 [0.02, 0.97], p=0.04) (Tables 8.6-8.7). At this

filtration fraction, the difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{2.5}$ levels between air cleaner and central system homes was not statistically significant (0.28 [-0.25, 0.80], p=0.31), indicating minimal differences in air quality improvements with true filtration between homes with air cleaners and homes with central systems.

As a comparison, in another scenario where homes with air cleaners had air filtration fraction of 2, $PM_{2.5}$ concentrations were 1.99 times higher in sham than in true filtration (β=0.69[0.56, 0.82], p<0.0001); while in homes with central systems and the same filtration fraction, $PM_{2.5}$ concentrations were 1.51 times higher in sham (0.41 [0.07, 0.75], p=0.02). At this filtration fraction, the difference in the sham vs. true filtration differences in log geometric mean indoor $PM_{2.5}$ levels between air cleaner and central system homes was not statistically significant (0.28 [-0.09, 0.64], p=0.14), indicating negligible differences in air quality improvements with true filtration in homes with air cleaners and homes with central systems.

9. Determine whether window usage modifies the relationship between filtration type and reflectance indoor/outdoor (I/O) ratios.

Moderator: The number of days per week windows were open >2 hours was categorized as almost always [6-7 days], sometimes [2-5 days] vs. rarely [<2 days].

Table 9.1: Number of days per week had open windows for >2 hours by filtration type

	SHAM		TRUE	
Days/week had open windows >2 hours	**n**	**%**	**n**	**%**
Rarely open (<2 days)	89	55.6	102	50.5
Sometimes open (2-5 days)	29	18.1	41	20.3
Almost always open (6-7 days)	42	26.3	59	29.2

The number of days that windows were open for more than 2 hours was similar by filtration type, as expected (Table 9.1). Approximately, 50-55% of households rarely opened windows (opened windows <2 days per week); 18-20% sometimes opened windows (3-5 days per week); and 26-29% always opened windows (>5 days per week).

Table 9.2: Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x window usage in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Always open: Sham vs True	0.5327	0.2253	218	2.36	0.0189	0.0887	0.9767
Sometimes open: Sham vs True	2.2535	0.4496	218	5.01	<.0001	1.3674	3.1395
Rarely open: Sham vs True	1.7112	0.2402	218	7.12	<.0001	1.2377	2.1847
Always vs. Rarely open diff in Sham vs True diffs	-1.1785	0.322	218	-3.66	0.0003	-1.8132	-0.5438
Sometimes vs. Rarely open diff in Sham vs True diffs	0.5422	0.5167	218	1.05	0.2952	-0.4762	1.5607

The 2-way interaction term filtration type (sham vs. true) x window usage (always, sometimes vs. rarely open) was statistically significant, indicating that the frequency (days per week) of opening windows for >2 hours modified the effect of sham versus true filtration on the reflectance I/O ratios (p<0.0001). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes that always (β=0.53 [95% CI: 0.09, 0.98], p=0.02), sometimes (2.25 [1.37, 3.14], p<0.0001), and rarely opened windows (1.71 [1.24, 2.18], p<0.0001) (Table 9.2). In addition, the sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes that always opened windows compared with homes that rarely did so (-1.18 [-1.81, -0.54], p=0.0003), indicating that improvements in air quality with true

filtration were greater in homes that opened windows less frequently. The sham vs. true log geometric mean differences in reflectance I/O ratios were not significantly different between homes that sometimes vs. rarely opened windows (0.54 [-0.48, 1.56], p=0.30).

Table 9.3: Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x window usage in the log-normal mixed-effects model

Filtration type	Window usage	Log GM	95% CI		GM	95% CI	
Sham	Almost always open	-0.9418	-1.3535	-0.5301	0.3899	0.2583	0.5885
Sham	Sometimes open	-0.4334	-0.7473	-0.1196	0.6483	0.4736	0.8873
Sham	Rarely open	-0.8432	-1.0560	-0.6304	0.4303	0.3478	0.5324
True	Almost always open	-1.4745	-1.7550	-1.1940	0.2289	0.1729	0.3030
True	Sometimes open	-2.6869	-3.5079	-1.8659	0.0681	0.0300	0.1548
True	Rarely open	-2.5545	-3.0184	-2.0905	0.0777	0.0489	0.1236

The geometric means (GM) of reflectance I/O ratios are presented in Table 9.3. In homes that almost always opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.39 [95% CI: 0.26, 0.59] and 0.23 [0.17, 0.30], respectively. In homes that sometimes opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.65 [0.47, 0.89] and 0.07 [0.03, 0.15]. Lastly, in homes that rarely opened windows, the GM reflectance I/O ratios in sham and true filtration were 0.43 [0.35, 0.53] and 0.08 [0.05, 0.12].

10. Determine whether proximity to a major roadway modifies the relationship between filtration type and reflectance indoor/outdoor (I/O) ratios.

Moderator: Proximity to a major roadway was categorized as <2 blocks [1 block = 360 ft], 2-4 blocks vs. >4 blocks.

Table 10.1: Proximity to a major roadway by filtration type

	SHAM		TRUE	
Proximity to roadway	n	%	n	%
<2 blocks (1 block = 360 ft)	49	29.9	64	30.8
2-4 blocks	49	29.9	59	28.4
5+ blocks	66	40.2	85	40.9

Proximity to roadway was similar by filtration type, as expected (Table 10.1). Approximately, 30-31% of households were <2 blocks from a major roadway; 28-30% 2-4 blocks away; and 40-41% 5 or more blocks away.

Table 10.2: Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x proximity to roadway in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
<2 blocks: Sham vs True	1.4890	0.2660	225	5.6	<.0001	0.9648	2.0133
2-4 blocks: Sham vs True	0.7277	0.2599	225	2.8	0.0056	0.2156	1.2397
5+ blocks: Sham vs True	1.9793	0.2960	225	6.69	<.0001	1.3959	2.5626
<2 vs 5+ blocks diff in Sham vs True diffs	-0.4903	0.3986	225	-1.23	0.2200	-1.2757	0.2952
2-4 vs 5+ blocks diff in Sham vs True diffs	-1.2516	0.3908	225	-3.2	0.0016	-2.0217	-0.4816

The 2-way interaction term filtration type (sham vs. true) x proximity to roadway (<2, 2-4 vs. 5+ blocks) was statistically significant, indicating that proximity to a major roadway modified the effect of sham versus true filtration on the reflectance I/O ratios (p=0.01). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes located <2 blocks (β=1.49 [95% CI: 0.96, 2.01], p<0.0001), 2-4 blocks (0.73 [0.22, 1.24], p=0.01), and ≥5 blocks from a major roadway (1.98 [1.40, 2.56], p<0.0001) (Table 10.2). In addition, the sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes located 2-4 blocks from a roadway compared with homes located 5 or more blocks away (-1.25 [-2.02, -0.48], p=0.002), indicating that improvements in air quality with true filtration were greater in homes that were farther from a major roadway. The sham vs. true log geometric mean differences in reflectance I/O ratios were also lower in homes located less than 2 blocks from a major roadway than in homes 5 or more blocks away, but this comparison did not reach statistical significance (-0.49 [-1.28, 0.30], p=0.22).

Table 10.3: Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x proximity to roadway in the log-normal mixed-effects model

Filtration type	Window usage	Log GM	95% CI		GM	95% CI	
Sham	<2 blocks (1 block = 360 ft)	-0.3890	-0.7503	-0.0277	0.6777	0.4722	0.9727
Sham	2-4 blocks	-1.0342	-1.4343	-0.6342	0.3555	0.2383	0.5304
Sham	5+ blocks	-0.9051	-1.1272	-0.6829	0.4045	0.3239	0.5051
True	<2 blocks (1 block = 360 ft)	-1.8780	-2.3793	-1.3767	0.1529	0.0926	0.2524
True	2-4 blocks	-1.7619	-2.2629	-1.2609	0.1717	0.1040	0.2834
True	5+ blocks	-2.8843	-3.4857	-2.2830	0.0559	0.0306	0.1020

The geometric means (GM) of reflectance I/O ratios are presented in Table 10.3. In homes located <2 blocks from a major roadway, the GM reflectance I/O ratios in sham and true filtration were 0.68 [95% CI: 0.47, 0.97] and 0.15 [0.09, 0.25], respectively. In homes located 2-4 blocks away, the GM reflectance I/O ratios in sham and true filtration were 0.36 [0.24, 0.53] and 0.17 [0.10, 0.28]. Lastly, in homes located 5 or more blocks from a major roadway, the GM reflectance I/O ratios in sham and true filtration were 0.41 [0.32, 0.51] and 0.06 [0.03, 0.10].

10a. Determine whether proximity to a major roadway modifies the relationship between filtration type and reflectance indoor/outdoor (I/O) ratios, dichotomized at 5 blocks.

Moderator: Proximity to a major roadway was categorized as <5 blocks [1 block = 360 ft] vs. 5+ blocks.

Table 10.4: Proximity to a major roadway by filtration type

	SHAM		TRUE	
Proximity to roadway	**n**	**%**	**n**	**%**
<5 blocks (1 block = 360 ft)	98	59.8	123	59.1
5+ blocks	66	40.2	85	40.9

Proximity to roadway was similar by filtration type, as expected (Table 10.4). Approximately, 59-60% of households were <5 blocks from a major roadway and 40-41% 5 or more blocks away.

Table 10.5: Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x proximity to roadway in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
<5 blocks: Sham vs True	1.1069	0.1930	227	5.74	<.0001	0.7266	1.4871
5+ blocks: Sham vs True	1.9793	0.2960	227	6.69	<.0001	1.3961	2.5626
<5 vs 5+ blocks diff in Sham vs True diffs	-0.8725	0.3523	227	-2.48	0.0140	-1.5667	-0.1783

The 2-way interaction term filtration type (sham vs. true) x proximity to roadway (<5 vs. 5+ blocks) was statistically significant, indicating that proximity to a major roadway modified the effect of sham versus true filtration on the reflectance I/O ratios (p=0.01). Reflectance I/O ratios were significantly higher in sham compared with true filtration in homes located <5 blocks (β=1.11 [95% CI: 0.73, 1.49], p<0.0001) and ≥5 blocks from a major roadway (1.98 [1.40, 2.56], p<0.0001) (Table 10.2). In addition, the sham vs. true log geometric mean difference in reflectance I/O ratios was significantly lower in homes located <5 blocks from a roadway compared with homes located 5 or more blocks away (-0.87 [-1.57, -0.18], p=0.01), indicating that improvements in air quality with true filtration were greater in homes that were farther from a major roadway.

Table 10.6: Log Geometric Means (GM) of reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x proximity to roadway in the log-normal mixed-effects model

Filtration type	Window usage	Log GM	95% CI		GM	95% CI	
Sham	<5 blocks (1 block = 360 ft)	-0.7168	-0.9795	-0.4542	0.4883	0.3755	0.6350
Sham	5+ blocks	-0.9061	-1.1247	-0.6876	0.4041	0.3247	0.5028
True	<5 blocks (1 block = 360 ft)	-1.8237	-2.1578	-1.4896	0.1614	0.1156	0.2255
True	5+ blocks	-2.8855	-3.4874	-2.2836	0.0558	0.0306	0.1019

The geometric means (GM) of reflectance I/O ratios are presented in Table 10.6. In homes located <5 blocks from a major roadway, the GM reflectance I/O ratios in sham and true filtration were 0.49 [95% CI: 0.38, 0.64] and 0.16 [0.12, 0.23], respectively. In homes located 5 or more blocks from a major roadway, the GM reflectance I/O ratios in sham and true filtration were 0.40 [0.32, 0.50] and 0.06 [0.03, 0.10].

3-way interaction: TRUE x HVAC x ROADWAY was not statistically significant p=0.25.

11. Determine whether filtration use ratio (proportion of volume normalized to what asked to use) modifies the relationship between filtration type and reflectance indoor/outdoor (I/O) ratios.

Table 11.1: Filtration use ratio by filtration type

Filtration use	N	Mean	Std Dev	Median	Minimum	Maximum
Sham	158	1.01	0.34	1.00	0	3.03
True	202	1.00	0.33	1.00	0	3.03

The mean filtration use ratios were the same in sham (Mean=1.01 [SD=0.34]) and true filtration (Mean=1.00 [SD=0.33]), as expected.

Table 11.2: Parameter estimates for log-normal mixed effects model examining the effect of filtration type on reflectance indoor/outdoor (I/O) ratios, with interaction term filtration type x filtration use ratio

Effect	City	Season	Filtration type	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Intercept				-1.6147	0.4724	132	-3.42	0.0008	-2.5493	-0.6802
true			Sham	1.1851	0.4766	220	2.49	0.0136	0.2459	2.1244
treu			True	0	.	.	.	.	.	.
USERATIO_SW				-0.5084	0.4008	220	-1.27	0.2059	-1.2983	0.2814
USERATIO_SW*true			Sham	0.2297	0.4484	220	0.51	0.6090	-0.6541	1.1135
USERATIO_SW*true			True	0	.	.	.	.	.	.
season		Fall		0.4203	0.2422	220	1.74	0.0841	-0.05707	0.8978
season		Summer		-0.00835	0.3028	220	-0.03	0.978	-0.605	0.5883
season		Winter		-0.08398	0.2981	220	-0.28	0.7784	-0.6715	0.5035
season		Spring		0	.	.	.	.	.	.
area	Fresno			-0.3898	0.225	220	-1.73	0.0846	-0.8333	0.05357
area	Riverside			0	.	.	.	.	.	.

Table 11.3: Contrasts in log geometric mean reflectance indoor/outdoor (I/O) ratios for each level of the interaction term filtration type x filtration use ratio in the log-normal mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Use ratio = 0.75: Sham vs True	1.3574	0.2007	220	6.76	<.0001	0.9618	1.7530
Use ratio = 1.00: Sham vs True	1.4148	0.1682	220	8.41	<.0001	1.0833	1.7463
Use ratio = 0.75 vs. 1.00 diff in Sham vs True diffs	-0.05742	0.1121	220	-0.51	0.6090	-0.2784	0.1635

The 2-way interaction term filtration type (sham vs. true) x filtration use ratio was not statistically significant, indicating that the amount of time the filtration system was used compared to the amount asked to use did not change the effect of sham versus true filtration on the reflectance I/O ratios (p=0.61) (Table 11.2). In a hypothetical scenario where households used their filtration systems 75% of the time asked (use ratio = 0.75), the reflectance I/O ratios were 3.9 times higher in sham than in true filtration (β=1.36 [95% CI: 0.96, 1.75], p<0.0001). As a comparison, in a hypothetical scenario where households used their filtration systems 100% of the time asked (use ratio = 1.00), the reflectance I/O ratios were 4.1 times higher in sham (1.41 [1.08, 1.75], p<0.0001) (Table 11.3). The difference in the sham-true log geometric mean differences between the two hypothetical use ratios (0.75 vs. 1.00) was not statistically significant (-0.06 [-0.28, 0.16], p=0.61). Stated differently, the improvements in indoor air quality with true filtration did not change much at different proportions of filtration utilization in the homes.

Appendix F.4 Days with Asthma Symptoms in the Last 2 Weeks

1. Primary analysis of days with asthma symptoms in the last 2 weeks
2. Scatter plots comparing mean days with asthma symptoms in Sham vs. True filtration treatment.

3-6. Subset analyses considering alternative time periods

7. Pre-Installation vs. Post-Installation Analysis

8-10. Mediation Analysis

11-17. Interaction Analysis

Section 1: Primary analysis of days with asthma symptoms in the last 2 weeks

Descriptive statistics and plots:

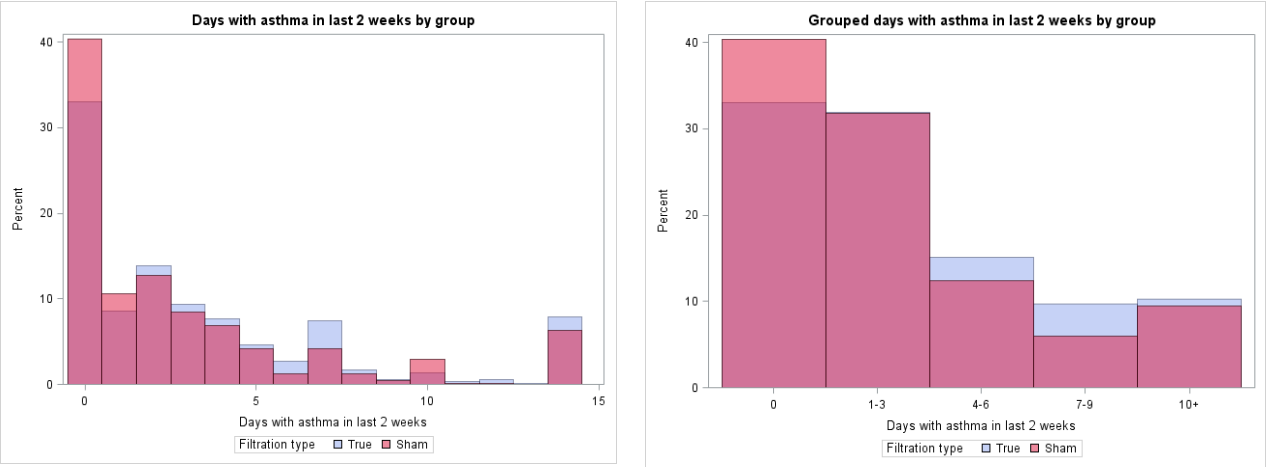


Figure 1. Days with asthma symptoms in the last 2 weeks by filtration status

Figure 1 illustrates the general distribution pattern of the primary health endpoint, days with asthma symptoms in the last 2 weeks. The Poisson distribution may be appropriate, but data do not entirely fit this distribution for the following reasons: (1) restricted to range 0 – 14, (2) a bump in frequency of observations with 14 days of symptoms. A grouped ordinal variable was also created as an alternative. The number of days the child experienced asthma symptoms appears to be slightly higher in the true filtration group. Descriptive statistics in the tables below also indicate a higher frequency of asthma symptoms in the true filtration group compared with sham.

Table 1.1 Days with asthma symptoms in the last 2 weeks by filtration status

Filtration status:	N	Mean	StdDev	Min	Max	P25	Median	P75	P90
sham	622	2.82	3.86	0	14	0	1	4	8
true	661	3.42	4.08	0	14	0	2	5	10

Table 1 shows higher mean days with asthma symptoms in the true filtration treatment. The results from mixed-effects models adjusted for covariates city and season revealed that the differences in days with asthma symptoms were significantly fewer in the sham treatment. Because the study was not balanced over time, with more true filtration than sham filtration in the first year and more sham filtration than sham in the second year, series of analysis were conducted to see if there were improvements in time for asthma symptoms. These analyses are in sections 3-6 of Appendix F4. To summarize, in analyses comparing days with asthma symptoms in the first year versus the second year of the study, children tended to have fewer asthma symptoms as they became older irrespective of the filtration status used in the home. Regardless of whether participants started in the true or sham filtration group, all households were using SHAM filters in the last 6 months of the study, therefore, calendar time was not fully controlled for in this crossover design. Hence, all final models with health endpoints include an indicator for study year (Year 1, Year 2) to control for time effects.

Table 1.2. Days with asthma symptoms in the last 2 weeks by filtration status, stratified by covariates Study Year, City, and Season

			Days with asthma symptoms in last 14 days											
			Filtration status											
			SHAM						TRUE					
Study	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	4.4	5.4	3	0	10	83	4	4.54	2	0	7
		Spring	28	4	4.75	2	0.5	5.5	85	3.9	4.25	3	1	5
		Summer	32	3	4.19	1	0	4	76	3.1	4.28	2	0	4
		Fall	40	3.5	4.1	2	0	7	72	4.4	4.21	3	1	7
	Riverside	Winter	30	3.4	4.17	2	0	5	34	3.8	4.04	2	1	7
		Spring	10	1.7	3.06	0.5	0	2	50	3.5	4.34	2	0	4
		Summer	5	1.8	2.49	0	0	4	56	2.8	3.7	1	0	4
		Fall	24	2.8	4.02	1	0	5	36	3.4	4.04	2	0	4
Year 2	Fresno	Winter	74	2.6	3.34	1.5	0	4	22	3.1	4.39	2	0	3
		Spring	70	3	3.85	2	0	4	25	3.4	3.81	2	0	6
		Summer	60	2.2	3.58	1	0	3	37	2.2	3.36	1	0	2
		Fall	69	3	3.57	2	0	4	31	3.2	3.3	2	0	6
	Riverside	Winter	27	1.7	3.04	0	0	3	24	2.8	3.84	2	0	4
		Spring	44	3.7	4.83	1	0	7	8	2.4	2.26	2.5	0	4
		Summer	51	1.7	2.98	0	0	3	2	1	1.41	1	0	2
		Fall	35	2.1	3.34	1	0	3	20	2.2	3.47	0.5	0	3

Stratified by study year, city, and season, Table 2 shows similar mean days with asthma in the sham and true filtration treatments.

The main analysis consisted of fitting two types of mixed-effects models: (a) Poisson and (b) Ordered multinomial (models with Beta and Negative Binomial distributions were attempted but did not converge). Both models produced comparable results. The final results presented below are from the Poisson model with the endpoint expressed as a continuous count of days with asthma symptoms.

The results from both models are shown below.

Table 1.3. Parameter estimates from Poisson mixed-effects model examining whether the number of days with asthma in the last 2 weeks differs by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					0.6511	0.1527	184	4.26	<.0001	0.3498	0.9524
TRUE			SHAM		-0.05488	0.06697	1092	-0.82	0.4127	-0.1863	0.07652
TRUE			TRUE		0	.	.	.	.	.	.
season		Fall			-0.0545	0.08125	1092	-0.67	0.5025	-0.2139	0.1049
season		Summer			-0.3161	0.0863	1092	-3.66	0.0003	-0.4855	-0.1468
season		Winter			-0.04985	0.08334	1092	-0.6	0.5499	-0.2134	0.1137
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.2998	0.1483	1092	2.02	0.0434	0.008948	0.5907
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	0.2591	0.07656	1092	3.38	0.0007	0.1089	0.4093
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 1.4. Log Geometric Mean (GM) counts of days the child had asthma symptoms in last 14 days by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
SHAM	0.7706	0.6078	0.9334	2.1610	1.8364	2.5431
TRUE	0.8255	0.6654	0.9855	2.2830	1.9453	2.6792

After controlling for season, city, and study year, the sham and true filtration treatments did not differ significantly with respect to the number of days the child experienced asthma symptoms (expressed as log counts) (β=-0.05 [0.07], p=0.41) (Table 1.3). The geometric means of the number of days with asthma symptoms during sham and true filtration periods are 2.16 days [1.84, 2.54] and 2.28 days [1.04, 2.68], respectively (Table 1.4).

Table 1.5. Ordered Multinomial Mixed-Effects Model: Is filtration status associated with the number of days (grouped) the child experienced asthma symptoms in the last 14 days?

Effect	Days w. asthma	City	Season	Filtration type	Study year	Est.	SE	DF	t Value	Pr > |t|
Intercept	10+					-2.9489	0.2505	184	-11.77	<.0001
Intercept	7-9					-2.1348	0.2416	184	-8.84	<.0001
Intercept	4-6					-1.1832	0.2363	184	-5.01	<.0001
Intercept	1-3					0.5573	0.2343	184	2.38	0.0184
TRUE				SHAM		-0.1080	0.1193	1089	-0.91	0.3656
TRUE				TRUE		0	.	.	.	.
season			Fall			-0.05345	0.1481	1089	-0.36	0.7182
season			Sum			-0.6001	0.1518	1089	-3.95	<.0001
season			Win			-0.1647	0.1494	1089	-1.10	0.2707
season			Spr			0	.	.	.	.
area		Fresno				0.3282	0.2283	1089	1.44	0.1509
area		Riverside				0	.	.	.	.
VisitYr1					Year 1	0.4780	0.1206	1089	3.96	<.0001
VisitYr1					Year 2	0	.	.	.	.

Table 1.6. Odds of experiencing more vs. fewer days with asthma symptoms in last 14 days by group:

Predictor	Odds Ratio	95% Confidence Limits	
SHAM vs. TRUE	0.898	0.710	1.134
Fall vs. Spring	0.948	0.709	1.268
Summer vs. Spring	0.549	0.407	0.739
Winter vs. Spring	0.848	0.633	1.137
Fresno vs. Riverside	1.388	0.887	2.173
Year 1 vs. Year 2	1.613	1.273	2.043

Section 2: Scatter plots comparing mean days with asthma symptoms in Sham vs. True filtration treatment.

Scatter plots comparing mean days with asthma symptoms in Sham vs. True filtration treatment. Each data point represents days with asthma symptoms in the last 2 weeks averaged over the entire Sham or True filtration period for each individual child. Data points falling on the diagonal line indicate no differences in mean days with asthma by filtration status. Points above the diagonal line indicate more days with asthma during the Sham filtration period while points below the diagonal line indicate fewer mean days with asthma in Sham.

Figure 2.1: All households irrespective of filter type at start of the study

Figure 2.2: Households with true filters installed at the start of the study

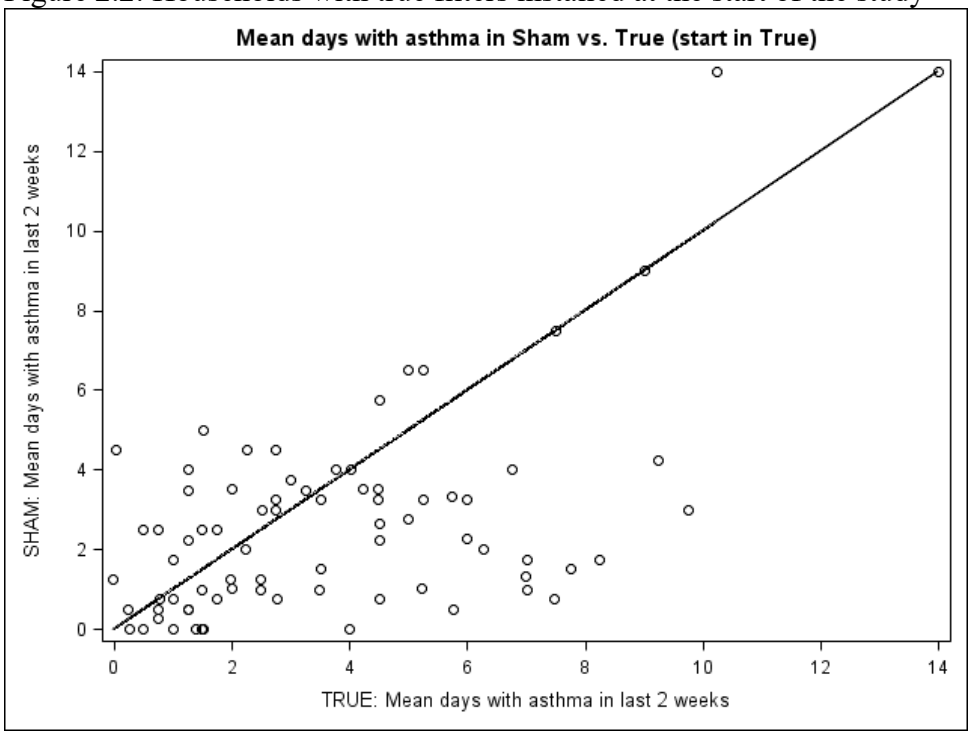


Figure 2.3: Households with sham filters installed at the start of the study

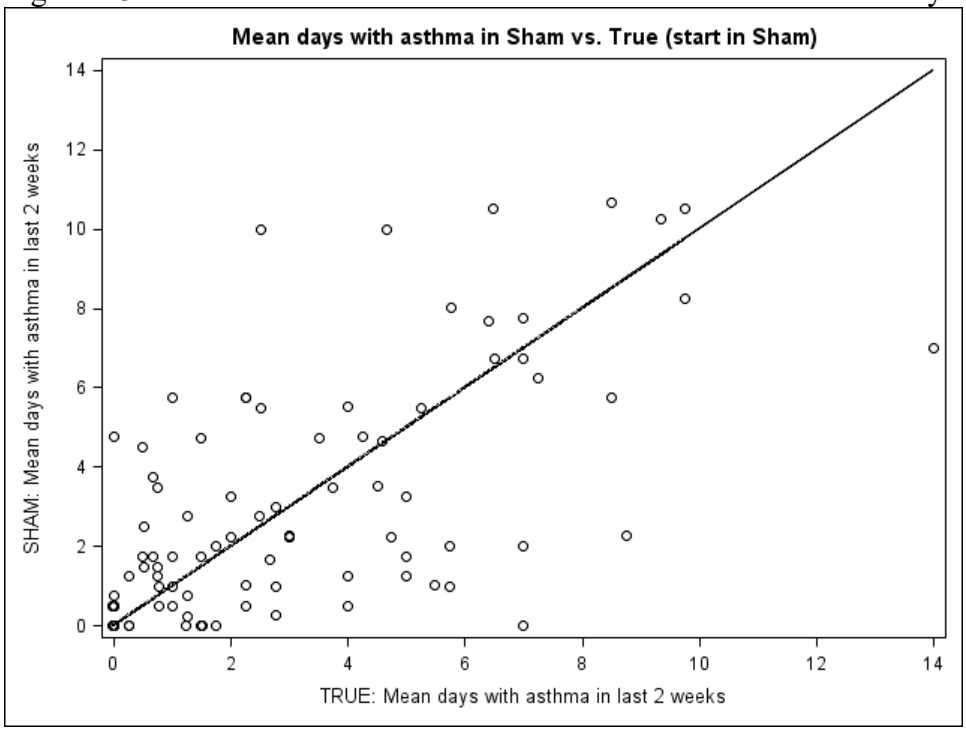


Figure 2.4: Households with sham filters at the start of the study in the first year

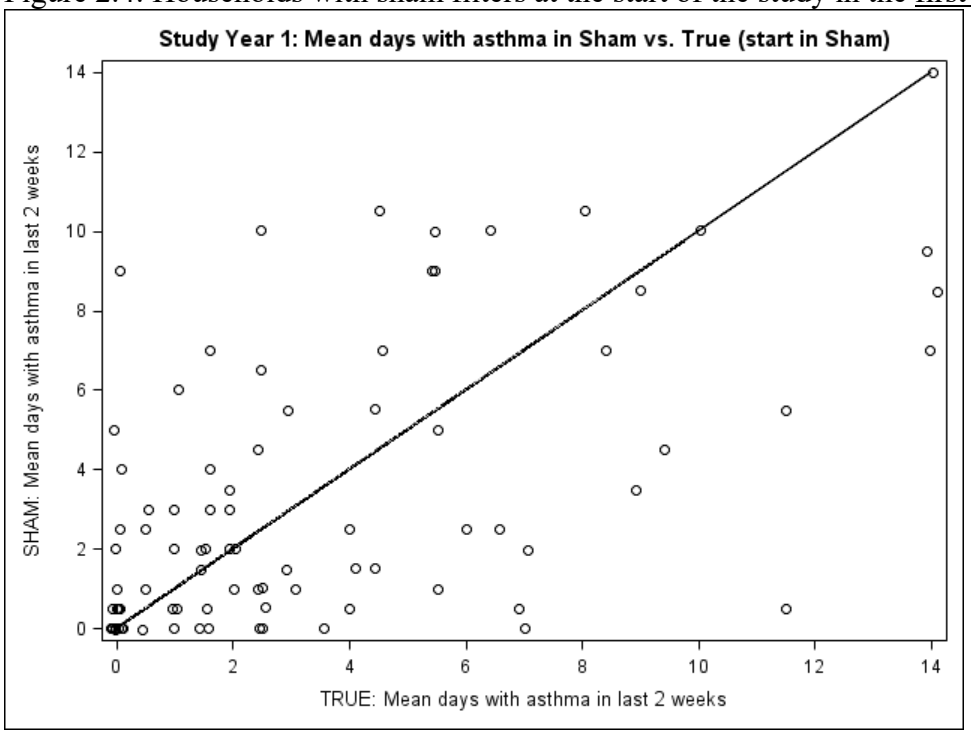
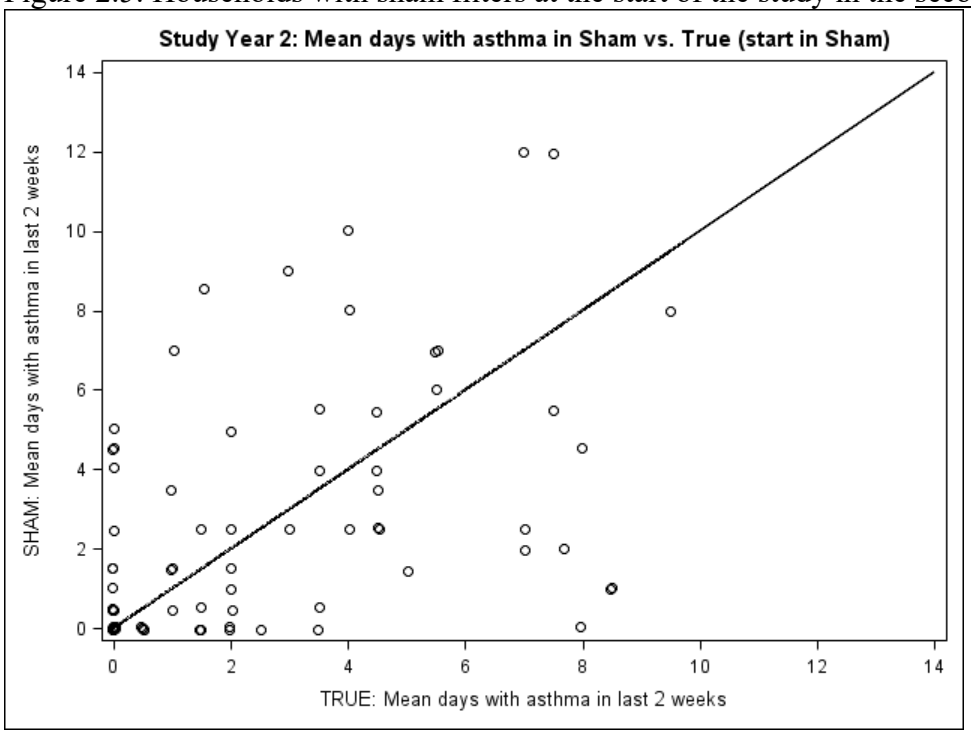


Figure 2.5: Households with sham filters at the start of the study in the second year



Sections 3-6: Subset Analyses Considering Alternative Time Periods

Purpose: Initial analyses that compared the number of days with asthma symptoms in the last 2 weeks in Sham vs. True groups showed fewer symptoms in the Sham treatment, an unexpected result. The results below are from follow-up analyses carried out to investigate possible changes in symptom frequency as a function of time.

3) Compare days with asthma symptoms in study months 1-6 vs. 19-24 during the SHAM period
4) Compare days with asthma symptoms in study months 7-12 vs. 13-18 during the TRUE filtration period
5) Compare days with asthma symptoms in Year 1 vs Year 2 of study
6) Compare days with asthma symptoms by filtration status in a balanced crossover design (study months 1-6 and 13-18 only)

3. Subset analysis: Compare days with asthma symptoms for participants who started SHAM, both occurring in study months 1-6 vs. 19-24 during the SHAM period

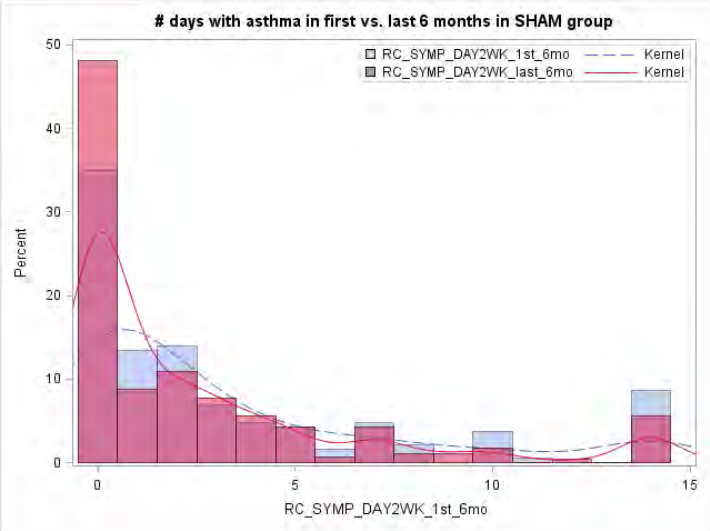


Figure 3. Distribution of days with asthma symptoms during the sham period in study months 1-6 and months 19-24

It appears that children had fewer symptoms in the last 6 months of the study (RED) compared with the first 6 months (BLUE). The same data are presented in table format below.

Table 3.1: Number of days with asthma symptoms during the sham period in study months 1-6 and months 19-24

RC_SYMP_DAY2WK (# Days with asthma symptoms in last 14 days)	SHAM in 1st 6 mo (n=186)		SHAM in last 6 mo (n=285)		Total
	n	%	n	%	
0	65	34.95	137	48.07	202
1	25	13.44	25	8.77	50
2	26	13.98	31	10.88	57
3	13	6.99	22	7.72	35
4	9	4.84	16	5.61	25
5	8	4.30	12	4.21	20
6	3	1.61	2	0.70	5
7	9	4.84	12	4.21	21
8	4	2.15	3	1.05	7
9	0	0.00	3	1.05	3
10	7	3.76	5	1.75	12
11	1	0.54	0	0.00	1
12	0	0.00	1	0.35	1
14	16	8.60	16	5.61	32

RC_SYMP_DAY2WK_G (Grouped days with asthma symptoms in last 14 days)	SHAM in 1st 6 mo (n=186)		SHAM in last 6 mo (n=285)		Total
	n	%	n	%	
0	65	34.95	137	48.07	202
1-3	64	34.41	78	27.37	142
4-6	20	10.75	30	10.53	50
7-9	13	6.99	18	6.32	31
10+	24	12.9	22	7.72	46

Table 3.2: Parameter estimates from Poisson Mixed-Effects Model examining the association between days with asthma symptoms during the sham period and time in study (1-6 vs 19-24)

Effect	City	Season	Visit	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.4905	0.2239	168	2.19	0.0299
Visit			SHAM in months 1-6	0.2259	0.1392	297	1.62	0.1056
Visit			SHAM in months 19-24	0	.	.	.	.
season		Fall		-0.122	0.1807	297	-0.68	0.5002
season		Summer		-0.3981	0.2079	297	-1.91	0.0565
season		Winter		-0.2006	0.1579	297	-1.27	0.2049
season		Spring		0	.	.	.	.
area	Fresno			0.2561	0.2067	297	1.24	0.2164
area	Riverside			0	.	.	.	.

Table 3.3: Mean days with asthma symptoms by time in study (months 1-6 and 19-24)

Visit	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM in months 1-6	0.6642	0.1269	1.9430	0.2465
SHAM in months 19-24	0.4383	0.1216	1.5501	0.1884

Analysis was conducted for participants who started in SHAM, and therefore had Sham filtration for months 1-6 and 19-29. During the sham period, the number of days with asthma was 1.25 times higher in the first 6 months compared with last 6 months of the study though the difference did not reach statistical significance (β=0.23, [SE=0.14], p=0.11) (Tables 3.1, 3.2; Figure 3). The geometric means of days with asthma symptoms in the first 6 months and in the last 6 months of the study were 1.94 days [SE=0.25] and 1.55 days [0.19], respectively (Table 3.3).

4. Subset analysis: Compare days with asthma symptoms for participants starting in sham in study months 7-12 vs. 13-18, both during the TRUE filtration period

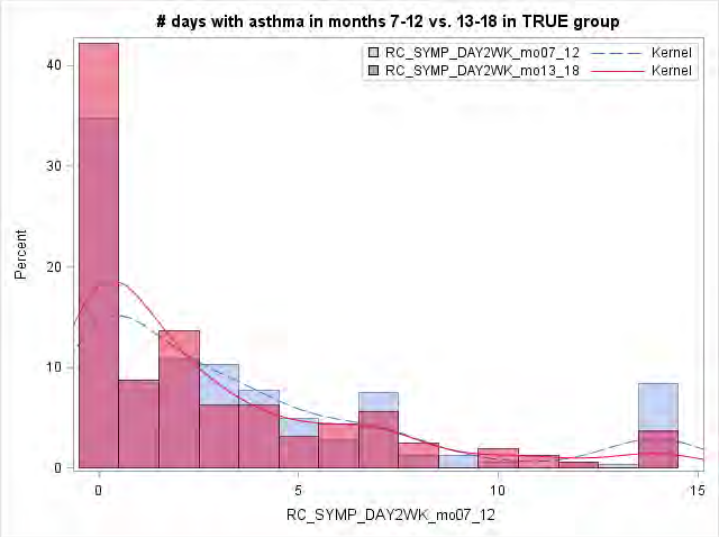


Figure 4. Distribution of days with asthma symptoms during the true filtration period in study months 7-12 and months 13-18

Analysis was conducted for participants who started in SHAM, and therefore were in true for both study months 7-12 and 13-18.

Again, children had fewer asthma symptoms later in the study (months 13-18) (RED) compared with the earlier period (months 7-12) (BLUE) (Figure 4). However, these two distributions overlap more in the TRUE filtration period than in the SHAM period (Figure 3), possibly because the two time intervals are consecutive in this comparison. The same data are presented in table format below.

Table 4.1: Number of days with asthma symptoms during the sham period in study months 7-12 and months 13-18

RC_SYMP_DAY2WK (# Days with asthma symptoms in last 14 days)	TRUE in mos 7-12 (n=322)		TRUE in mos 13-18 (n=161)		
	n	%	n	%	Total
0	112	34.78	68	42.24	180
1	28	8.70	14	8.70	42
2	35	10.87	22	13.66	57
3	33	10.25	10	6.21	43
4	25	7.76	10	6.21	35
5	16	4.97	5	3.11	21
6	9	2.80	7	4.35	16
7	24	7.45	9	5.59	33
8	4	1.24	4	2.48	8
9	4	1.24	0	0.00	4
10	2	0.62	3	1.86	5
11	0	0.00	2	1.24	2
12	2	0.62	1	0.62	3
13	1	0.31	0	0.00	1
14	27	8.39	6	3.73	33

RC_SYMP_DAY2WK_G (Grouped days with asthma symptoms in last 14 days)	TRUE in mos 7-12 (n=322)		TRUE in mos 13-18 (n=161)		
	n	%	n	%	Total
0	112	34.78	68	42.24	180
1-3	96	29.81	46	28.57	142
4-6	50	15.53	22	13.66	72
7-9	32	9.94	13	8.07	45
10+	32	9.94	12	7.45	44

Table 4.2: Parameter estimates from Poisson Mixed-Effects Model examining the association between days with asthma symptoms during the true filtration period and time in study (7-12 vs 13-18)

Effect	City	Season	Visit	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.5789	0.1916	169	3.02	0.0029
Visit			TRUE in mos 7-12	0.2570	0.1363	308	1.89	0.0604
Visit			TRUE in mos 13-18	0	.	.	.	.
season		Fall		-0.05659	0.1463	308	-0.39	0.6992
season		Summer		-0.2144	0.1313	308	-1.63	0.1035
season		Winter		-0.0326	0.1374	308	-0.24	0.8125
season		Spring		0	.	.	.	.
area	Fresno			0.1609	0.1851	308	0.87	0.3853
area	Riverside			0	.	.	.	.

Table 4.3: Mean days with asthma symptoms by time in study (months 7-12 and 13-18)

Visit	Log Mean	SE of Log Mean	Mean	SE of Mean
TRUE in mos 7-12	0.8404	0.09916	2.3174	0.2298
TRUE in mos 13-18	0.5835	0.1377	1.7922	0.2468

During the true filtration period, the number of days with asthma was 1.29 times higher in study months 7-12 compared with months 13-18 though the difference did not reach statistical significance (β=0.26, [SE=0.14], p=0.06) (Tables 4.1, 4.2; Figure 4). The geometric means of days with asthma symptoms in study months 7-12 and months 13-18 were 2.32 days [SE=0.23] and 1.79 days [0.25], respectively (Table 4.3).

5. Subset analysis: Compare days with asthma symptoms in Year 1 vs Year 2 of study

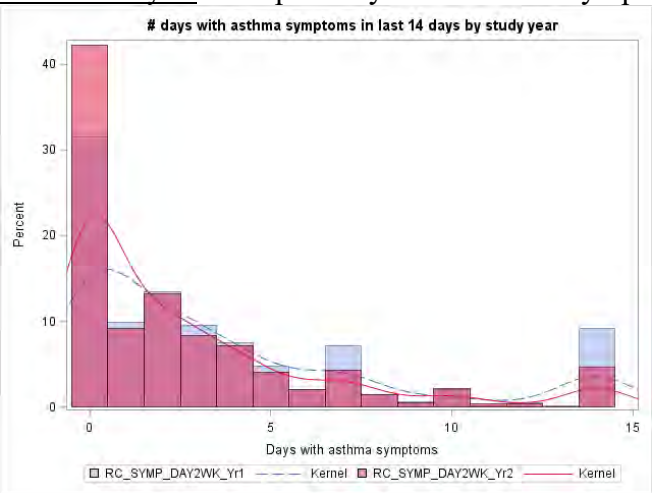


Figure 5. Distribution of days with asthma symptoms in study year 1 (months 1-12) and year 2 (months 13-24) during the sham and true filtration periods

Children had fewer asthma symptoms in year 2 of the study compared with year 1 (Figure 5). All participants were included in this analysis.

Table 5.1: Number of days with asthma symptoms in study year 1 and year 2 during the sham and true filtration periods

	Year 1				Year 2			
	SHAM		TRUE		SHAM		TRUE	
Days with asthma symptoms	n	%	n	%	n	%	n	%
0	66	34.38	150	30.49	185	43.02	68	40.24
1-3	65	33.85	160	32.52	133	30.93	51	30.18
4-6	22	11.46	76	15.45	55	12.79	24	14.2
7-9	13	6.77	50	10.16	24	5.58	14	8.28
10+	26	13.54	56	11.38	33	7.67	12	7.1

Table 5.2: Parameter estimates from Poisson Mixed-Effects Model examining the association between days with asthma symptoms and time in study (year 1 vs 2) during the sham and true filtration periods

Effect	City	Season	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.6122	0.1462	184	4.19	<.0001
VisitYr1			Year 1	0.2825	0.06965	1093	4.06	<.0001
VisitYr1			Year 2	0	.	.	.	.
season		Fall		-0.05885	0.08088	1093	-0.73	0.4670
season		Summer		-0.3159	0.08628	1093	-3.66	0.0003
season		Winter		-0.05222	0.08284	1093	-0.63	0.5286
season		Spring		0	.	.	.	.
area	Fresno			0.3009	0.1483	1093	2.03	0.0427
area	Riverside			0	.	.	.	.

Table 5.3: Mean days with asthma symptoms by time in study (year 1 and year 2) during the sham and true filtration periods

Study Year	Log Mean	SE of Log Mean	Mean	SE of Mean
Year 1	0.9384	0.07807	2.5560	0.1996
Year 2	0.6559	0.08741	1.9269	0.1684

During the sham and true filtration periods (combined), the number of days with asthma was significantly higher in study year 1 compared with year 2 (β=0.28, [SE=0.07], p<0.0001) (Tables 5.1, 5.2; Figure 5). The geometric means of days with asthma symptoms in study years 1 and 2 were 2.56 days [SE=0.20] and 1.93 days [0.17], respectively (Table 5.3).

Table 5.4: Parameter estimates from Poisson Mixed-Effects Model examining the association between days with asthma symptoms and filtration status with study year as a covariate

Effect	City	Season	Study year	Filtration type	Estimate	SE	DF	t Value	Pr > |t|
Intercept					0.6511	0.1527	184	4.26	<.0001
VisitYr1			Year 1		0.2591	0.07656	1092	3.38	0.0007
VisitYr1			Year 2		0	.	.	.	.
TRUE				SHAM	-0.05488	0.06697	1092	-0.82	0.4127
TRUE				TRUE	0	.	.	.	.
season		Fall			-0.0545	0.08125	1092	-0.67	0.5025
season		Summer			-0.3161	0.0863	1092	-3.66	0.0003
season		Winter			-0.04985	0.08334	1092	-0.6	0.5499
season		Spring			0	.	.	.	.
area	Fresno				0.2998	0.1483	1092	2.02	0.0434
area	Riverside				0	.	.	.	.

Table 5.5: Mean days with asthma symptoms by filtration status and time in study (year 1 and year 2)

Study Year	Log Mean	SE of Log Mean	Mean	SE of Mean
Sham	0.7706	0.08297	2.1610	0.1793
True	0.8255	0.08157	2.2830	0.1862
Year 1	0.9276	0.07994	2.5284	0.2021
Year 2	0.6685	0.08852	1.9513	0.1727

When study year was added to the base model, the number of days with asthma was not statistically different by filtration status (β=-0.05, [SE=0.07], p=0.41) (Table 5.4). The geometric means of days with asthma symptoms in the sham and true filtration periods were 2.16 days [SE=0.18] and 2.28 days [0.19], respectively (Table 5.5).

6. Subset analysis: Compare days with asthma symptoms in study months 1-6 and 13-18 only

NOTE: The objective was to examine the primary health endpoint in a balanced cross-over design with respect to calendar time.

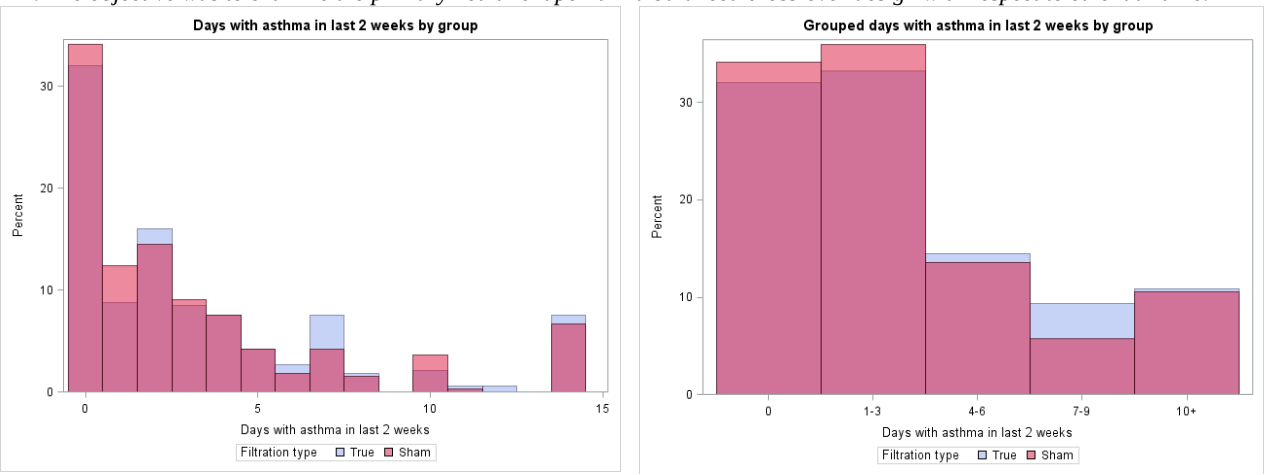


Figure 6.1: Days with asthma symptoms in the last 2 weeks by filtration status

Figure 6.1 illustrates the general distribution pattern of the primary health endpoint, days with asthma symptoms in the last 2 weeks. The Poisson distribution may be appropriate, but data do not entirely fit this distribution for the following reasons: (1) restricted to range 0 – 14, (2) a bump in frequency of observations with 14 days of symptoms. A grouped ordinal variable was therefore created as a reasonable alternative for a Ordinal Multinomial model. The number of days the child experienced asthma symptoms appears to be similar during both filtration periods. Descriptive statistics in the tables below also show similar frequencies of asthma symptoms during both filtration periods.

Table 6.1: Days with asthma symptoms in the last 2 weeks by filtration status

Filtration status:	N	Mean	StdDev	Min	Max	P25	Median	P75	P90
sham	331	3.05	3.90	0	14	0	2	4	10
true	331	3.42	4.06	0	14	0	2	5	10

Table 6.2. Days with asthma symptoms in the last 2 weeks by filtration status, stratified by covariates City and Season

		Days with asthma symptoms in last 14 days											
		Filtration status											
		SHAM						TRUE					
City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Fresno	Winter	43	3.9	4.67	2	0	6	44	4.3	5.00	2	0	7
	Spring	45	3.7	4.31	2	0	6	47	3.5	3.79	2	0	5
	Summer	54	2.8	3.87	1	0	3	64	2.8	4.06	1	0	4.5
	Fall	68	3.1	3.48	2	0	4	63	4.4	4.28	3	1	7
Riverside	Winter	46	2.6	3.64	1	0	4	43	3.0	3.46	2	0	4
	Spring	20	2.5	3.75	1.5	0	2.5	19	2.1	2.07	2	0	4
	Summer	15	2.6	3.72	2	0	4	12	2.4	3.92	1	0.5	2.5
	Fall	40	2.6	3.75	1	0	3.5	39	3.2	3.97	2	0	4

Stratified by study year, city, and season, Table 6.2 shows similar mean days with asthma during the sham and true filtration periods.

The main analysis consisted of fitting two types of mixed-effects models: (a) Poisson and (b) Ordered multinomial; the latter did not converge.

Table 6.3. Parameter estimates from Poisson Mixed-Effects Model examining the association between days with asthma symptoms and filtration status

Effect	City	Season	Filtration type	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.6501	0.1757	184	3.70	0.0003
TRUE			SHAM	-0.08236	0.0878	472	-0.94	0.3487
TRUE			TRUE	0	.	.	.	.
season		Fall		0.1320	0.1504	472	0.88	0.3807
season		Summer		-0.06413	0.1339	472	-0.48	0.6321
season		Winter		0.1108	0.163	472	0.68	0.4970
season		Spring		0	.	.	.	.
area	Fresno			0.3437	0.1551	472	2.22	0.0272
area	Riverside			0	.	.	.	.

Table 6.4. Mean number of days the child had asthma symptoms in last 14 days by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	0.7843	0.0926	2.1908	0.2029
TRUE	0.8666	0.0882	2.3789	0.2098

By considering only months 1-6 and 13-18, there was a balanced study design. Approximately half the population was in true for months 1-6 and in sham for months 13-18, with the other half of the population having the opposite filtration schedule.

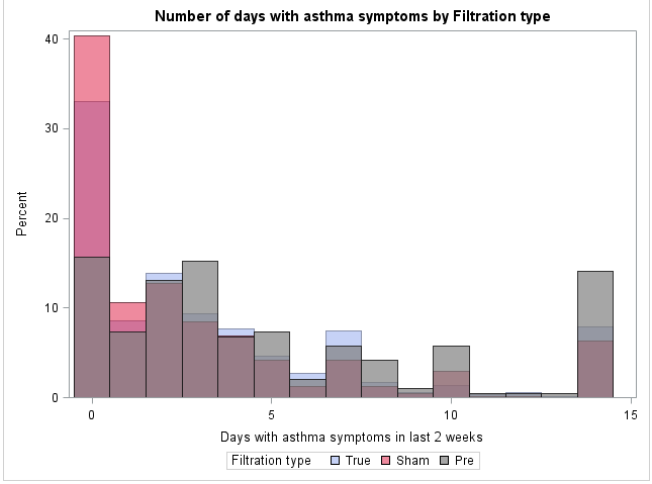
After controlling for season and city, the sham and true filtration treatments did not differ significantly with respect to the number of days the child experienced asthma symptoms (Mean [SE]: 2.19 [0.20] vs. 2.38 [0.21], p=0.35) (Tables 6.3, 6.4). Stated differently, asthma symptoms during sham were 0.92 times as likely to occur as symptoms during true filtration, but the difference was not statistically significant (β=-0.08 [0.09], p=0.35). In other words, there were no changes.

Section 7: Pre-installation vs. Post-installation Analyses

Results:

7. **Number of days with asthma symptoms in the last 14 days**
   a. Compare days with asthma symptoms in the previous 2 weeks at pre-installation vs. sham and pre-installation vs. true filtration, with study period limited to the first year (to account for time-effects)
   b. Determine whether the association between days with asthma symptoms and filtration status is modified by asthma severity **BEST MODEL**

7. Compare days with asthma symptoms in the previous 2 weeks at pre-installation vs. sham and pre-installation vs. true filtration



Days with symptoms	TRUE (n=622)		SHAM (n 661)		PRE (n=191)	
	n	%	n	%	n	%
0	251	40.35	218	32.98	30	15.71
1	66	10.61	57	8.62	14	7.33
2	79	12.7	92	13.92	25	13.09
3	53	8.52	62	9.38	29	15.18
4	43	6.91	51	7.72	13	6.81
5	26	4.18	31	4.69	14	7.33
6	8	1.29	18	2.72	4	2.09
7	26	4.18	49	7.41	11	5.76
8	8	1.29	11	1.66	8	4.19
9	3	0.48	4	0.61	2	1.05
10	18	2.89	9	1.36	11	5.76
11	1	0.16	2	0.3	1	0.52
12	1	0.16	4	0.61	1	0.52
13	0	0	1	0.15	1	0.52
14	39	6.27	52	7.87	27	14.14

Figure 7.1: Distribution of days with asthma symptoms in the last 2 weeks

The number of days with asthma symptoms appear follow a Poisson distribution.

Table 7.1: Descriptive statistics for days with asthma symptoms, stratified by study year, city and season

			Number of days with asthma symptoms																	
			Filtration status																	
			SHAM						TRUE						PRE-INSTALLATION					
Study year	City	Season	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75	N	Mean	SD	Med	P25	P75
Year 0	Fresno	Winter	.	.	.	.	.	.	.	.	.	.	.	.	36	6.2	4.68	4.5	2	10
		Spring	.	.	.	.	.	.	.	.	.	.	.	.	37	4.9	4.22	3	2	8
		Summer	.	.	.	.	.	.	.	.	.	.	.	.	32	5.8	5.28	3.5	2	11
		Fall	.	.	.	.	.	.	.	.	.	.	.	.	16	5	4.83	3.5	1	8.5
	Riverside	Winter	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.	3	3	3
		Spring	.	.	.	.	.	.	.	.	.	.	.	.	16	4.3	4.33	3	2	5
		Summer	.	.	.	.	.	.	.	.	.	.	.	.	32	5.3	4.8	4.5	0.5	8.5
		Fall	.	.	.	.	.	.	.	.	.	.	.	.	21	3.3	4.08	2	1	3
Year 1	Fresno	Winter	23	4.4	5.4	3	0	10	83	4	4.54	2	0	7	.	.	.	.	.	.
		Spring	28	4	4.75	2	0.5	5.5	85	3.9	4.25	3	1	5	.	.	.	.	.	.
		Summer	32	3	4.19	1	0	4	76	3.1	4.28	2	0	4	.	.	.	.	.	.
		Fall	40	3.5	4.1	2	0	7	72	4.4	4.21	3	1	7	.	.	.	.	.	.
	Riverside	Winter	30	3.4	4.17	2	0	5	34	3.8	4.04	2	1	7	.	.	.	.	.	.
		Spring	10	1.7	3.06	0.5	0	2	50	3.5	4.34	2	0	4	.	.	.	.	.	.
		Summer	5	1.8	2.49	0	0	4	56	2.8	3.7	1	0	4	.	.	.	.	.	.
		Fall	24	2.8	4.02	1	0	5	36	3.4	4.04	2	0	4	.	.	.	.	.	.
Year 2	Fresno	Winter	74	2.6	3.34	1.5	0	4	22	3.1	4.39	2	0	3	.	.	.	.	.	.
		Spring	70	3	3.85	2	0	4	25	3.4	3.81	2	0	6	.	.	.	.	.	.
		Summer	60	2.2	3.58	1	0	3	37	2.2	3.36	1	0	2	.	.	.	.	.	.
		Fall	69	3	3.57	2	0	4	31	3.2	3.3	2	0	6	.	.	.	.	.	.
	Riverside	Winter	27	1.7	3.04	0	0	3	24	2.8	3.84	2	0	4	.	.	.	.	.	.
		Spring	44	3.7	4.83	1	0	7	8	2.4	2.26	2.5	0	4	.	.	.	.	.	.
		Summer	51	1.7	2.98	0	0	3	2	1	1.41	1	0	2	.	.	.	.	.	.
		Fall	35	2.1	3.34	1	0	3	20	2.2	3.47	0.5	0	3	.	.	.	.	.	.

Stratified by study year, city and season, the median days with symptoms were higher during the pre-installation period compared with sham and true filtration periods in both study years (Table 7.1).

Poisson Mixed-Effects Model: Is filtration status associated with the number of days the child experienced asthma symptoms in the last 14 days?
NOTE: Study period was restricted to the first year of study to account for time effects.

Table 7.2. Parameter estimates for Poisson mixed-effects model examining the number of days with asthma symptoms pre-installation compared with sham and true filtration periods during the first year of study

Effect	City	Season	Filtration type	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept				0.8883	0.131	189	6.78	<.0001	0.6299	1.1467
true			Pre	0.3527	0.08027	679	4.39	<.0001	0.1951	0.5103
true			Sham	-0.1156	0.09515	679	-1.21	0.2248	-0.3024	0.07122
true			True	0	.	.	.	.	.	.
season		Fall		0.0673	0.09647	679	0.7	0.4857	-0.1221	0.2567
season		Summer		-0.1517	0.09233	679	-1.64	0.1008	-0.333	0.02958
season		Winter		0.1204	0.09081	679	1.33	0.1853	-0.05789	0.2987
season		Spring		0	.	.	.	.	.	.
area	Fresno			0.26	0.1327	679	1.96	0.0504	-0.00049	0.5205
area	Riverside			0	.	.	.	.	.	.

Table 7.3: Contrasts in log geometric mean days with asthma symptoms in the last 14 days by filtration type in the Poisson mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Pre vs Sham	0.4683	0.1054	679	4.44	<.0001	0.2613	0.6752
Pre vs True	0.3527	0.08027	679	4.39	<.0001	0.1951	0.5103
Sham vs True	-0.1156	0.09515	679	-1.21	0.2248	-0.3024	0.07122

Table 7.4. Log Geometric Means (GM) of days the child had asthma symptoms in last 14 days by filtration type in the Poisson mixed-effects model

Filtration type	Log GM	95% CI		GM	95% CI	
Pre	1.380	1.227	1.533	3.975	3.411	4.632
Sham	0.912	0.711	1.112	2.489	2.037	3.041
True	1.027	0.874	1.180	2.794	2.398	3.255

The log mean number of days with asthma symptoms was significantly higher at pre-installation than in sham (β=0.47 [95% CI: 0.26, 0.68]; p<0.0001) and true filtration (0.35 [0.20, 0.51]; p<0.0001) in the first year of the study (Table 1.3). Days with asthma symptoms did not differ significantly between sham and true filtration. The geometric mean (GM) number of days with asthma symptoms at pre-installation, in sham, and true filtration was 3.98 days [3.41, 4.63], 2.49 days [2.04, 3.04], and 2.79 days [2.40, 3.26], respectively (Table 1.4).

Table 7.5. Type III tests of fixed effects for Poisson mixed-effects model with interaction term filtration type x asthma severity (TRUE x SEVERITY)

Effect	Num DF	Den DF	F Value	Pr > F
true	2	675	6.87	0.0011
Severity	2	675	14.34	<.0001
true*Severity	4	675	9.12	<.0001
season	3	675	2.22	0.0843
area	1	675	1.99	0.1584

Table 7.6. Contrasts in log geometric mean days with asthma symptoms in the last 14 days for each level of the interaction term filtration type x asthma severity (TRUE x SEVERITY) in the Poisson mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Mild: Pre vs Sham	-0.1848	0.1737	675	-1.06	0.2878	-0.5259	0.1563
Moderate: Pre vs Sham	0.8566	0.1473	675	5.82	<.0001	0.5674	1.1458
Severe: Pre vs Sham	0.4180	0.2227	675	1.88	0.0609	-0.01916	0.8552
Severe vs Mild diff in Pre vs Sham diffs	0.6028	0.2779	675	2.17	0.0304	0.0571	1.1485
Moderate vs Mild diff in Pre vs Sham diffs	1.0414	0.2221	675	4.69	<.0001	0.6053	1.4775
Mild: Pre vs True	-0.2118	0.112	675	-1.89	0.0589	-0.4316	0.008028
Moderate: Pre vs True	0.6294	0.1152	675	5.46	<.0001	0.4033	0.8556
Severe: Pre vs True	0.4417	0.2276	675	1.94	0.0528	-0.00529	0.8887
Severe vs Mild diff in Pre vs True diffs	0.6535	0.2523	675	2.59	0.0098	0.1582	1.1488
Moderate vs Mild diff in Pre vs True diffs	0.8412	0.1599	675	5.26	<.0001	0.5272	1.1553
Mild: Sham vs True	-0.02701	0.1695	675	-0.16	0.8734	-0.3598	0.3058
Moderate: Sham vs True	-0.2272	0.1311	675	-1.73	0.0836	-0.4846	0.03025
Severe: Sham vs True	0.02366	0.2286	675	0.1	0.9176	-0.4252	0.4725
Severe vs Mild diff in Sham vs True diffs	0.05067	0.2835	675	0.18	0.8582	-0.506	0.6074
Severe vs Mild diff in Sham vs True diffs	-0.2002	0.2123	675	-0.94	0.3461	-0.617	0.2167

Table 7.7. Log Geometric Means (GM) of days the child had asthma symptoms in last 14 days for each level of interaction term filtration type x asthma severity (TRUE x SEVERITY)

Filtration type	Asthma severity	Log GM	95% CI		GM	95% CI	
Pre	moderate	1.830	1.663	1.997	6.233	5.275	7.366
Pre	severe	1.935	1.502	2.369	6.926	4.489	10.684
Pre	mild	0.627	0.421	0.834	1.872	1.523	2.301
Sham	moderate	0.973	0.691	1.255	2.647	1.997	3.509
Sham	severe	1.517	1.019	2.016	4.559	2.769	7.506
Sham	mild	0.812	0.485	1.139	2.252	1.624	3.125
True	moderate	1.201	0.991	1.410	3.322	2.693	4.098
True	severe	1.494	0.974	2.014	4.453	2.647	7.490
True	mild	0.839	0.632	1.046	2.314	1.881	2.846

Asthma severity significantly modified the association between filtration type and days with asthma symptoms (p<0.0001) at pre-installation and in the first year of the study (Table 7.5). Among children with mild asthma, the log mean days with symptoms did not differ significantly between pre-installation and either sham or true filtration, and the mean differences were also not significant between sham and true filtration (Table 7.6). Similarly, no differences in log mean days with asthma were observed between pre-installation and either sham or true filtration, or between sham and true filtration among children with severe asthma. Interestingly, among children with moderately severe asthma, the log mean days with asthma were higher at pre-installation than in sham (β=0.86 [95% CI: 0.57, 1.15], p<0.0001) or in true filtration (0.63 [0.40, 0.86], p<0.0001). In addition, the pre- vs. sham and pre- vs. true differences in log mean days with asthma were greater among children with severe (pre vs. sham: 0.60 [0.06, 1.15], p=0.03; pre vs. true: 0.65 [0.16, 1.15], p=0.01) or moderately severe asthma (pre vs. sham: 1.04 [0.61, 1.48], p<0.0001; pre vs. true: 0.84 [0.53, 1.16], p<0.0001) compared to those with mild asthma. No differences in log mean days with asthma were observed between sham and true filtration among children with moderate asthma.

The geometric mean (GM) days with asthma symptoms are presented in Table 7.7. At pre-installation, the GMs of days with asthma symptoms in children with mild, moderate, and severe asthma were 1.87 days [1.52, 2.30], 6.23 days [5.28, 7.37], and 6.93 days [4.49, 10.68], respectively. In sham, the GM days with asthma symptoms in children with mild, moderate, and severe asthma were 2.25 days [1.62, 3.13], 2.65 days [2.00, 3.51], and 4.56 days [2.77, 7.51]. In true filtration, the GM days with asthma symptoms in children with mild, moderate, and severe asthma were 2.31 days [1.88, 2.85], 3.32 days [2.69, 4.10], and 4.45 days [2.65, 7.49].

Sections 8-10: Mediation analyses:

The first step in mediation analysis is to determine whether the potential mediator is associated with (a) the treatment group and (b) the health outcome. If the factor is associated with both the treatment and outcome, the mediator is included in the main model to find out how relationship between treatment group and health outcome changes. The models all control for season, city and study year.

8. Determine whether controller medication use mediates the association between days with asthma symptoms and filtration status.
9. Determine whether a cold/flu episode in the past 2 weeks mediates the association between days with asthma symptoms and filtration status.
10. Determine whether indoor $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations mediate the association between days with asthma symptoms and filtration status.

8. Mediation analysis: Determine whether controller medication use mediates the association between days with asthma symptoms and filtration status.

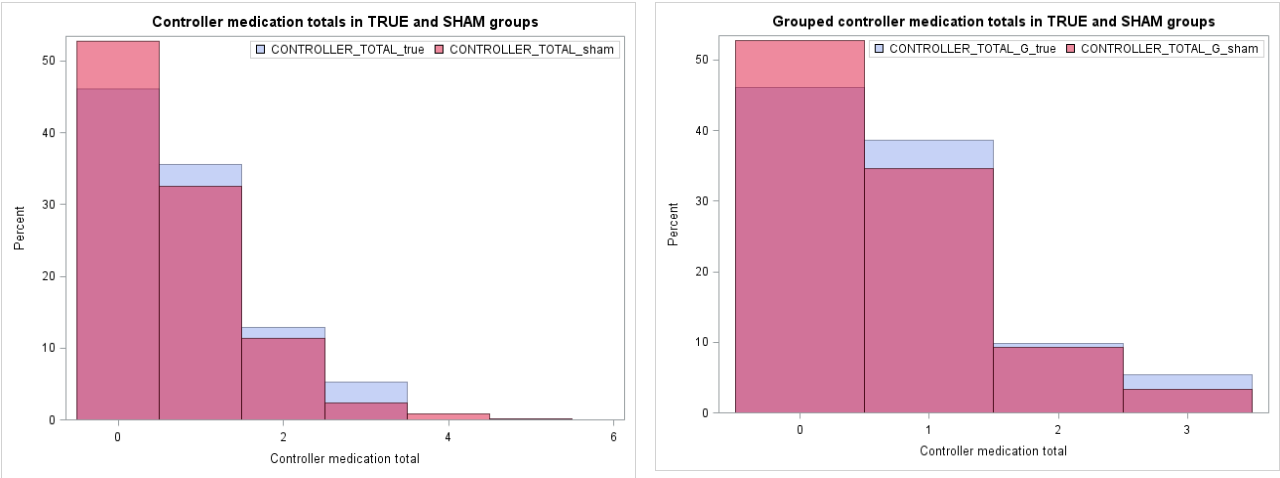


Figure 8. Distribution of controller medication totals (up to 5) by filtration status. Grouped categories were defined as 0 = none, 1 = 0.5-1.5, 2 = 2, and 3 = 3-5 medications.

Table 8.1: Number of controller medications

Controller med total	n	%
0	630	49.3
0.5	153	11.97
1	283	22.14
1.5	33	2.58
2	122	9.55
3	50	3.91
4	5	0.39
5	2	0.16

Table 8.2: Parameter estimates from the Ordered Multinomial Mixed-Effects Model examining the association between total controller medications (grouped) and filtration status

Effect	Controller med total	City	Season	Filtration type	Study year	Est.	SE	DF	t Value	Pr > |t|
Intercept	3+					-6.4901	0.4714	181	-13.77	<.0001
Intercept	2					-4.1376	0.4329	181	-9.56	<.0001
Intercept	1					-0.3379	0.4147	181	-0.81	0.4163
TRUE				SHAM		-0.3834	0.1503	1088	-2.55	0.0109
TRUE				TRUE		0	.	.	.	.
season			Fall			-0.1521	0.1874	1088	-0.81	0.417
season			Sum			-0.2708	0.1895	1088	-1.43	0.1532
season			Win			0.1365	0.1859	1088	0.73	0.4629
season			Spr			0	.	.	.	.
area		Fresno				1.0124	0.4595	1088	2.2	0.0278
area		Riverside				0	.	.	.	.
VisitYr1					Year 1	0.3572	0.151	1088	2.37	0.0182
VisitYr1					Year 2	0	.	.	.	.

The controller medication totals were significantly lower during sham compared with the true filtration period (β=-0.38 [SE=0.15], p=0.01).

Table 8.3: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms and total controller medications (grouped)

Effect	City	Season	Controller med score	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					0.5166	0.164	181	3.15	0.0019
controller_total_g			1		0.2302	0.1176	1088	1.96	0.0506
controller_total_g			2		0.3374	0.1767	1088	1.91	0.0565
controller_total_g			3+		0.2045	0.2584	1088	0.79	0.4290
controller_total_g			0		0	.	.	.	.
season		Fall			-0.05973	0.08246	1088	-0.72	0.469
season		Summer			-0.3187	0.08803	1088	-3.62	0.0003
season		Winter			-0.05763	0.08517	1088	-0.68	0.4988
season		Spring			0	.	.	.	.
area	Fresno				0.2795	0.1469	1088	1.9	0.0573
area	Riverside				0	.	.	.	.
VisitYr1					0.258	0.06861	1088	3.76	0.0002
VisitYr1					0	.	.	.	.

Table 8.4: Type III Tests of Fixed Effects from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms and total controller medications (grouped)

Effect	Num DF	Den DF	F Value	Pr > F
controller_total_g	3	1088	1.60	0.1889
season	3	1088	4.69	0.0029
area	1	1088	3.62	0.0573
VisitYr1	1	1088	14.14	0.0002

Table 8.5. Mean number of days the child had asthma symptoms in last 14 days by controller medication totals (grouped)

Controller medications	Log Mean	SE of Log Mean	Mean	SE of Mean
0	0.6764	0.1046	1.9668	0.2057
1	0.9066	0.08748	2.4759	0.2166
2	1.0138	0.1512	2.7561	0.4166
3+	0.8809	0.2361	2.4130	0.5696

The number of days with asthma symptoms was higher in children using one or more controller medications versus none (1 med: β=0.23 [SE=0.12], p=0.05; 2 meds: 0.34 [0.18], p=0.06; 3+ meds: 0.20 [0.26], p=0.43) although none of the comparisons reached statistical significance (Table 8.3). The geometric means of days with asthma symptoms for those with no controller medications, 1 medication, 2 medications, and 3+ medications were 1.97 days [0.21], 2.48 days [0.22], 2.76 days [0.42], and 2.41 days [0.57], respectively (Table 8.5).

Controller medication total (M) is associated with the predictor (filtration status) (X) and marginally associated with the outcome (number of days with asthma symptoms) (Y) and so appears to be a mediating factor: $X \rightarrow M \rightarrow Y$

Next, this mediator was included in the model as a covariate.

Table 8.6: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms and filtration status, with total controller medications (grouped) as an added covariate

Effect	City	Season	Filtration type	Controller med score	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept						0.5577	0.1711	181	3.26	0.0013
TRUE			SHAM			-0.05479	0.06584	1087	-0.83	0.4055
TRUE			TRUE			0	.	.	.	.
controller_total_g				1		0.2269	0.1183	1087	1.92	0.0554
controller_total_g				2		0.3279	0.1762	1087	1.86	0.0630
controller_total_g				3+		0.1871	0.262	1087	0.71	0.4752
controller_total_g				0		0	.	.	.	.
season		Fall				-0.05563	0.08279	1087	-0.67	0.5017
season		Summer				-0.3192	0.08809	1087	-3.62	0.0003
season		Winter				-0.05513	0.08554	1087	-0.64	0.5194
season		Spring				0	.	.	.	.
area	Fresno					0.2788	0.147	1087	1.9	0.0581
area	Riverside					0	.	.	.	.
VisitYr1					Year 1	0.2348	0.07507	1087	3.13	0.0018
VisitYr1					Year 2	0	.	.	.	.

Table 8.7. Mean number of days the child had asthma symptoms in last 14 days by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	0.8378	0.1035	2.3112	0.2392
TRUE	0.8925	0.09909	2.4413	0.2419

The number of days with asthma symptoms did not differ significantly by filtration status (β=-0.05 [0.07], p=0.41) (Table 8.6). Including controller medication total as a covariate did not change the association between filtration status and the number of days with asthma symptoms. The geometric means of days with asthma symptoms for the sham and true filtration periods were 2.31 days [0.24] and 2.44 days [0.24], respectively (Table 8.7).

9. Mediation analysis: Determine whether a cold/flu episode in the past 2 weeks mediates the association between days with asthma symptoms and filtration status.

Table 9.1: Cold or flu in the last 2 week by filtration status

	Filtration status			
	SHAM		TRUE	
Cold/Flu in last 2 weeks?	n	%	n	%
No	462	74.4	472	71.41
Yes	159	25.6	189	28.59

The frequencies of having a cold/flu in the last 2 weeks by filter type do not appear to differ by type of filtration.

Table 9.2: Parameter estimates from the Binomial Mixed-Effects Model examining the association between filtration status and an episode of cold/flu in the last 2 weeks

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					-3.828	0.6294	314	-6.08	<.0001
TRUE			SHAM		-0.06634	0.4338	961	-0.15	0.8785
TRUE			TRUE		0	.	.	.	.
season		Fall			-0.1326	0.5282	961	-0.25	0.8018
season		Summer			-0.6967	0.5938	961	-1.17	0.241
season		Winter			0.09269	0.5145	961	0.18	0.8571
season		Spring			0	.	.	.	.
area	Fresno				0.02255	0.4787	961	0.05	0.9624
area	Riverside				0	.	.	.	.
Year1				Year 1	0.07125	0.4332	961	0.16	0.8694
Year1				Year 2	0	.	.	.	.

Filtration status was not associated with having a cold/flu in the last 2 weeks. Having a cold/flu does not appear to be a mediating factor since the X → M relationship was not met.

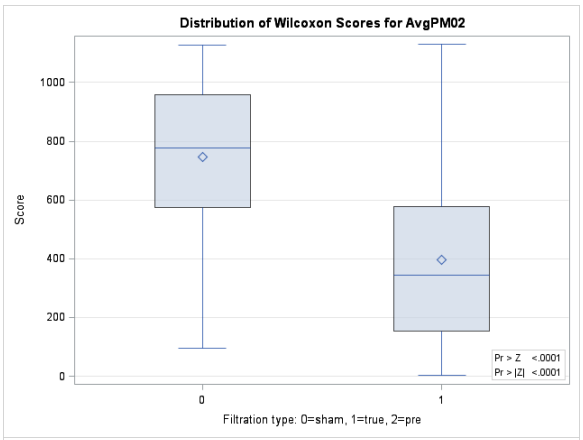
10. Mediation analysis: Determine whether indoor $PM_{0.2}$, $PM_{2.5}$, and PM_{10} concentrations mediate the association between days with asthma symptoms and filtration status.

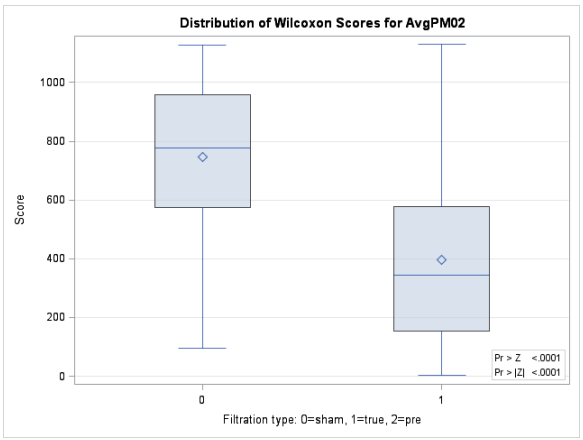
Indoor $PM_{0.2}$, $PM_{2.5}$, and PM_{10} measurements were taken every 6 months over the course of 2 years, with up to 2 measurements during the sham and true filtration treatments each. For the analyses below, the average of measurements taken during the true filtration phase and the average of measurements taken during sham treatment were calculated. Pre-intervention values were used as sham values were used if the 24 month measurements were missing. Only measurements meeting data quality criteria were included.

Table 10.1: Summary statistics for indoor PM concentrations ($\mu g/m^3$) by filtration status

TRUE	Variable	Label	N	Mean	Std Dev	P25	Median	P75	P90	Min	Max
0	AvgPM02	Averaged indoor $PM_{0.2}$	549	2.96	1.76	1.82	2.47	3.36	4.96	0.71	12.96
	AvgPM25	Averaged indoor $PM_{2.5}$	541	8.53	5.4	4.86	7.22	10.17	14.46	2.15	33.04
	AvgPMCI10	Averaged indoor PM_{10}	549	15.31	7.58	9.13	14.34	18.05	25.81	3.25	42.41
1	AvgPM02	Averaged indoor $PM_{0.2}$	586	1.63	1.38	0.94	1.32	1.82	2.81	0.24	16.86
	AvgPM25	Averaged indoor $PM_{2.5}$	586	5.35	7.59	2.59	3.88	5.45	8.89	0.44	79.64
	AvgPMCI10	Averaged indoor PM_{10}	586	10.45	6.08	6.74	9.27	12.25	17.03	2.09	58.91

The averaged indoor PM levels were significantly lower in the TRUE vs. SHAM filtration group, as one would expect (all $p<0.0001$, Wilcoxon Two-Sample Test). Please note that mean values in this section differ slightly from values in the air pollution section as average values for true and sham were calculated and then used in the analysis. If only one true value was recorded, it is used as the true value. This difference in approach was necessary to have a single value for mediation analysis.





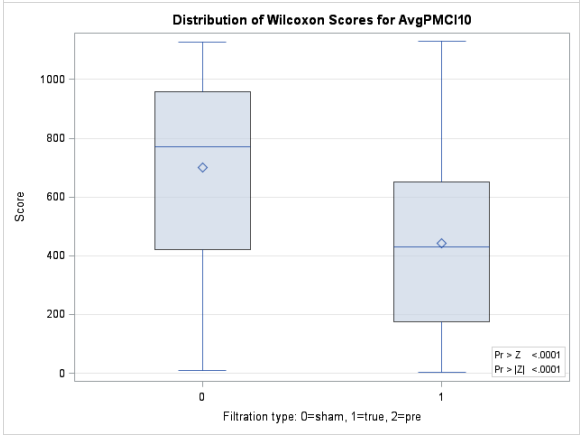


Figure 10.1: Distributions of indoor PM concentration Wilcoxon scores by filtration status

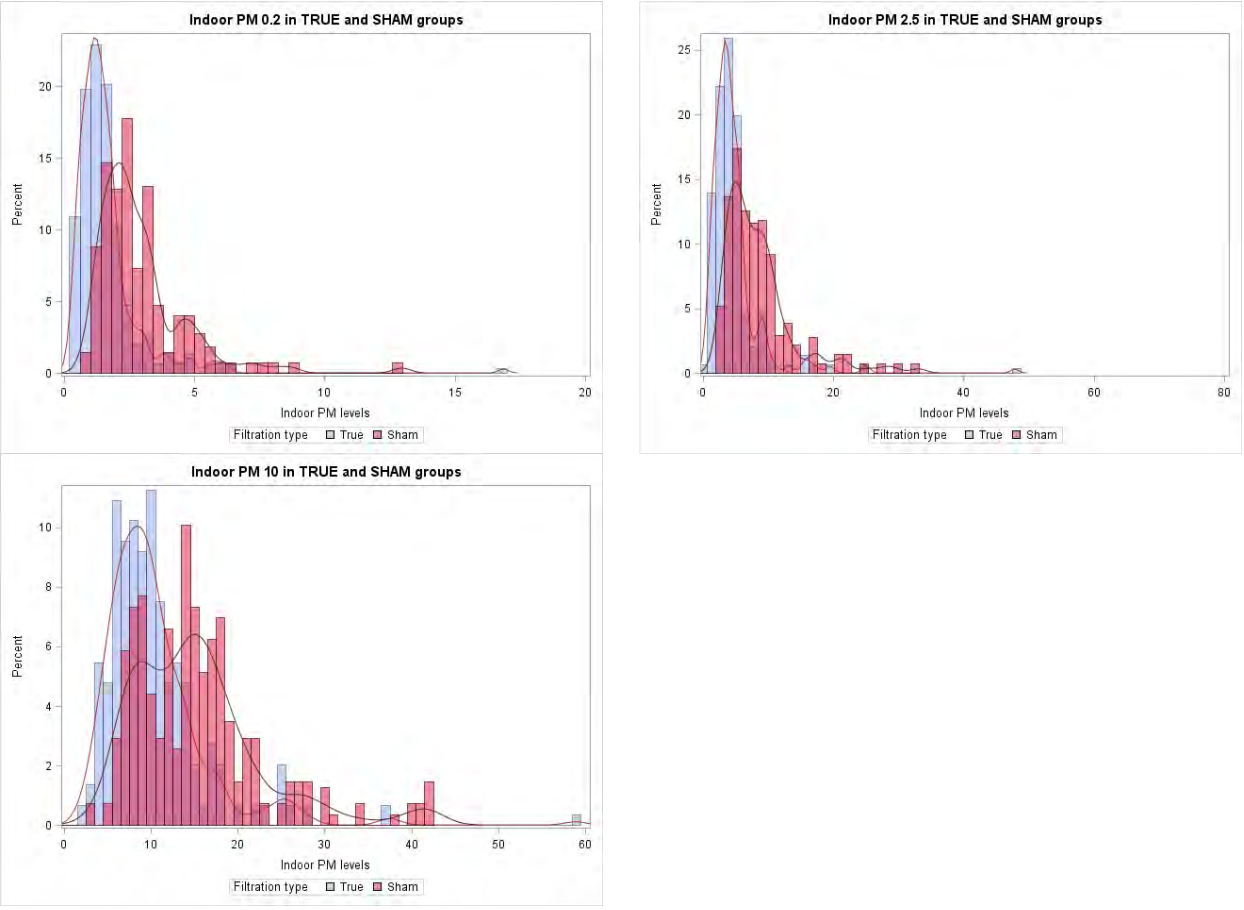


Figure 10.2: Distributions of indoor PM concentrations (μg/m^3) by filtration status

Table 10.2: Parameter estimates from the Log-linear Mixed-Effects Model examining the association between indoor $PM_{0.2}$ concentrations and filtration status

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					0.1046	0.06668	154	1.57	0.1187
TRUE			SHAM		0.7185	0.05559	953	12.93	<.0001
TRUE			TRUE		0	.	.	.	.
season		Fall			0.01012	0.006634	953	1.53	0.1273
season		Summer			0.001942	0.00405	953	0.48	0.6318
season		Winter			-0.00028	0.006461	953	-0.04	0.9653
season		Spring			0	.	.	.	.
area	Fresno				0.1951	0.07698	953	2.53	0.0114
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.07918	0.04352	953	1.82	0.0692
VisitYr1				Year 2	0	.	.	.	.

Table 10.3: Log Geometric Means (GM) of indoor $PM_{0.2}$ levels (μg/m^3) by filtration status

Filtration status	Log GM	SE of Log GM	GM	SE of GM
SHAM	0.9632	0.04541	2.6201	1.0465
TRUE	0.2447	0.04933	1.2772	1.0506

Indoor $PM_{0.2}$ concentrations were significantly higher during sham compared with the true filtration period (β=0.72 [0.06], p<0.0001) (Table 10.2). The geometric means of $PM_{0.2}$ concentrations during sham and true filtration were 2.62 [1.05] and 1.28 [1.05], respectively (Table 10.3)

Table 10.4: Parameter estimates from the Log-linear Mixed-Effects Model examining the association between indoor $PM_{2.5}$ concentrations and filtration status

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.1862	0.07106	154	16.69	<.0001
TRUE			SHAM		0.7268	0.0591	950	12.3	<.0001
TRUE			TRUE		0	.	.	.	.
season		Fall			0.01117	0.005594	950	2	0.0462
season		Summer			0.000482	0.004579	950	0.11	0.9161
season		Winter			0.000581	0.006633	950	0.09	0.9302
season		Spring			0	.	.	.	.
area	Fresno				0.1314	0.08287	950	1.59	0.1130
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.09049	0.04506	950	2.01	0.0449
VisitYr1				Year 2	0	.	.	.	.

Table 10.5: Log Geometric Means (GM) of indoor $PM_{2.5}$ levels by filtration status

Filtration status	Log GM	SE of Log GM	GM	SE of GM
SHAM	2.0269	0.04789	7.5905	1.0491
TRUE	1.3002	0.05358	3.6700	1.0550

Indoor $PM_{2.5}$ concentrations were significantly higher during sham compared with the true filtration period (β=0.73 [0.06], p<0.0001) (Table 10.4). The geometric means of $PM_{2.5}$ concentrations during sham and true filtration were 7.59 [1.05] and 3.67 [1.06], respectively (Table 10.5)

Table 10.6: Parameter estimates from the Log-linear Mixed-Effects Model examining the association between indoor PM_{10} concentrations and filtration status

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					2.0849	0.0565	154	36.9	<.0001
TRUE			SHAM		0.4366	0.04025	953	10.85	<.0001
TRUE			TRUE		0	.	.	.	.
season		Fall			0.008434	0.004927	953	1.71	0.0873
season		Summer			-0.00088	0.003369	953	-0.26	0.7941
season		Winter			0.003083	0.004934	953	0.62	0.5322
season		Spring			0	.	.	.	.
area	Fresno				0.1595	0.06907	953	2.31	0.0211
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.05344	0.03089	953	1.73	0.084
VisitYr1				Year 2	0	.	.	.	.

Table 10.7: Log Geometric Means (GM) of indoor PM_{10} levels by filtration status

Filtration status	Log GM	SE of Log GM	GM	SE of GM
SHAM	2.6307	0.0402	13.8835	1.0410
TRUE	2.1941	0.0397	8.9719	1.0405

Indoor PM_{10} concentrations were significantly higher during sham compared with the true filtration period (β=0.44 [0.04], p<0.0001) (Table 10.6). The geometric means of PM_{10} concentrations during sham and true filtration were 13.88 [1.04] and 8.97 [1.04], respectively (Table 10.7)

The next set of models examined whether indoor PM concentrations were associated with the number of days the child experienced asthma symptoms.

Table 10.8: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms in the last 14 days and indoor $PM_{0.2}$ concentrations

Effect	City	Season	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.5275	0.1655	154	3.19	0.0017
AvgPM02				0.03347	0.02695	953	1.24	0.2147
season		Fall		-0.09226	0.08624	953	-1.07	0.2850
season		Summer		-0.3121	0.09339	953	-3.34	0.0009
season		Winter		-0.07766	0.08929	953	-0.87	0.3846
season		Spring		0	.	.	.	.
area	Fresno			0.2389	0.1641	953	1.46	0.1459
area	Riverside			0	.	.	.	.
VisitYr1			Year 1	0.3282	0.07547	953	4.35	<.0001
VisitYr1			Year 2	0	.	.	.	.

Table 10.9: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms in the last 14 days and indoor $PM_{2.5}$ concentrations

Effect	City	Season	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.5285	0.1633	154	3.24	0.0015
AvgPM25				0.01028	0.006847	950	1.5	0.1337
season		Fall		-0.08415	0.08558	950	-0.98	0.3257
season		Summer		-0.3055	0.09365	950	-3.26	0.0011
season		Winter		-0.08091	0.09112	950	-0.89	0.3748
season		Spring		0	.	.	.	.
area	Fresno			0.2445	0.163	950	1.5	0.134
area	Riverside			0	.	.	.	.
VisitYr1			Year 1	0.3328	0.07632	950	4.36	<.0001
VisitYr1			Year 2	0	.	.	.	.

Table 10.10: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days with asthma symptoms in the last 14 days and indoor PM_{10} concentrations

Effect	City	Season	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept				0.4998	0.17	154	2.94	0.0038
AvgPMCl10				0.008196	0.005575	953	1.47	0.1419
season		Fall		-0.09389	0.08615	953	-1.09	0.2760
season		Summer		-0.3121	0.09342	953	-3.34	0.0009
season		Winter		-0.07822	0.08895	953	-0.88	0.3794
season		Spring		0	.	.	.	.
area	Fresno			0.2362	0.1629	953	1.45	0.1473
area	Riverside			0	.	.	.	.
VisitYr1			Year 1	0.3312	0.0753	953	4.4	<.0001
VisitYr1			Year 2	0	.	.	.	.

Indoor PM concentrations were not associated with the number of days the child had asthma symptoms (Tables 10.8-10.10). Therefore, indoor PM does not appear to be a mediating factor for the relationship between filtration status and asthma symptoms in the last 2 weeks.

11 – 17: Interaction analyses

All models with interaction terms below include the study year covariate (unless stated otherwise) in addition to the covariates specified for the base model.

11. Determine whether having an air cleaner vs. central filtration in the home modifies the association between days with asthma symptoms and filtration status.
12. Determine whether asthma severity modifies the association between days with asthma symptoms and filtration status.
13. Determine whether having a gas stove in the home modifies the association between days with asthma symptoms and filtration status.
14. Determine whether the presence of mold or water damage modifies the association between days with asthma symptoms and filtration status.
15. Determine whether filtration use ratio modifies the association between days with asthma symptoms and filtration status.
16. Determine whether having allergies to furry pets in homes with furry pets modifies the association between days with asthma symptoms and filtration status.
17. Determine whether the difference in indoor $PM_{0.2\text{-}2.5}$ between sham and true filtration periods modifies the association between days with asthma symptoms and filtration status in a balanced crossover deign (study months 1-6 and 13-18).

11. Interaction analysis: Determine whether having an air cleaner vs. central filtration in the home modifies the association between days with asthma symptoms and filtration status.

Table 11.1: Homes with air cleaners or central filtration by filtration status

	SHAM		TRUE	
Filtration system	**n**	**%**	**n**	**%**
Air cleaner	484	76.46	527	78.42
Central filtration	149	23.54	145	21.58

The proportions of homes with air cleaners vs. central filtration were similar by filtration status, as expected.

Table 11.2: Type III tests of fixed effect for negative binomial mixed-effects model with interaction term TRUE × INTERVENTION

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1090	2.81	0.0942
hvac_ac	1	1090	2.02	0.1550
true*hvac_ac	1	1090	3.28	0.0703
season	3	1090	5.74	0.0007
area	1	1090	4.35	0.0373
VisitYr	1	1090	11.82	0.0006

Table 11.3: Contrasts in log mean days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x filtration system (TRUE x HVAC) interaction term in the negative binomial mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Air Cleaner: Sham vs True	0.002191	0.08222	1090	0.03	0.9788	-0.1591	0.1635
Central: Sham vs True	-0.301	0.1522	1090	-1.98	0.0482	-0.5996	-0.00244
Air Cleaner vs Central diff in Sham vs True diffs	**0.3032**	**0.1674**	**1090**	**1.81**	**0.0703**	**-0.0252**	**0.6317**

Table 11.4: Contrasts in log mean days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x filtration system (TRUE x HVAC) interaction term in the negative binomial mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
Sham: Air cleaner vs Central filtration	0.3650	0.1837	1090	1.99	0.0472
True: Air cleaner vs Central filtration	0.06176	0.1588	1090	0.39	0.6974

Table 11.5: Log means of days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x filtration system (TRUE x HVAC) interaction term in the negative binomial mixed-effects model

Filtration type	Filtration system	Log Mean	95% CI		Mean	95% CI	
Sham	Air Cleaner	0.8434	0.6634	1.0234	2.3242	1.9413	2.7825
Sham	Central	0.4784	0.1476	0.8091	1.6134	1.1591	2.2458
True	Air Cleaner	0.8412	0.6600	1.0224	2.3191	1.9347	2.7798
True	Central	0.7794	0.4937	1.0651	2.1802	1.6384	2.9011

The proportions of homes with air cleaners vs. central filtration were similar by filtration status, as expected, with approximately 22-24% of homes using central filtration (Table 11.1). The 2-way interaction term TRUE × INTERVENTION (filtration status x intervention type) was marginally

significant, indicating that having a central filtration system in the home modified the association between days with asthma symptoms and filtration status (p=0.07) (Table 11.2).

In homes with central filtration systems, the number of days with asthma symptoms was significantly lower during sham compared with the true filtration period (β=0.30 [0.15], p=0.05) (Table 11.3); however, in homes with air cleaners, no differences were detected in days with asthma symptoms by filtration status (p=0.98).

During the sham period, days with asthma symptoms were significantly higher in homes with air cleaners compared with homes with central filtration (0.37 [0.18] p=0.05); in contrast, during the true filtration period, the number of days with asthma symptoms did not differ by whether or not the homes used central filtration (p=0.70)(Table 11.4).

The geometric means (GM) of days with asthma symptoms are presented in Table 11.5. During the sham period, the GMs of days with asthma in homes with air cleaners and central filtration were 2.32 days [1.94,2.78] and 1.61 days [1.16, 2.25], respectively. During the true filtration period, the GMs of days with asthma in homes with air cleaners and central filtration were 2.32 days [1.93, 2.78] and 2.18 days [1.63, 2.90], respectively.

12. Interaction analysis: Determine whether asthma severity modifies the association between days with asthma symptoms and filtration status.

Table 12.1: Asthma severity by filtration status

	Filtration status			
	SHAM		TRUE	
Asthma severity	n	%	n	%
Mild	322	50.87	323	48.07
Moderate	255	40.28	285	42.41
Severe	56	8.85	64	9.52

The proportions of children with mild, moderate, and severe asthma were similar by filtration status, as expected.

Table 12.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1090	0.02	0.8961
Severity	2	1090	5.80	0.0031
true*Severity	2	1090	3.09	0.0459
season	3	1090	4.75	0.0027
area	1	1090	3.78	0.0520
VisitYr1	1	1090	11.76	0.0006

Table 12.3: Contrasts in log mean days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Mild: sham vs true	0.0249	0.1105	1090	0.23	0.8217	-0.1919	0.2417
Mod: sham vs true	-0.2034	0.09065	1090	-2.24	0.0250	-0.3813	-0.02553
Sev: sham vs true	0.1524	0.1232	1090	1.24	0.2162	-0.08928	0.3941
Sev vs Mild diff in Sham vs True diffs	**0.1275**	**0.1589**	**1090**	**0.8**	**0.4225**	**-0.1843**	**0.4393**
Mod vs Mild diff in Sham vs True diffs	**-0.2283**	**0.1371**	**1090**	**-1.67**	**0.0962**	**-0.4973**	**0.04072**

Table 12.4: Mean differences in days with asthma symptoms between severity groups in the TRUE × SEVERITY interaction term in the Poisson mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.01341	0.1656	1090	0.08	0.9355
SHAM: sev vs mild	0.7786	0.2148	1090	3.62	0.0003
TRUE: mod vs mild	0.2417	0.1534	1090	1.58	0.1154
TRUE: sev vs mild	0.6510	0.2341	1090	2.78	0.0055

Table 12.5: Log means of days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Filtration type	Asthma severity	Log Mean	95% CI		Mean	95% CI	
Sham	Moderate	0.6958	0.4443	0.9472	2.0053	1.5594	2.5785
Sham	Severe	1.4609	1.0922	1.8297	4.3098	2.9808	6.2320
Sham	Mild	0.6824	0.4630	0.9017	1.9786	1.5888	2.4638
True	Moderate	0.8992	0.6620	1.1363	2.4576	1.9387	3.1152
True	Severe	1.3085	0.8900	1.7270	3.7006	2.4351	5.6238
True	Mild	0.6575	0.4462	0.8688	1.9300	1.5624	2.3840

The proportions of children with mild (48-51%), moderate (40-42%), and severe asthma (9-10%) were similar by filtration status, as expected (Table 12.1). The 2-way interaction term TRUE × SEVERITY (filtration status x asthma severity) was statistically significant, indicating that asthma severity modified the association between days with asthma symptoms and filtration status (p=0.05) (Table 12.2).

The number of days with asthma symptoms did not differ significantly by filtration status in children with mild asthma and those with severe asthma; interestingly, among children with moderate asthma, the number of days with asthma symptoms was significantly lower during sham compared with the true filtration period (-0.20 [0.09], p=0.03). There were fewer symptoms reported with true filtration among severe asthmatics, but due to small sample size, the difference was not significant (β=0.15[0.12], p=0.22) (Table 12.3).

During the sham period, days with asthma symptoms were significantly higher in children with severe asthma compared to children with mild asthma (0.78 [0.21] p=0.0003); similarly, during the true filtration period, days with asthma symptoms were higher in children with severe asthma (0.65 [0.23], p=0.01) (Table 12.4).

The geometric means (GM) of days with asthma symptoms are presented in Table 12.5. During the sham period, the GMs of days with asthma in children with mild, moderate, and severe asthma were 1.98 days [1.59, 2.46], 2.01 days [1.56, 2.58], and 4.31 days [2.98, 6.23], respectively. During the true filtration period, the GMs of days with asthma in children with mild, moderate, and severe asthma were 1.93 days [1.56, 2.38], 2.46 days [1.94, 3.12], and 3.70 days [2.44, 5.62], respectively.

13. Interaction analysis: Determine whether having a gas stove in the home modifies the association between days with asthma symptoms and filtration status.

Table 13.1: Stove type by filtration status

	Filtration status			
	SHAM		TRUE	
Stove type	n	%	n	%
Electric	164	28.32	172	28.01
Gas	415	71.68	442	71.99

The proportions of homes with gas stoves were similar by filtration status, as expected.

Table 13.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × STOVE

Effect	Num DF	Den DF	F Value	Pr > F
true	1	997	0.01	0.9101
bsl_stove_type	1	997	0.16	0.6892
true*bsl_stove_type	1	997	1.2	0.2737
season	3	997	4.38	0.0045
area	1	997	1.81	0.1783
VisitYr1	1	997	14.2	0.0002

Table 13.3: Contrasts in log mean days with asthma symptoms for each level of the TRUE × STOVE interaction term in the Poisson mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: gas vs electric	-0.1619	0.2092	997	-0.77	0.4392
TRUE: gas vs electric	-0.00196	0.2253	997	-0.01	0.9931
Electric: sham vs true	0.08893	0.1316	997	0.68	0.4993
Gas: sham vs true	-0.07102	0.07698	997	-0.92	0.3564

Table 13.4: Log means of days with asthma symptoms for each level of the interaction term in the Poisson mixed-effects model

Filtration x STOVE		Log Mean	SE of Log Mean	Mean	SE of Mean
sham	Gas	0.7650	0.10220	2.1490	1.10760
sham	Electric	0.9269	0.17860	2.5267	1.19554
True	Gas	0.8360	0.10290	2.3071	1.10838
True	Electric	0.8380	0.18830	2.3117	1.20720

The proportions of homes with gas stoves were the same by filtration status, as expected, with approximately 72% of homes with gas stoves (Table 13.1). The 2-way interaction term TRUE × STOVE (filtration status x stove type) was not significant, indicating that ever having any allergies did not modify the association between days with asthma symptoms and filtration status (p=0.27) (Table 13.2).

The number of days with asthma symptoms did not differ by filtration status irrespective of stove type (Table 13.3). Likewise, days with asthma symptoms did not differ by stove type irrespective of filtration status.

The geometric means (GM) of days with asthma symptoms are presented in Table 13.4. During the sham period, the GMs of days with asthma in homes with and without gas stoves were 2.15 days [1.11] and 2.53 days [1.20], respectively. During the true filtration period, the GMs of days with asthma in homes with and without gas stoves were 2.31 days [1.11] and 2.31 days [1.21], respectively.

14. Interaction analysis: Determine whether the presence of mold or water damage modifies the association between days with asthma symptoms and filtration status.

Table 14.1: Presence of mold or water damage in the home by filtration status

	Filtration status			
	SHAM		TRUE	
Mold or water damage	n	%	n	%
No	497	80.03	486	73.86
Yes	124	19.97	172	26.14

The proportions of homes with mold or water damage were slightly higher during true filtration (26%) than sham filtration (20%).

Table 14.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × MOLD

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1087	0.12	0.7344
rc_moldwtrdmg	1	1087	0.08	0.7720
true*rc_moldwtrdmg	1	1087	0.87	0.3499
season	3	1087	4.49	0.0038
area	1	1087	3.79	0.0517
VisitYr1	1	1087	11.08	0.0009

Table 14.3: Contrasts in log mean days with asthma symptoms for each level of the TRUE × MOLD interaction term in the Poisson mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mold/water damage vs none	0.09019	0.1178	1087	0.77	0.4441
TRUE: mold/water damage vs none	-0.03825	0.1077	1087	-0.36	0.7226
No mold/water damage: sham vs true	-0.08962	0.07668	1087	-1.17	0.2427
Mold/Water damage: sham vs true	0.03882	0.1215	1087	0.32	0.7494

Table 14.4: Log means of days with asthma symptoms for each level of the interaction term in the Poisson mixed-effects model

Filtration x MOLD		Log Mean	SE of Log Mean	Mean	SE of Mean
sham	Mold	0.83680	0.12460	2.30897	1.13270
sham	No mold	0.74660	0.08666	2.10981	1.09053
True	Mold	0.79800	0.11460	2.22109	1.12142
True	No mold	0.83620	0.08633	2.30758	1.09017

The proportions of homes with mold or water damage were slightly higher during true filtration (26%) than sham filtration (20%) (Table 14.1). The 2-way interaction term TRUE × MOLD (filtration status x mold or water damage in home) was not significant, indicating that ever having any allergies did not modify the association between days with asthma symptoms and filtration status (p=0.35) (Table 14.2).

The number of days with asthma symptoms did not differ by filtration status irrespective of presence of mold or water damage in the home (Table 14.3). Likewise, days with asthma symptoms did not differ by presence of mold or water damage irrespective of filtration status.

The geometric means (GM) of days with asthma symptoms are presented in Table 14.4. During the sham period, the GMs of days with asthma in homes with and without mold or water damage were 2.31 days [1.13] and 2.11 days [1.09], respectively. During the true filtration period, the GMs of

days with asthma in homes with and without mold or water damage were 2.22 days [1.12] and 2.31 days [1.09], respectively.

15. Interaction analysis: Determine whether filtration use ratio modifies the association between days with asthma symptoms and filtration status.

Table 15.1: Filtration use ratio by filtration status

Filtration use	N	Mean	Std Dev	Median	Minimum	Maximum
Sham	236	0.99	0.325	1.00	0	3.03
True	283	0.98	0.309	1.00	0	3.03

The mean filtration use ratios were similar by filtration status, as expected.

Table 15.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × USERATIO

Effect	Num DF	Den DF	F Value	Pr > F
true	1	352	0.26	0.6076
useratio_sw	1	352	1.63	0.2023
useratio_sw*true	1	352	0.18	0.6758
season	3	352	1.27	0.2851
area	1	352	0.58	0.4472
VisitYr1	1	352	6.53	0.011

Table 15.3: Parameter estimates for Poisson mixed-effects model with interaction term TRUE × USERATIO

Effect	City	Season	Filtration status	Visit	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept					1.0857	0.3856	157	2.82	0.0055
TRUE			sham		-0.1992	0.3875	352	-0.51	0.6076
TRUE			TRUE		0	.	.	.	.
useratio_sw					-0.3513	0.3137	352	-1.12	0.2635
useratio_sw*true			sham		0.1622	0.3876	352	0.42	0.6758
useratio_sw*true			TRUE		0	.	.	.	.
season		Fall			-0.2177	0.1339	352	-1.63	0.1048
season		Summer			-0.2471	0.1825	352	-1.35	0.1766
season		Winter			-0.1226	0.1676	352	-0.73	0.4652
season		Spring			0	.	.	.	.
area	Fresno				0.1336	0.1755	352	0.76	0.4472
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.2908	0.1138	352	2.56	0.011
VisitYr1				Year 2	0	.	.	.	.

Table 15.4: Contrasts in log mean days with asthma symptoms for each level of the TRUE × USERATIO interaction term in the Poisson mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|
Use ratio=1: Sham vs True	-0.03694	0.1055	352	-0.35	0.7263
Use ratio=0.75: Sham vs. True	-0.0775	0.1331	352	-0.58	0.5608

The mean filtration use ratio (proportion of volume normalized to what asked to use) was approximately the same during the sham (Mean=0.99) and true filtration periods (Mean=0.99), as

expected (Table 15.1). The 2-way interaction term TRUE × USERATIO (filtration status x filtration use ratio) was not significant, indicating that ratio of time the filtration system was used compared to the amount of time asked did not modify the association between days with asthma symptoms and filtration status (p=0.68) (Table 15.2).

The number of days with asthma symptoms did not differ by filtration status in homes that ran their filtration system 100% of the amount of time asked (i.e., use ratio = 1) (β=-0.04 [0.11], p=0.73) (Tables 15.3 and 15.4). By comparison, in homes that ran their filtration system 75% of the amount of time asked (i.e., use ratio = 0.75), the mean difference between sham and true filtration was -0.08 [0.13] (p=0.56).

16. Interaction analysis: Determine whether having allergies to furry pets in homes with furry pets modifies the association between days with asthma symptoms and filtration status.

Table 16.1: Have allergies to furry pets in homes with furry pets by filtration status

	Filtration status			
	SHAM		TRUE	
Allergies to furry pets and having a furry pet indoors	n	%	n	%
No	465	73.46	498	74.10
Yes	168	26.54	174	25.90

The proportions of with allergies to furry pets in homes with furry pets were similar by filtration status, as expected.

Table 16.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × FURRY_ALLG

Effect	Num DF	Den DF	F Value	Pr > F
TRUE	1	1091	0.37	0.5428
furry_allg	1	1091	3.41	0.0651
TRUE*furry_allg	1	1091	0.17	0.6796
season	3	1091	4.8	0.0025
area	1	1091	3.25	0.0716
VisitYr1	1	1091	11.24	0.0008

Table 16.3: Contrasts in log mean days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x allergies to furry pets interaction term in the Poisson mixed-effects model. Allergies to a furry pet and having a furry pet at home abbreviated to "pet allergies".

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Sham: Pet Allergies vs None	0.2974	0.1706	1091	1.74	0.0816	-0.03739	0.6322
True: Pet Allergies vs None	0.2398	0.1515	1091	1.58	0.1137	-0.05742	0.537
Pet Allergies: Sham vs True	-0.01664	0.1226	1091	-0.14	0.8921	-0.2572	0.2239
No allergies: Sham vs True	-0.07424	0.07641	1091	-0.97	0.3314	-0.2242	0.07568
Pet Allergies vs None diff in Sham vs True diffs	0.0576	0.1395	1091	0.41	0.6796	-0.216	0.3312

Table 16.4: Log means of days the child had asthma symptoms in the last 2 weeks for each level of the filtration type x allergies to furry pets interaction term in the Poisson mixed-effects model

Filtration type	Presence of pet allergies	Log Mean	95% CI		Mean	95% CI	
Sham	Allergies	0.9920	0.6918	1.2922	2.6966	1.9973	3.6408
Sham	None	0.6946	0.5137	0.8755	2.0029	1.6715	2.4001
True	Allergies	1.0087	0.7440	1.2733	2.7420	2.1043	3.5726
True	None	0.7688	0.5864	0.9513	2.1572	1.7975	2.5891

The proportions of with allergies to furry pets in homes with furry pets were similar by filtration status, as expected, with approximately 26-27% with allergies to furry pets and a furry pet in the home (Table 16.1). The 2-way interaction term TRUE × FURRY_ALLG (filtration status x allergies to furry pets) was not significant, indicating that ever having any allergies did not modify the association between days with asthma symptoms and filtration status (p=0.68) (Table 16.2).

The number of days with asthma symptoms did not differ by filtration status irrespective of whether children had allergies to furry pets in homes with furry pets (Table 16.3). Days with asthma symptoms for children that had allergies to furry pets were statistically significantly higher for children without a furry pet with sham filtration and marginally higher during true filtration.

The geometric means (GM) of days with asthma symptoms are presented in Table 16.4. During the sham period, the GMs of days with asthma in children with and without allergies to furry pets were 2.70 days [2.00, 3.64] and 2.00 days [1.67, 2.40], respectively. During the true filtration period, the GMs of days with asthma in children with and without allergies to furry pets were 2.74 days [2.10, 3.57] and 2.16 days [1.80, 2.59], respectively.

17. Interaction analysis: Determine whether the difference in indoor $PM_{0.2\text{-}2.5}$ between sham and true filtration periods modifies the association between days with asthma symptoms and filtration status in a balanced crossover design (study months 1-6 and 13-18).

Table 17.1: Mean difference in indoor $PM_{0.2\text{-}2.5}$ between sham and true filtration during study months 1-6 and 13-18 only

N	Mean	Std Dev	Median	Minimum	Maximum
336	2.79	4.041	2.08	-6.33	23.58

The mean difference in indoor $PM_{0.2\text{-}2.5}$ between sham and true filtration was 2.79 (SD=4.04), indicating that, on average, the indoor $PM_{0.2\text{-}2.5}$ concentrations were higher during the sham period compared with true filtration.

Table 17.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × PM0225_DIFF

Effect	Num DF	Den DF	F Value	Pr > F
True	1	273	0	0.9484
pm0225shamtrue_avg	1	273	0.73	0.3925
pm0225shamtrue_*true	1	273	0.02	0.8908
Season	3	273	0.29	0.8355
Area	1	273	1.14	0.2865

Table 17.3: Parameter estimates for Poisson mixed-effects model with interaction term TRUE × PM0225_DIFF

Effect	City	Season	Filtration status	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept				0.4397	0.3685	90	1.19	0.2359
True			sham	-0.01019	0.1571	273	-0.06	0.9484
True			true	0	.	.	.	.
pm0225shamtrue_avg				0.02073	0.02733	273	0.76	0.4488
pm0225shamtrue_*true			sham	-0.0032	0.02327	273	-0.14	0.8908
pm0225shamtrue_*true			true	0	.	.	.	.
season		Fall		0.2237	0.2957	273	0.76	0.4499
season		Summer		0.04526	0.2491	273	0.18	0.8559
season		Winter		0.2003	0.3272	273	0.61	0.5409
season		Spring		0	.	.	.	.
area	Fresno			0.2407	0.2254	273	1.07	0.2865
area	Riverside			0	.	.	.	.

Table 17.4: Contrasts in log mean days with asthma symptoms for each level of the TRUE × PM0225_DIFF interaction term in the Poisson mixed-effects model

	Estimate	Standard Error	DF	t Value	Pr > |t|
Diff in PM=1: Sham vs True	-0.01338	0.1438	273	-0.09	0.9259
Diff in PM=2: Sham vs True	-0.01658	0.1332	273	-0.12	0.9010
Diff in PM=5: Sham vs True	-0.02618	0.1242	273	-0.21	0.8332
Diff in PM=-5: Sham vs True	0.005804	0.2470	273	0.02	0.9813

The mean difference in indoor $PM_{0.2\text{-}2.5}$ between sham and true filtration was 2.79 (SD=4.04), indicating that, on average, the indoor $PM_{0.2\text{-}2.5}$ concentrations were higher during the sham period compared with true filtration (Table 17.1). The 2-way interaction term TRUE × PM0225_DIFF (filtration status x averaged difference in $PM_{0.2\text{-}2.5}$ between sham and true filtration) was not significant, indicating that the averaged difference in $PM_{0.2\text{-}2.5}$ between sham and true filtration did not modify the association between days with asthma symptoms and filtration status (p=0.89) (Table 17.2).

The number of days with asthma symptoms did not differ by filtration status in homes where the mean difference between sham and true filtration periods in indoor $PM_{0.2\text{-}2.5}$ concentrations was 1 ug/m^3 (β=-0.01 [0.14], p=0.93) (Tables 17.3 and 17.4). By comparison, the mean differences in days with asthma between sham and true filtration periods in homes with average sham – true differences in $PM_{0.2\text{-}2.5}$ of 2, 5, and -5 were -0.02 [0.13], -0.03 [0.12], and 0.01 [0.25], respectively; none of these comparisons reached statistical significance.

Appendix F.5 Secondary health endpoints

All models for secondary health endpoints were adjusted for covariates city, season, and study year as in the main analysis. The interaction term TRUE * SEVERITY was also added to determine whether asthma severity modified the relationship between filtration status and a given health endpoint. No other moderators or mediators were explored in this set of analyses.

1) Compare the number of days the child used a rescue inhaler in the last 14 days in sham vs. true filtration
2) Compare the number of missed school days due to asthma in the last 14 days in sham vs. true filtration
3) Compare the number of hospital, ER, or clinic visits in the last 3 months in sham vs. true filtration
4) Compare the number of hospital visits in the last 3 months in sham vs. true filtration
5) Compare the number of ER visits in the last 3 months in sham vs. true filtration
6) Compare the number of clinic visits in the last 3 months in sham vs. true filtration
7) Compare the number of times child received steroid treatment in the last 3 months in sham vs. true filtration
8) Compare Mini PAQL symptom scores in sham vs. true filtration
9) Compare Mini PAQL emotional function scores in sham vs. true filtration
10) Compare Mini PAQL activity limitation scores in sham vs. true filtration
11) Compare exhaled eNO in sham vs. true filtration
12) Compare Forced vital capacity (FCV) in sham vs. true filtration
13) Compare Forced expiratory volume at 1.0 second (FEV1) in sham vs. true filtration
14) Compare FEV1/FCV in sham vs. true filtration
15) Compare the number of clinic visits in the last 3 months in sham vs. true filtration only in study months 1-6 and 13-18 only, providing a balanced crossover design.
16) Compare night waking due to asthma in sham vs. true filtration for air cleaner homes, modified by having the bedroom door open vs. closed.

1. Compare the number of days the child used a rescue inhaler in the last 14 days in sham vs. true filtration

Table 1.1: Descriptive statistics for the number of days the child used a rescue inhaler in the last 2 weeks during the sham and true filtration periods, stratified by study year, city, and season

			# days child used rescue inhaler in the last 2 weeks											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	2.5	4.28	0	0	4	83	2.2	3.76	0	0	3
		Spring	28	2.4	4.12	1	0	2	85	2.9	4.35	1	0	4
		Summer	32	1.4	3.94	0	0	0	76	2.6	4.05	1	0	3
		Fall	40	2.1	4.08	0	0	1.5	72	2.5	3.56	1	0	4
	Riverside	Winter	30	1.6	2.95	1	0	2	34	2.3	3.20	1	0	3
		Spring	10	0.3	0.67	0	0	0	50	2.3	4.18	0	0	2
		Summer	5	0.8	1.79	0	0	0	56	1.9	3.36	0	0	3
		Fall	24	2.0	3.75	0	0	1	36	1.3	2.12	0	0	2
Year 2	Fresno	Winter	74	1.9	3.16	0	0	3	22	2.1	4.22	0	0	2
		Spring	70	1.8	2.51	0	0	3	25	1.7	2.26	0	0	4
		Summer	60	2.4	3.99	0	0	3	37	1.4	2.81	0	0	2
		Fall	69	2.3	3.95	1	0	2	31	2.2	3.98	0	0	3
	Riverside	Winter	27	1.2	2.83	0	0	2	24	1.7	2.31	0.5	0	3
		Spring	44	2.2	3.84	0	0	3	8	1.4	2.07	0	0	3
		Summer	51	1.1	2.60	0	0	1	2	0.5	0.71	0.5	0	1
		Fall	35	1.0	1.72	0	0	1	20	1.8	3.42	0	0	2

Stratified by study year, city, and season, the median days the child used a rescue inhaler were similar during the sham and true filtration periods (Table 1.1).

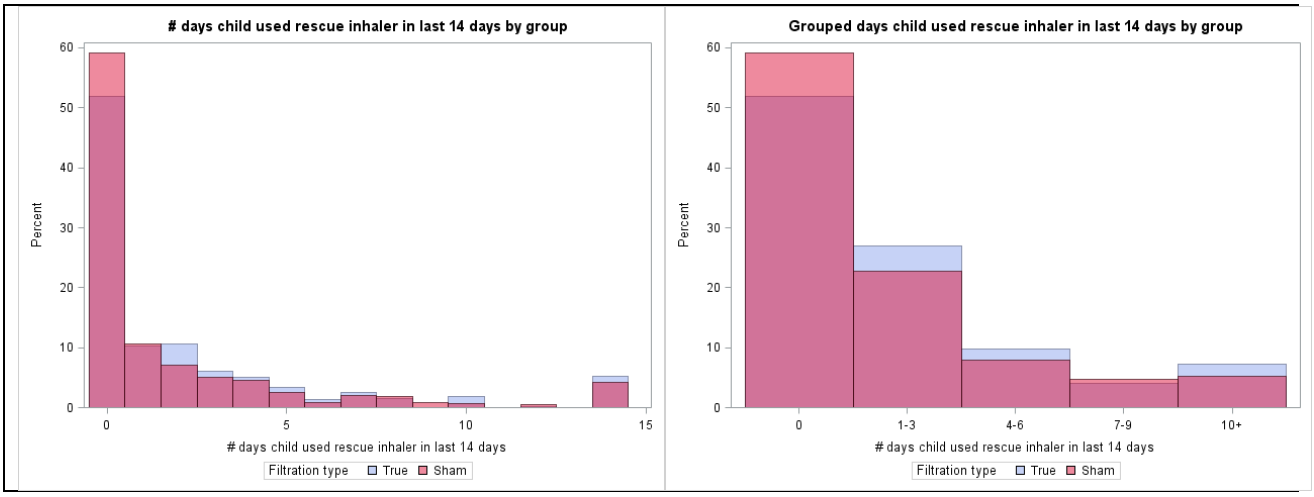


Figure 1.1: Distribution of days the child used a rescue inhaler in the last 2 weeks

The Poisson distribution seems appropriate, but the data do not exactly fit this distribution: (1) restricted to range 0 – 14 and (2) a bump in frequency of observations with 14 days of symptoms (Figure 1.1). A grouped ordinal variable was also created as an alternative.

Poisson Mixed-Effects Model: Is filtration status associated with the number of days the child used a rescue inhaler in the last 14 days?

Table 1.2: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of days the child used a rescue inhaler in the last 14 days and filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					-0.06691	0.2174	184	-0.31	0.7586
TRUE			SHAM		-0.06017	0.08966	1092	-0.67	0.5023
TRUE			TRUE		0	.	.	.	.
season		Fall			-0.1099	0.09934	1092	-1.11	0.2687
season		Summer			-0.1589	0.1092	1092	-1.45	0.146
season		Winter			-0.1048	0.09821	1092	-1.07	0.2863
season		Spring			0	.	.	.	.
area	Fresno				0.3176	0.2237	1092	1.42	0.1559
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.1024	0.1066	1092	0.96	0.3369
VisitYr1				Year 2	0	.	.	.	.

Table 1.3: Log arithmetic mean count of days the child used a rescue inhaler in last 2 weeks by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	-0.01048	0.1206	0.9896	0.1193
TRUE	0.0497	0.1202	1.051	0.1263

Table 1.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
TRUE	1	1090	0.52	0.4714
SEVERITY	2	1090	7.73	0.0005
TRUE*SEVERITY	2	1090	0.14	0.8717
season	3	1090	0.81	0.4862
area	1	1090	1.6	0.2062
VisitYr1	1	1090	0.76	0.3822

Table 1.5: Contrasts in log mean days the child used a rescue inhaler for each level of the interaction term in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.3005	0.2548	1090	1.18	0.2384
SHAM: sev vs mild	1.2644	0.3207	1090	3.94	<.0001
TRUE: mod vs mild	0.2174	0.2407	1090	0.90	0.3666
TRUE: sev vs mild	1.2372	0.3477	1090	3.56	0.0004
Mild: sham vs true	-0.1018	0.1501	1090	-0.68	0.4978
Mod: sham vs true	-0.01865	0.1115	1090	-0.17	0.8673
Sev: sham vs true	-0.07457	0.1537	1090	-0.49	0.6275

The number of days the child used a rescue inhaler did not differ by filtration status (p=0.50) (Table 1.2). Children used a rescue inhaler one time, on average, in the previous 2 weeks during true and sham filtration periods (Table 1.3). Overall, asthma severity did not modify the relationship between filtration status and using a rescue inhaler (p=0.87) (Table 1.4). Not surprisingly, the number of days the child used a rescue inhaler was significantly higher for children with severe asthma compared with mild asthma irrespective of filtration status (SHAM: β=1.26 [SE=0.32], p<0.0001; TRUE: 1.24 [0.35], p=0.0004) (Table 1.5).

2. Compare the number of missed school days due to asthma in the last 14 days in sham vs. true filtration

All analyses were restricted to observations during the school year. Excluded were observations that would have overlapped with school breaks.

Table 2.1: Descriptive statistics for the number of missed school days due to asthma in the last 2 weeks during the sham and true filtration periods, stratified by study year, city, and season

			# missed school days due to asthma in the last 2 weeks											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	22	0.4	0.85	0	0	0	75	0.4	1.10	0	0	0
		Spring	28	0.3	1.00	0	0	0	82	0.5	1.34	0	0	0
		Summer	7	0.3	0.76	0	0	0	24	0.5	1.50	0	0	0
		Fall	38	0.3	0.9.	0	0	0	72	0.3	0.71	0	0	0
	Riverside	Winter	29	0	0.19	0	0	0	29	0.3	0.80	0	0	0
		Spring	9	0	0.00	0	0	0	45	0.4	1.17	0	0	0
		Summer	1	0	.	0	0	0	33	0.1	0.38	0	0	0
		Fall	24	0.2	0.51	0	0	0	35	0.3	0.83	0	0	0
Year 2	Fresno	Winter	71	0.4	1.26	0	0	0	20	0.5	1.54	0	0	0
		Spring	69	0.2	0.66	0	0	0	25	0.2	0.72	0	0	0
		Summer	13	0.2	0.60	0	0	0	7	0	0	0	0	0
		Fall	69	0.2	0.53	0	0	0	31	0.2	0.72	0	0	0
	Riverside	Winter	25	0.2	0.52	0	0	0	21	0.1	0.36	0	0	0
		Spring	41	0.4	0.89	0	0	0	7	0	0	0	0	0
		Summer	28	0	0.19	0	0	0	2	0	0	0	0	0
		Fall	32	0.2	0.57	0	0	0	19	0.1	0.23	0	0	0

Stratified by study year, city, and season, the median missed school days due to asthma were similar during the sham and true filtration periods (Table 2.1).

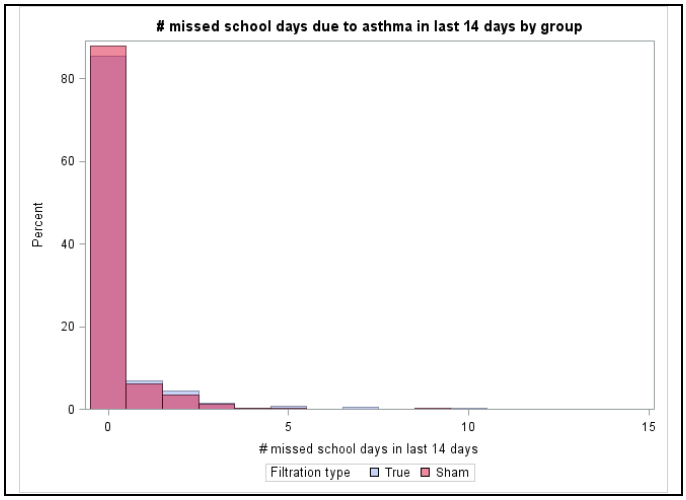


Figure 2.1: Distribution of missed school days due to asthma in the last 2 weeks

The Poisson distribution seems appropriate for these data.

Poisson Mixed-Effects Model: Is filtration status associated with the number of missed school days due to asthma in the last 14 days?

Table 2.2: Parameter estimates from the Poisson Mixed-Effects Model examining the association between the number of missed school days due to asthma in the last 14 days and filtration

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					-1.9967	0.3134	183	-6.37	<.0001
TRUE			SHAM		-0.1214	0.1597	843	-0.76	0.4476
TRUE			TRUE		0	.	.	.	.
season		Fall			-0.3804	0.2495	843	-1.52	0.1278
season		Summer			-0.8942	0.3815	843	-2.34	0.0193
season		Winter			-0.04742	0.2328	843	-0.2	0.8386
season		Spring			0	.	.	.	.
area	Fresno				0.4043	0.2919	843	1.38	0.1664
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.1326	0.1864	843	0.71	0.4769
VisitYr1				Year 2	0	.	.	.	.

Table 2.3: Log arithmetic mean count of missed school days due to asthma in last 2 weeks by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	-2.1801	0.1831	0.1130	0.02070
TRUE	-2.0588	0.1742	0.1276	0.02223

The number of missed school days due to asthma did not differ by filtration status (p=0.45) (Table 2.2). Children missed 0.1 school days, on average, in the previous 2 weeks during true and sham filtration periods (Table 2.3). Given the lack of association and low counts of missed days overall, asthma severity was not evaluated as a possible effect modifier.

3. Compare the number of hospital, ER, or clinic visits in the last 3 months in sham vs. true filtration

Table 3.1: Descriptive statistics for the number of hospital, ER, and clinic visits in the last 3 months during the sham and true filtration periods, stratified by study year, city, and season

			# hospital, ER, and clinic visits in the last 3 months											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	1.3	1.92	0	0	3	83	1	1.66	0	0	2
		Spring	28	1.6	3.57	0	0	1	85	1.3	1.77	1	0	2
		Summer	32	0.3	0.57	0	0	0	76	0.9	1.49	0	0	1
		Fall	40	1.1	2.07	0	0	1	72	0.9	1.26	0	0	1
	Riverside	Winter	30	0.7	1.2	0	0	1	34	1	1.68	0	0	2
		Spring	10	1	1.15	0.5	0	2	50	1.1	2.23	1	0	1
		Summer	5	0	0	0	0	0	56	0.8	2.31	0	0	1
		Fall	24	0.8	2.18	0	0	0.5	36	0.9	1.97	0	0	1
Year 2	Fresno	Winter	74	0.5	0.83	0	0	1	22	0.9	1.75	0	0	1
		Spring	70	0.7	1.27	0	0	1	25	0.6	1	0	0	1
		Summer	60	0.5	1.08	0	0	1	37	0.2	0.53	0	0	0
		Fall	69	0.4	0.85	0	0	1	31	0.5	1.39	0	0	1
	Riverside	Winter	27	0.9	1.29	0	0	2	24	0.3	0.55	0	0	0.5
		Spring	44	1.2	2.5	0	0	1	8	0	0	0	0	0
		Summer	51	0.6	1.53	0	0	1	2	0.5	0.71	0.5	0	1
		Fall	35	0.3	0.62	0	0	0	20	0.1	0.31	0	0	0

Stratified by study year, city, and season, the median hospital, ER, and clinic visits in the last 3 months were similar during the sham and true filtration periods (Table 3.1).

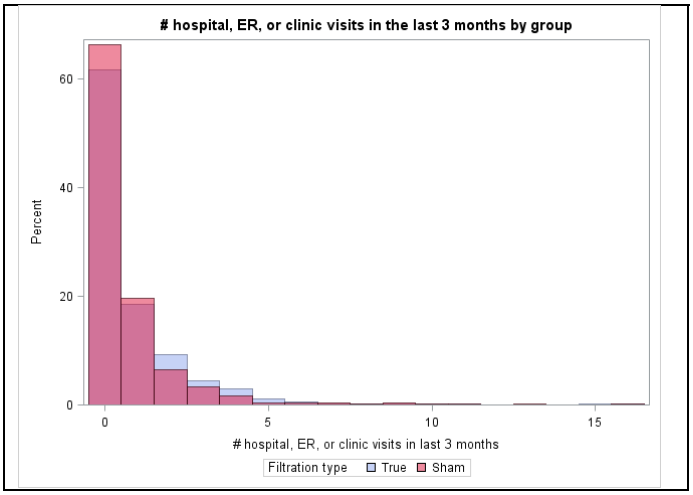


Figure 3.1: Distribution of hospital, ER, and clinic visits in the last 3 months

The Poisson distribution seems appropriate for these data.

Poisson Mixed-Effects Model: Is filtration status associated with the number of hospital, ER, and clinic visits in the last 3 months?

Table 3.2: Parameter estimates for Poisson mixed-effects model examining the number of hospital, ER, and clinic visits in the last 3 months by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					-0.9895	0.1861	184	-5.32	<.0001	-1.3566	-0.6223
TRUE			SHAM		0.2108	0.1066	1092	1.98	0.0481	0.001739	0.4199
TRUE			TRUE		0	.	.	.	.	.	.
season		Fall			-0.4313	0.1329	1092	-3.25	0.0012	-0.692	-0.1705
season		Summer			-0.5056	0.1215	1092	-4.16	<.0001	-0.744	-0.2672
season		Winter			-0.2388	0.1113	1092	-2.14	0.0322	-0.4572	-0.02029
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.1625	0.1799	1092	0.9	0.3665	-0.1904	0.5154
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	0.6639	0.1081	1092	6.14	<.0001	0.4518	0.8759
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 3.3: Log arithmetic mean visits to the hospital, ER, and clinic in the last 3 months by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
SHAM	-0.6594	-0.8685	-0.4503	0.5172	0.4196	0.6375
TRUE	-0.8702	-1.0772	-0.6632	0.4189	0.3406	0.5152

Table 3.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
TRUE	1	1090	4.76	0.0294
Severity	2	1090	10.88	<.0001
true*Severity	2	1090	1.82	0.1621
season	3	1090	8.41	<.0001
area	1	1090	0.57	0.4496
VisitYr1	1	1090	33.03	<.0001

Table 3.5: Contrasts in log mean visits to the hospital, ER, and clinic in the last 3 months for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Mild: Sham vs True	0.1959	0.1428	1090	1.37	0.1703	-0.08428	0.4762
Moderate: Sham vs True	-0.01114	0.1556	1090	-0.07	0.9429	-0.3165	0.2942
Severe: Sham vs True	0.5456	0.2524	1090	2.16	0.0309	0.0503	1.0409
Severe vs Mild diff in Sham vs True diffs	0.3496	0.2937	1090	1.19	0.2341	-0.2266	0.9259
Moderate vs Mild diff in Sham vs True diffs	-0.2071	0.1905	1090	-1.09	0.2773	-0.5809	0.1668

Table 3.6: Contrasts in log mean visits to the hospital, ER, and clinic in the last 3 months for each level of the filtration type x asthma severity interaction term in the Poisson mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.2230	0.2023	1090	1.10	0.2706
SHAM: sev vs mild	1.5353	0.2850	1090	5.39	<.0001
TRUE: mod vs mild	0.4301	0.1859	1090	2.31	0.0209
TRUE: sev vs mild	1.1857	0.3676	1090	3.23	0.0013

Children had more combined hospital, ER, and clinic visits during the sham period compared with the true filtration period (p=0.048) (Table 3.2). The geometric mean number of visits during the sham period was 0.52 [SE=0.06] versus 0.42 [0.04] during the true filtration period (Table 3.3). Overall, asthma severity did not modify the relationship between filtration status and hospital, ER, and clinic visits (p=0.16) (Table 3.4). Not surprisingly, the number of hospital, ER, and clinic visits (expressed as log counts) was significantly higher for children with severe asthma compared with mild asthma irrespective of filtration status (SHAM: β=1.54 [SE=0.29], p<0.0001; TRUE: 1.19 [0.37], p=0.001) (Table 3.6). During the true filtration period, children with moderate symptoms were also significantly more likely to visit the hospital, ER, or clinic compared with children who had mild asthma (0.43 [0.19], p=0.02). Among children with severe asthma, the number of hospital, ER, and clinic visits was significantly higher during the sham period (0.55 [0.25], p=0.03), data not shown.

4. Compare the number of hospital visits in the last 3 months in sham vs. true filtration

Table 4.1: Descriptive statistics for the number of hospital visits in the last 3 months during the sham and true filtration periods, stratified by study year, city, and season

			# hospital visits in the last 3 months											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	0	0.21	0	0	0	83	0	0.15	0	0	0
		Spring	28	0.1	0.57	0	0	0	85	0.1	0.43	0	0	0
		Summer	32	0	0	0	0	0	76	0.1	0.53	0	0	0
		Fall	40	0	0.16	0	0	0	72	0	0.12	0	0	0
	Riverside	Winter	30	0	0	0	0	0	34	0.1	0.69	0	0	0
		Spring	10	0	0	0	0	0	50	0	0.14	0	0	0
		Summer	5	0	0	0	0	0	56	0.1	0.94	0	0	0
		Fall	24	0	0	0	0	0	36	0.1	0.33	0	0	0
Year 2	Fresno	Winter	74	0	0	0	0	0	22	0	0	0	0	0
		Spring	70	0	0.12	0	0	0	25	0	0	0	0	0
		Summer	60	0	0	0	0	0	37	0	0	0	0	0
		Fall	69	0	0.12	0	0	0	31	0	0.18	0	0	0
	Riverside	Winter	27	0.1	0.38	0	0	0	24	0	0	0	0	0
		Spring	44	0	0.15	0	0	0	8	0	0	0	0	0
		Summer	51	0	0.28	0	0	0	2	0	0	0	0	0
		Fall	35	0.1	0.34	0	0	0	20	0	0	0	0	0

Stratified by study year, city, and season, the median hospital visits in the last 3 months did not differ during the sham and true filtration periods (Table 4.1).

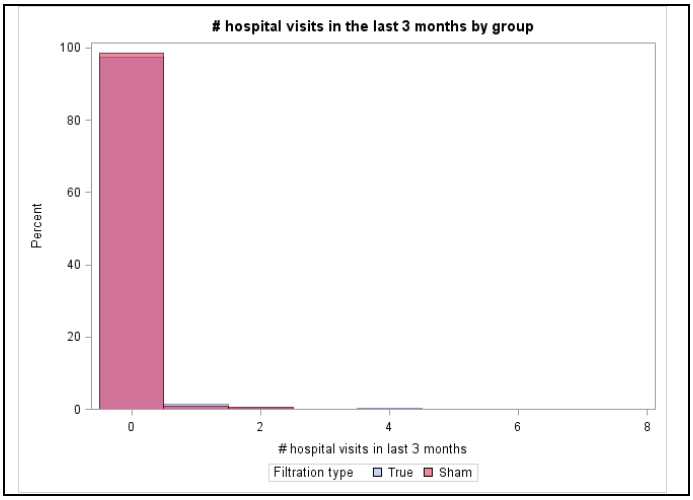


Figure 4.1: Distribution of hospital, ER, and clinic visits in the last 3 months

Table 4.2: Number of hospital visits in the last 3 months by filtration status

	SHAM		TRUE	
Hospital visits	**n**	**%**	**n**	**%**
0	613	98.55	644	97.43
1	5	0.8	10	1.51
2	3	0.48	3	0.45
3	1	0.16	1	0.15
4	0	0	2	0.3
7	0	0	1	0.15

Given the low counts of hospital visits (range 0 – 7), the Poisson distribution does not seem appropriate for these data (Figure 4.1). Hence, these data were dichotomized as any vs. no hospital visits but could not be modeled due to sparseness. Less than 3% of children had any hospital visits (2.6% during true filtration and 1.5% during sham) (Table 4.2).

5. Compare the number of ER visits in the last 3 months in sham vs. true filtration

Table 5.1: Descriptive statistics for the number of ER visits in the last 3 months during the sham and true filtration periods, stratified by study year, city, and season

			# ER visits in the last 3 months											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	0.3	0.54	0	0	0	83	0.1	0.47	0	0	0
		Spring	28	0.1	0.57	0	0	0	85	0.2	0.45	0	0	0
		Summer	31	0	0	0	0	0	76	0.2	0.51	0	0	0
		Fall	40	0.2	0.69	0	0	0	72	0.1	0.26	0	0	0
	Riverside	Winter	30	0.1	0.57	0	0	0	34	0.1	0.29	0	0	0
		Spring	10	0.1	0.32	0	0	0	50	0.1	0.42	0	0	0
		Summer	5	0	0	0	0	0	56	0.1	0.47	0	0	0
		Fall	24	0.1	0.34	0	0	0	36	0.1	0.37	0	0	0
Year 2	Fresno	Winter	74	0.1	0.41	0	0	0	22	0.1	0.29	0	0	0
		Spring	70	0.1	0.55	0	0	0	25	0.2	0.47	0	0	0
		Summer	60	0.1	0.39	0	0	0	37	0	0	0	0	0
		Fall	69	0	0.12	0	0	0	31	0.1	0.36	0	0	0
	Riverside	Winter	27	0.1	0.46	0	0	0	24	0.1	0.28	0	0	0
		Spring	44	0.2	0.66	0	0	0	8	0	0	0	0	0
		Summer	51	0.2	0.76	0	0	0	2	0	0	0	0	0
		Fall	35	0.1	0.28	0	0	0	19	0	0	0	0	0

Stratified by study year, city, and season, the median ER visits in the last 3 months were similar during the sham and true filtration periods (Table 5.1).

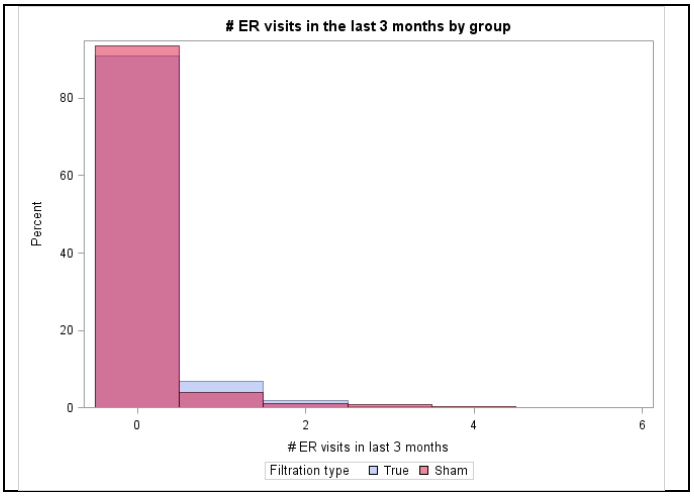


Figure 5.1: Distribution of ER visits in the last 3 months

Given the low counts of ER visits (range 0 – 5), the Poisson distribution does not seem appropriate for these data (Figure 5.1). Hence, these data were dichotomized as any vs. no ER visits. Less than 9% of children had any ER visits (8.9% during true filtration and 6.4% during sham) (Table 5.2).

Table 5.2: Number of ER visits in the last 3 months by filtration status

	SHAM		TRUE	
ER visits	n	%	n	%
0	581	93.56	601	91.06
1	25	4.03	45	6.82
2	7	1.13	12	1.82
3	5	0.81	2	0.3
4	2	0.32	0	0
5	1	0.16	0	0

Binomial Mixed-Effects Model: Is filtration status associated with any ER visits in the last 3 months?

Table 5.3: Parameter estimates for Binomial mixed-effects model examining associations between any ER visits in the last 3 months and filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					-3.0016	0.4101	183	-7.32	<.0001
TRUE			SHAM		0.000769	0.2566	1091	0	0.9976
TRUE			TRUE		0	.	.	.	.
season		Fall			-0.6095	0.3392	1091	-1.8	0.0727
season		Summer			-0.6073	0.2817	1091	-2.16	0.0313
season		Winter			-0.03988	0.2567	1091	-0.16	0.8766
season		Spring			0	.	.	.	.
area	Fresno				0.0562	0.3374	1091	0.17	0.8677
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.7442	0.2833	1091	2.63	0.0087
VisitYr1				Year 2	0	.	.	.	.

Table 5.4: Type III tests of fixed effect for Binomial mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1089	0.01	0.9094
Severity	2	1089	9.17	0.0001
true*Severity	2	1089	0.30	0.7390
season	3	1089	2.55	0.0545
area	1	1089	0.03	0.8555
VisitYr1	1	1089	6.42	0.0114

Table 5.5: Contrasts in log odds of any ER visits for each level of the interaction term in the Binomial mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.4649	0.4835	1089	0.96	0.3365
SHAM: sev vs mild	2.3132	0.6422	1089	3.60	0.0003
TRUE: mod vs mild	0.6200	0.4104	1089	1.51	0.1311
TRUE: sev vs mild	1.9464	0.5617	1089	3.47	0.0006
Mild: sham vs true	-0.03906	0.4212	1089	-0.09	0.9261
Mod: sham vs true	-0.1941	0.3981	1089	-0.49	0.6259
Sev: sham vs true	0.3277	0.5536	1089	0.59	0.5539

ER visits (any vs. none) did not differ by filtration status (p=1.00) (Table 5.3). Overall, asthma severity did not modify the relationship between filtration status and ER visits (p=0.74) (Table 5.4). Children with severe asthma were significantly more likely to have had any ER visits (expressed as log odds) irrespective of filtration status though the stratified data are sparse (SHAM: β=2.31 [SE=0.64], p=0.0003; TRUE: 1.95 [0.56], p=0.001) (Table 5.5).

6. Compare the number of clinic visits in the last 3 months in sham vs. true filtration

Table 6.1: Descriptive statistics for the number of clinic visits in the last 3 months during the sham and true filtration periods, stratified by study year, city, and season

			# clinic visits in the last 3 months											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	1	1.45	0	0	2	83	0.8	1.46	0	0	1
		Spring	28	1.4	2.77	0	0	1	85	1	1.49	0	0	1
		Summer	31	0.3	0.58	0	0	0	75	0.7	1.13	0	0	1
		Fall	40	0.8	1.48	0	0	1	72	0.8	1.14	0	0	1
	Riverside	Winter	30	0.6	0.77	0	0	1	34	0.8	1.17	0	0	1
		Spring	10	0.9	1.1	0.5	0	2	50	1	1.81	1	0	1
		Summer	5	0	0	0	0	0	56	0.5	1.33	0	0	1
		Fall	24	0.7	2.12	0	0	0	36	0.8	1.65	0	0	1
Year 2	Fresno	Winter	74	0.4	0.65	0	0	1	22	0.8	1.48	0	0	1
		Spring	70	0.6	0.94	0	0	1	25	0.4	0.65	0	0	1
		Summer	60	0.5	0.87	0	0	1	37	0.2	0.53	0	0	0
		Fall	69	0.4	0.81	0	0	1	31	0.5	0.96	0	0	1
	Riverside	Winter	27	0.6	1.15	0	0	1	24	0.2	0.41	0	0	0
		Spring	44	1	2.03	0	0	1	8	0	0	0	0	0
		Summer	51	0.4	1.2	0	0	0	2	0.5	0.71	0.5	0	1
		Fall	35	0.1	0.36	0	0	0	20	0.1	0.31	0	0	0

Stratified by study year, city, and season, the median clinic visits in the last 3 months were similar during the sham and true filtration periods (Table 6.1).

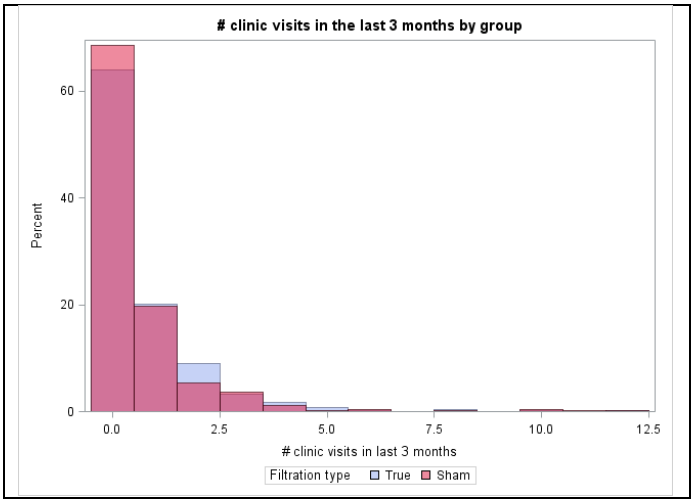


Figure 6.1: Distribution of clinic visits in the last 3 months

The Poisson distribution seem to be appropriate for these data (Figure 6.1).

Poisson Mixed-Effects Model: Is filtration status associated with the number of clinic visits in the last 3 months?

Table 6.2: Parameter estimates for Poisson mixed-effects model examining the number of clinic visits in the last 3 months by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					-1.1294	0.1856	183	-6.09	<.0001	-1.4955	-0.7632
TRUE			SHAM		0.2153	0.1041	1091	2.07	0.0389	0.01103	0.4195
TRUE			TRUE		0	.	.	.	.	.	.
season		Fall			-0.4021	0.1358	1091	-2.96	0.0031	-0.6685	-0.1357
season		Summer			-0.5981	0.1343	1091	-4.45	<.0001	-0.8616	-0.3346
season		Winter			-0.257	0.1326	1091	-1.94	0.0528	-0.5172	0.003167
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.16	0.1742	1091	0.92	0.3584	-0.1817	0.5018
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	0.6752	0.1127	1091	5.99	<.0001	0.4541	0.8963
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 6.3: Log arithmetic mean clinic visits in the last 3 months by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
SHAM	-0.8108	-1.0117	-0.6099	0.4445	0.3636	0.5434
TRUE	-1.0261	-1.2281	-0.8240	0.3584	0.2928	0.4387

Table 6.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1089	4.88	0.0274
Severity	2	1089	8.74	0.0002
true*Severity	2	1089	2.25	0.1063
season	3	1089	7.81	<.0001
area	1	1089	0.7	0.4043
VisitYr1	1	1089	31.05	<.0001

Table 6.5: Estimates for each level of the interaction term in the Poisson mixed-effect model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Mild: Sham vs True	0.2369	0.1354	1089	1.75	0.0804	-0.02873	0.5025
Moderate: Sham vs True	-0.03627	0.1423	1089	-0.25	0.7988	-0.3154	0.2429
Severe: Sham vs True	0.5694	0.2839	1089	2.01	0.0451	0.01237	1.1264
Severe vs Mild diff in Sham vs True diffs	0.3325	0.3157	1089	1.05	0.2925	-0.287	0.9519
Moderate vs Mild diff in Sham vs True diffs	-0.2732	0.1772	1089	-1.54	0.1234	-0.6208	0.07448

Table 6.6: Comparison of visits between severity groups in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.1413	0.1930	1089	0.73	0.4644
SHAM: sev vs mild	1.3583	0.2811	1089	4.83	<.0001
TRUE: mod vs mild	0.4144	0.1823	1089	2.27	0.0232
TRUE: sev vs mild	1.0258	0.3675	1089	2.79	0.0053

The number of clinic visits (expressed as log counts) was significantly higher during the sham period compared with the true filtration period (β=0.22 [SE=0.10], p=0.04) (Tables 6.2 and 6.3). Overall, asthma severity did not modify the relationship between filtration status and clinic visits (p=0.11) (Table 6.4). Perhaps not surprisingly, the number of clinic visits for asthma was significantly higher for children with severe compared with mild symptoms irrespective of filtration status (SHAM: 1.36 [0.28], p<0.0001; TRUE: 1.03 [0.37], p=0.01) (Table 6.6). Additionally, among children with severe asthma, the sham period was associated with more clinic visits than the true filtration period (0.57 [0.28], p=0.05), data not shown. For mild asthmatics, there were moderately more visits in sham than true (0.24 [0.13], p=0.08) , data not shown. During true filtration, children with moderate asthma symptoms were more likely to have clinic visits than those with mild asthma (0.41 [0.18], p=0.02) , data not shown.

7. Compare the number of times child received steroid treatment in the last 3 months in sham vs. true filtration

Table 7.1: Descriptive statistics for the number of times the child received a steroid treatment in the last 3 months during the sham and true filtration periods, stratified by study year, city, and season

			# steroid treatments in the last 3 months											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	23	0.7	1.07	0	0	1	83	0.4	1.32	0	0	0
		Spring	28	2.4	7.06	0	0	0.5	85	0.6	1.34	0	0	1
		Summer	32	2.9	16.08	0	0	0	76	0.6	3.29	0	0	0
		Fall	40	0.8	2.01	0	0	1	72	0.2	0.40	0	0	0
	Riverside	Winter	30	0.4	1.30	0	0	0	34	0.9	2.90	0	0	0
		Spring	10	0.4	0.70	0	0	1	50	2.2	12.69	0	0	1
		Summer	5	0	0.00	0	0	0	56	3.3	15.22	0	0	0
		Fall	24	0.3	1.09	0	0	0	36	0.4	2.01	0	0	0
Year 2	Fresno	Winter	74	0.2	0.50	0	0	0	22	0.3	0.63	0	0	0
		Spring	70	0.5	2.44	0	0	0	25	0.2	0.41	0	0	0
		Summer	60	0.1	0.33	0	0	0	37	0	0.00	0	0	0
		Fall	69	0.1	0.43	0	0	0	31	1.3	5.74	0	0	0
	Riverside	Winter	27	0.1	0.42	0	0	0	24	0	0.20	0	0	0
		Spring	44	2.3	13.55	0	0	0	8	0	0.00	0	0	0
		Summer	51	0.4	1.99	0	0	0	2	0	0.00	0	0	0
		Fall	35	0.4	2.37	0	0	0	20	0	0.00	0	0	0

Stratified by study year, city, and season, the median steroid treatments in the last 3 months were similar during the sham and true filtration periods (Table 7.1).

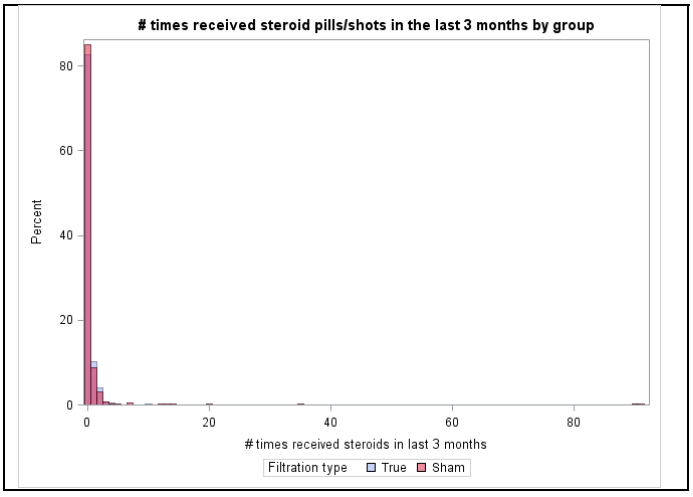


Figure 7.1: Distribution of steroid treatments in the last 3 months

The Poisson distribution seem to be appropriate for these data (Figure 7.1).

Poisson Mixed-Effects Model: Is filtration status associated with the number of steroid treatments received in the last 3 months?

Table 7.2: Parameter estimates for Poisson mixed-effects model examining the number of steroid treatments received in the last 3 months by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					-2.8100	1.0123	184	-2.78	0.0061
TRUE			SHAM		0.7537	0.7402	1092	1.02	0.3088
TRUE			TRUE		0	.	.	.	.
season		Fall			-1.1020	0.6989	1092	-1.58	0.1151
season		Summer			-0.01606	0.573	1092	-0.03	0.9776
season		Winter			-1.1772	0.6195	1092	-1.90	0.0576
season		Spring			0	.	.	.	.
area	Fresno				0.08307	0.3354	1092	0.25	0.8044
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	1.4723	0.7473	1092	1.97	0.0491
VisitYr1				Year 2	0	.	.	.	.

Table 7.3: Log arithmetic mean count of steroid treatments received in the last 3 months by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	-1.8524	0.2227	0.1569	0.03493
TRUE	-2.6061	0.6223	0.07382	0.04594

Table 7.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	1090	0.9	0.3436
Severity	2	1090	6.92	0.001
true*Severity	2	1090	0.06	0.9383
season	3	1090	1.72	0.1617
area	1	1090	0	0.9858
VisitYr1	1	1090	4.05	0.0445

Table 7.5: Contrasts in log mean number of steroid treatments for each level of the interaction term in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|	RR	95% CI	
SHAM: mod vs mild	0.7114	0.5435	1090	1.31	0.1908	2.0368	0.7012	5.917
SHAM: sev vs mild	1.7994	0.8844	1090	2.03	0.0421	6.046	1.0661	34.2873
TRUE: mod vs mild	0.8268	0.4944	1090	1.67	0.0948	2.286	0.8665	6.0309
TRUE: sev vs mild	2.1693	0.6308	1090	3.44	0.0006	8.7526	2.5384	30.1794
Mild: sham vs true	0.8907	1.0425	1090	0.85	0.3931	2.4368	0.3151	18.844
Mod: sham vs true	0.7753	0.5588	1090	1.39	0.1656	2.1712	0.7253	6.4993
Sev: sham vs true	0.5207	1.1383	1090	0.46	0.6474	1.6833	0.1804	15.7089

The number of times the child received steroid treatments (expressed as log counts) did not differ significantly by filtration status (β=0.75 [0.74], p=0.31) (Tables 7.2 and 7.3). Asthma severity did not modify the relationship between filtration status and steroid treatments (p=0.94) (Table 7.4). The number of steroid treatments received was significantly higher for children with severe compared with mild symptoms irrespective of filtration status, though the stratified data are sparse and should be interpreted with caution (SHAM: 1.80 [0.88], p=0.04; TRUE: 2.17 [0.63], p=0.001) (Table 7.5).

8. Compare Mini PAQL symptom scores in sham vs. true filtration

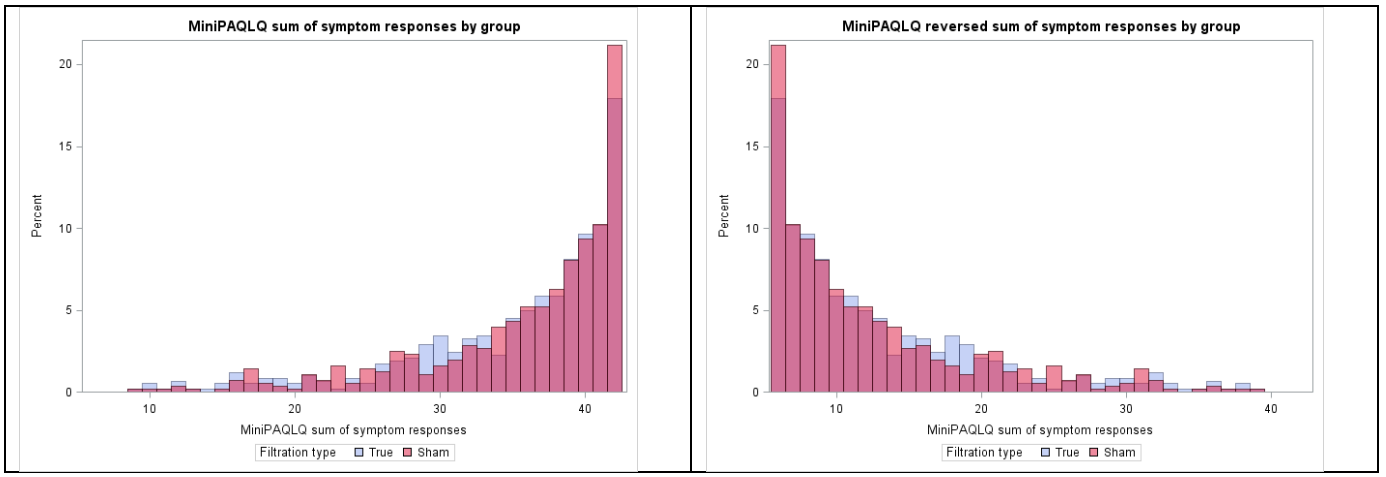


Figure 8.1: Distribution of Mini PAQL asthma symptom scores presented in the (A) original scale where higher scores indicate fewer asthma symptoms and (B) reversed scale where higher scores indicate more asthma symptoms

Figure 8.1 shows the distribution of Mini PAQL symptom scores on the original scale (A) and reversed scale (B). Higher scores indicate fewer symptoms on the original scale and the opposite is true for the reversed scores. The reversed scores are suitable for a Poisson distribution.

Table 8.1: Descriptive statistics for Mini PAQL asthma symptom scores (reversed) during the sham and true filtration periods, stratified by study year, city, and season

			MninPAQLQ symptom scores (reversed)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	22	12.8	7.43	9.5	8	14	75	14.7	7.94	12	9	19
		Spring	22	12	4.85	11.5	9	14	75	13.7	8.07	10	8	18
		Summer	29	11.4	6.78	9	7	13	65	12.9	6.95	11	8	16
		Fall	36	14.6	8.88	12.5	7	19.5	63	14.4	8.26	12	8	19
	Riverside	Winter	28	11.8	6.44	9.5	7	14.5	32	13.5	8.89	11	7	16
		Spring	10	10.6	6.75	7.5	7	13	47	11.8	5.95	11	7	13
		Summer	5	8	2.12	8	6	9	44	12.1	6.98	9	7	17.5
		Fall	21	11.7	6	10	8	13	31	12.1	5.88	10	8	15
Year 2	Fresno	Winter	69	12.3	7.52	9	7	15	18	12	6.62	11	7	15
		Spring	70	12.6	6.62	11	8	16	18	12.1	7.05	8.5	6	15
		Summer	52	11.1	5.85	9.5	6.5	13	36	10.4	5.25	8	6	12.5
		Fall	48	13.6	7.41	11	7	20.5	28	10.7	6.99	9	6.5	11.5
	Riverside	Winter	27	12.8	7.56	10	6	17	23	11	6.42	9	6	13
		Spring	40	13.6	8.83	10	7	18	8	11.6	4.53	9	8.5	16.5
		Summer	46	9.4	4.5	7	6	12	1	7	.	7	7	7
		Fall	32	11.2	5.74	9.5	7	13.5	17	8.7	4.81	6	6	9

Stratified by study year, city, and season, the median asthma symptom scores on Mini PAQL were similar during the sham and true filtration periods (Table 8.1).

Poisson Mixed-Effects Model: Is filtration status associated with Mini PAQL symptom scores (reversed)?

Table 8.2: Parameter estimates for Poisson mixed-effects model parameters examining Mini PAQL symptom scores (reversed) by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Intercept					2.3563	0.05923	179	39.78	<.0001	2.2394	2.4732
TRUE			SHAM		0.0425	0.02326	952	1.83	0.0681	-0.00316	0.08815
TRUE			TRUE		0	.	.	.	.	.	.
season		Fall			0.01086	0.03387	952	0.32	0.7486	-0.05561	0.07732
season		Summer			-0.1142	0.03696	952	-3.09	0.0021	-0.1868	-0.04172
season		Winter			0.01365	0.04402	952	0.31	0.7566	-0.07274	0.1
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.1128	0.06149	952	1.83	0.0669	-0.00788	0.2335
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	0.09388	0.02742	952	3.42	0.0006	0.04006	0.1477
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 8.3: Log arithmetic mean symptoms scores (reversed) on Mini PAQL by filtration type

Filtration type	Log GM	95% CI		GM	95% CI	
SHAM	2.4797	2.413	2.5464	11.9379	11.1674	12.7616
TRUE	2.4372	2.3747	2.4997	11.4412	10.7479	12.1793

Table 8.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	950	0.56	0.4525
Severity	2	950	4.38	0.0128
true*Severity	2	950	1.94	0.1443
season	3	950	6.21	0.0004
area	1	950	2.65	0.1038
VisitYr1	1	950	11.92	0.0006

Table 8.5: Contrasts in log mean MiniPAQL symptom scores for each level of the interaction term in the Poisson mixed-effect model

Contrast	Estimate	SE	DF	t Value	Pr > |t|	Lower	Upper
Mild: Sham vs True	0.03776	0.03734	950	1.01	0.3122	-0.03552	0.111
Moderate: Sham vs True	0.07592	0.0361	950	2.1	0.0357	0.005077	0.1468
Severe: Sham vs True	-0.05536	0.05669	950	-0.98	0.3291	-0.1666	0.05589
Severe vs Mild diffs in Sham vs True diffs	-0.09311	0.06626	950	-1.41	0.1603	-0.2231	0.03692
Moderate vs Mild diffs in Sham vs True diffs	0.03816	0.05356	950	0.71	0.4763	-0.06694	0.1433

Table 8.6: Contrasts in log mean MiniPAQL symptom scores for each level of the interaction term in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.1216	0.07254	950	1.68	0.0939
SHAM: sev vs mild	0.2444	0.1070	950	2.28	0.0226
TRUE: mod vs mild	0.08346	0.0618	950	1.35	0.1772
TRUE: sev vs mild	0.3375	0.1125	950	3.00	0.0028
Mild: sham vs true	0.03776	0.03734	950	1.01	0.3122
Mod: sham vs true	0.07592	0.0361	950	2.10	0.0357
Sev: sham vs true	-0.05536	0.05669	950	-0.98	0.3291

The Mini PAQL symptom scores were reversed for modeling purposes, with higher scores indicating more asthma symptoms. The Mini PAQL symptom scores (expressed as log counts) were marginally higher with sham than true filtration (β=0.04 [SE=0.02], p=0.07) (Tables 8.2 and 8.3). Asthma severity did not modify the relationship between filtration status and symptom scores (p=0.14) (Table 8.4). As expected, symptom scores were significantly higher, indicating more asthma symptoms, for children with severe compared with mild symptoms irrespective of filtration status (SHAM: 0.24 [0.11], p=0.02; TRUE: 0.34 [0.11], p=0.003) (Table 8.5). Among children with moderately severe asthma, the Mini PAQL symptom scores were higher during the sham period than the true filtration period (0.08 [0.04], p=0.04).

9. Compare Mini PAQL emotional function scores in sham vs. true filtration

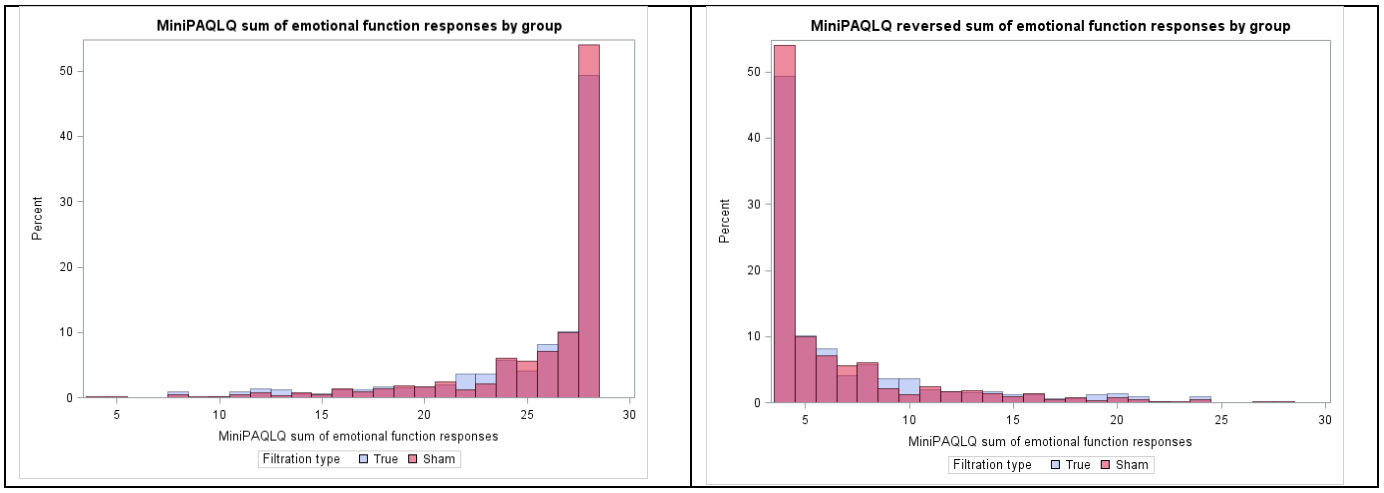


Figure 9.1: Distribution of Mini PAQL emotional function scores presented in the (A) original scale where higher scores indicate less emotional distress and (B) reversed scale where higher scores indicate more emotional distress

Figure 9.1 shows the distribution of Mini PAQL emotional function scores on the original scale (A) and reversed scale (B). Higher scores indicate less emotional distress on the original scale and the opposite is true for the reversed scores. The reversed scores are suitable for a Poisson distribution.

Table 9.1: Descriptive statistics for Mini PAQL emotional function scores (reversed) during the sham and true filtration periods, stratified by study year, city, and season

			MninPAQLQ emotional function scores (reversed)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	22	6.9	5.05	4	4	8	76	7.5	4.28	6	4	10
		Spring	22	7.7	5.18	6	4	8	76	7.4	5.20	5	4	8
		Summer	30	5.7	3.16	4	4	6	65	6.9	4.06	5	4	8
		Fall	36	7.8	5.92	5	4	9	65	8.4	5.28	6	4	11
	Riverside	Winter	29	7.2	3.80	5	4	10	32	6.8	4.25	5	4	8
		Spring	10	4.9	0.74	5	4	5	46	6.0	3.58	4.5	4	6
		Summer	5	4.0	0.00	4	4	4	45	6.3	4.29	4	4	6
		Fall	21	6.8	5.48	4	4	7	31	5.9	3.84	4	4	7
Year 2	Fresno	Winter	68	5.6	3.00	4	4	6	18	6.3	4.16	4	4	7
		Spring	70	6.2	3.63	4.5	4	7	17	7.5	5.27	4	4	12
		Summer	53	6.2	4.12	4	4	6	36	6.3	4.22	4	4	6.5
		Fall	49	8.0	5.04	6	4	11	28	5.5	3.19	4	4	5.5
	Riverside	Winter	27	5.9	3.40	4	4	6	24	5.5	2.84	4	4	5.5
		Spring	40	6.9	5.10	4	4	8	8	4.9	1.81	4	4	5
		Summer	46	5.0	2.12	4	4	5	1	4.0	.	4	4	4
		Fall	31	6.0	3.57	4	4	7	17	5.8	4.95	4	4	4

Stratified by study year, city, and season, the median emotional function scores on Mini PAQL were similar during the sham and true filtration periods (Table 9.1).

Poisson Mixed-Effects Model: Is filtration status associated with Mini PAQL emotional function scores (reversed)?

Table 9.2: Parameter estimates for Poisson mixed-effects model parameters examining Mini PAQL emotional function scores (reversed) by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.6922	0.06221	179	27.2	<.0001
TRUE			SHAM		0.01644	0.02799	958	0.59	0.5571
TRUE			TRUE		0	.	.	.	.
season		Fall			0.06259	0.04073	958	1.54	0.1247
season		Summer			-0.07904	0.0472	958	-1.67	0.0943
season		Winter			-0.0239	0.04466	958	-0.54	0.5927
season		Spring			0	.	.	.	.
area	Fresno				0.1516	0.0636	958	2.38	0.0173
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.1119	0.02818	958	3.97	<.0001
VisitYr1				Year 2	0	.	.	.	.

Table 9.3: Log arithmetic mean emotional function scores (reversed) on Mini PAQL by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	1.8303	0.0349	6.2360	0.2176
TRUE	1.8139	0.03428	6.1343	0.2103

Table 9.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	956	0.10	0.755
Severity	2	956	7.01	0.0009
true*Severity	2	956	0.71	0.4912
season	3	956	3.03	0.0288
area	1	956	5.58	0.0184
VisitYr1	1	956	14.77	0.0001

Table 9.5: Contrasts in log mean Mini PAQL emotional function scores (reversed) for each level of the interaction term in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.1001	0.06876	956	1.46	0.1456
SHAM: sev vs mild	0.4970	0.1357	956	3.66	0.0003
TRUE: mod vs mild	0.03105	0.06451	956	0.48	0.6304
TRUE: sev vs mild	0.4903	0.1452	956	3.38	0.0008
Mild: sham vs true	-0.01429	0.04391	956	-0.33	0.7449
Mod: sham vs true	0.05481	0.03985	956	1.38	0.1693
Sev: sham vs true	-0.00761	0.08455	956	-0.09	0.9283

The Mini PAQL emotional function scores were reversed for modeling purposes, with higher scores indicating more emotional distress. The Mini PAQL emotional function scores (expressed as log counts) did not differ significantly by filtration status (β=0.02 [SE=0.03], p=0.56) (Tables 9.2 and 9.3). Asthma severity did not modify the relationship between filtration status and emotional function scores (p=0.49) (Table 9.4). Children with severe asthma had emotional functions scores that were significantly higher, indicating more emotional distress, than children with mild symptoms irrespective of filtration status (SHAM: 0.50 [0.14], p=0.0003; TRUE: 0.49 [0.15], p=0.001) (Table 9.5).

10. Compare Mini PAQL activity limitation scores in sham vs. true filtration

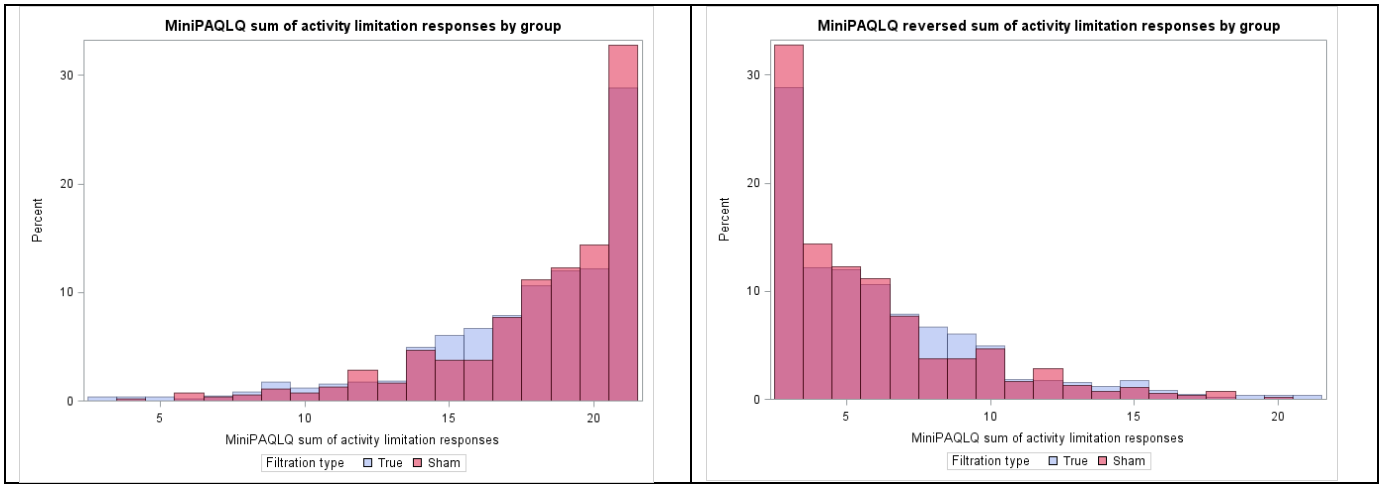


Figure 10.1: Distribution of Mini PAQL activity limitation scores presented in the (A) original scale where higher scores indicate fewer limitations and (B) reversed scale where higher scores indicate more activity limitations

Figure 10.1 shows the distribution of Mini PAQL activity limitation scores on the original scale (A) and reversed scale (B). Higher scores indicate fewer activity limitations on the original scale and the opposite is true for the reversed scores. The reversed scores are suitable for a Poisson distribution.

Table 10.1: Descriptive statistics for Mini PAQL activity limitations scores (reversed) during the sham and true filtration periods, stratified by study year, city, and season

			MninPAQLQ activity limitations scores (reversed)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	21	5.8	2.91	5	4	6	75	6.5	3.64	6	3	9
		Spring	22	6.3	2.85	6	4	8	77	6.4	3.56	5	4	8
		Summer	28	5.1	2.93	4	3	6	65	6.2	3.70	5	3	8
		Fall	35	7.1	4.28	6	4	10	64	7.2	3.35	7	5	9
	Riverside	Winter	29	5.9	2.53	5	4	8	31	6.4	3.57	5	3	8
		Spring	10	4.6	2.67	4	3	4	44	6.4	4.08	5	3	8
		Summer	5	4.6	1.34	4	4	6	44	6.3	3.48	5.5	3	8
		Fall	20	5.6	3.32	4	3	8	31	6.5	4.33	4	4	9
Year 2	Fresno	Winter	69	5.4	3.02	5	3	6	18	6.7	3.05	7	4	8
		Spring	68	5.5	2.92	5	3	7	18	6.2	3.66	5	3	9
		Summer	53	5.2	3.26	4	3	6	37	5.3	2.60	5	3	7
		Fall	50	6.1	3.15	5.5	3	9	28	5.3	2.61	4	3	6.5
	Riverside	Winter	27	6.4	3.33	6	3	8	24	5.0	3.29	4	3	5.5
		Spring	40	6.8	4.61	5.5	3	8	8	5.1	2.47	4.5	3	6.5
		Summer	46	5.1	2.78	4	3	6	1	3.0	.	3	3	3
		Fall	32	6.0	3.44	5	4	7	17	4.6	4.24	3	3	4

Stratified by study year, city, and season, the median activity limitation scores on Mini PAQL were similar during the sham and true filtration periods (Table 10.1).

Poisson Mixed-Effects Model: Is filtration status associated with Mini PAQL activity limitation scores (reversed)?

Table 10.2: Parameter estimates for Poisson mixed-effects model parameters examining Mini PAQL activity limitation scores (reversed) by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|
Intercept					1.6894	0.07232	179	23.36	<.0001
TRUE			SHAM		-0.00406	0.02667	951	-0.15	0.8790
TRUE			TRUE		0	.	.	.	.
season		Fall			0.0309	0.03734	951	0.83	0.4080
season		Summer			-0.08272	0.04136	951	-2.00	0.0458
season		Winter			-0.01414	0.04452	951	-0.32	0.7508
season		Spring			0	.	.	.	.
area	Fresno				0.05637	0.06276	951	0.90	0.3693
area	Riverside				0	.	.	.	.
VisitYr1				Year 1	0.09704	0.02834	951	3.42	0.0006
VisitYr1				Year 2	0	.	.	.	.

Table 10.3: Log arithmetic mean activity limitation scores (reversed) on Mini PAQL by filtration status

Filtration status	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	1.7456	0.03253	5.7291	0.1863
TRUE	1.7496	0.03587	5.7524	0.2063

Table 10.4: Type III tests of fixed effect for Poisson mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	949	0.18	0.6711
Severity	2	949	6.25	0.0020
true*Severity	2	949	0.47	0.6229
season	3	949	3.71	0.0114
area	1	949	0.57	0.4519
VisitYr1	1	949	11.74	0.0006

Table 10.5: Contrasts in log mean activity limitation scores (reversed) on Mini PAQL for each level of the interaction term in the Poisson mixed-effect model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	0.05643	0.06488	949	0.87	0.3847
SHAM: sev vs mild	0.3468	0.1167	949	2.97	0.0030
TRUE: mod vs mild	0.09884	0.0636	949	1.55	0.1205
TRUE: sev vs mild	0.4067	0.1143	949	3.56	0.0004
Mild: sham vs true	0.01975	0.03642	949	0.54	0.5877
Mod: sham vs true	-0.02266	0.03921	949	-0.58	0.5636
Sev: sham vs true	-0.04013	0.07896	949	-0.51	0.6114

The Mini PAQL activity limitation scores were reversed for modeling purposes, with higher scores indicating greater activity limitations. The Mini PAQL activity limitation scores did not differ significantly by filtration status (β=-0.01 [SE=0.03], p=0.88) (Tables 10.2 and 10.3). Asthma severity did not modify the relationship between filtration status and activity limitation scores (p=0.62) (Table 10.4). Activity limitation scores were higher, indicating more limitations, for children with severe asthma than children with mild symptoms irrespective of filtration status (SHAM: 0.35 [0.12], p=0.003; TRUE: 0.41 [0.11], p=0.0004) (Table 10.5).

11. Compare exhaled NO in sham vs. true filtration

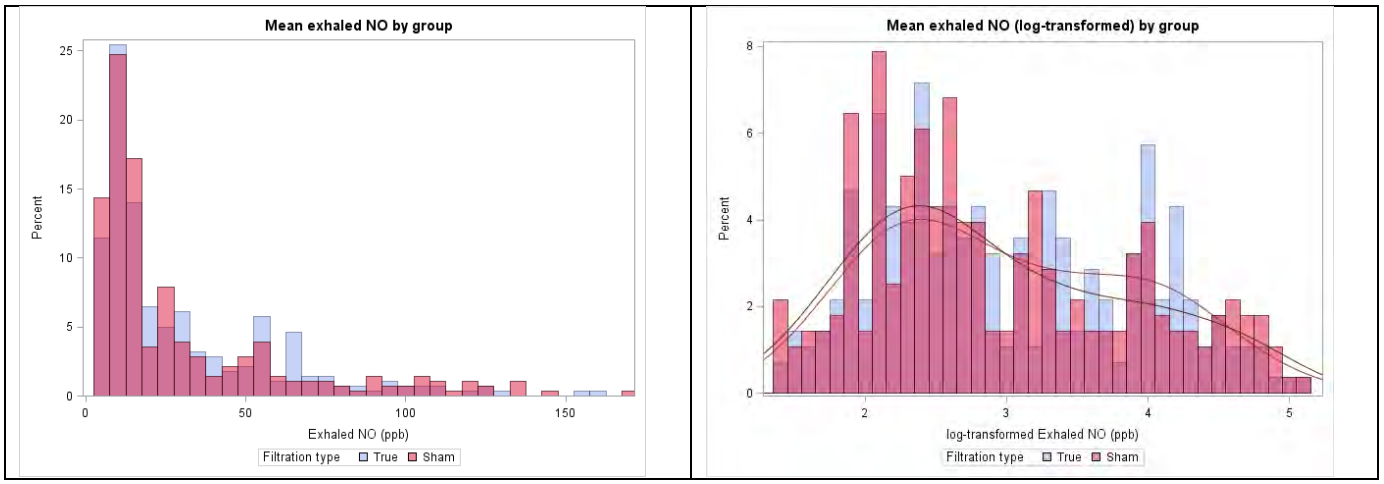


Figure 11.1: Distribution of exhaled nitric oxide (NO) measurements (ppb) presented on the (A) original scale and (B) natural log-transformed scale

Figure 11.1 shows the distribution of exhaled nitric oxide (NO) measurements (ppb) on the original scale (A) and natural log-transformed scale (B). Lower values indicate better health. These data are suitable for a log-normal distribution.

Table 11.1: Descriptive statistics for exhaled nitric oxide (NO) measurements (log-transformed from ppb) during the sham and true filtration periods, stratified by study year, city, and season

			Exhaled NO (ppb) (log-transformed)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	15	3.0	0.93	3.2	2.4	3.5	32	2.9	0.93	2.7	2.1	3.6
		Spring	5	3.4	1.11	3.5	2.6	3.9	36	2.8	0.93	2.8	2	3.4
		Summer	14	2.8	0.73	2.6	2.3	3	35	3.1	0.81	2.9	2.4	4
		Fall	20	2.9	0.88	2.6	2.3	3.3	27	2.9	0.81	2.6	2.2	3.4
	Riverside	Winter	17	2.9	0.67	2.7	2.5	3.4	8	3.3	0.57	3.3	2.8	3.7
		Spring	8	2.8	0.67	2.9	2.1	3.4	21	3.2	0.91	3.3	2.6	3.8
		Summer	.	.	.	.	.	.	22	3.3	0.80	3.1	2.6	4.1
		Fall	4	2.9	1.25	2.4	2.2	3.6	23	3.1	0.90	3.2	2.3	3.9
Year 2	Fresno	Winter	32	2.8	0.96	2.4	2.1	3.2	12	3.2	0.94	2.9	2.2	4.1
		Spring	35	2.8	0.97	2.4	2.1	3.7	8	3.3	1.07	3.5	2.4	4.1
		Summer	32	3.0	0.84	2.8	2.4	3.8	13	2.7	0.82	2.4	2.1	2.9
		Fall	22	2.6	0.94	2.2	1.9	3.3	17	2.6	1.07	2.1	1.8	3.3
	Riverside	Winter	7	3.2	1.18	3.3	1.9	3.9	16	3.1	0.87	3	2.4	4
		Spring	18	3.4	1.20	3.5	2.8	4.4	7	3.0	0.85	2.9	2.5	4
		Summer	24	3.0	0.81	2.9	2.4	3.6	.	.	.	.	.	.
		Fall	26	3.1	1.03	2.9	2.4	4.1	2	3.5	1.66	3.5	2.4	4.7

Stratified by study year, city, and season, the median exhaled NO measurements were similar during the sham and true filtration periods (Table 11.1).

Log-Normal Mixed-Effects Model: Is filtration status associated with exhaled NO?

Table 11.2: Parameter estimates for log-normal mixed-effects model examining whether exhaled NO concentrations (ppb) differ by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	95% CI	
Intercept					3.1456	0.1404	169	22.4	<.0001	2.8683	3.4228
TRUE			SHAM		-0.01165	0.04174	382	-0.28	0.7803	-0.09371	0.07041
TRUE			TRUE		0	.	.	.	.	.	.
season		Fall			-0.06879	0.05694	382	-1.21	0.2278	-0.1807	0.04316
season		Summer			0.02891	0.1332	382	0.22	0.8283	-0.2331	0.2909
season		Winter			-0.03642	0.1381	382	-0.26	0.7922	-0.308	0.2352
season		Spring			0	.	.	.	.	.	.
area	Fresno				-0.2417	0.1341	382	-1.8	0.0723	-0.5054	0.02202
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	0.009023	0.04192	382	0.22	0.8297	-0.07341	0.09145
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 11.3: Log Geometric Means (GM) of exhaled NO (ppb) by filtration status

Filtration status	Log GM	95% CI		GM	95% CI	
SHAM	2.999	2.862	3.136	20.055	17.488	23.000
TRUE	3.010	2.869	3.151	20.291	17.619	23.369

Table 11.4: Type III tests of fixed effects for Log-Normal mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	380	0.01	0.9214
Severity	2	380	2.91	0.0559
true*Severity	2	380	1.78	0.1703
season	3	380	1.11	0.3445
area	1	380	3.77	0.053
VisitYr1	1	380	0.01	0.9044

Table 11.5: Contrasts in log geometric mean exhaled NO (ppb) for each level of the TRUE x SEVERITY interaction term in the log-linear mixed-effects model

Contrast	Estimate	95% CI		DF	t Value	Pr > |t|
SHAM: mod vs mild	0.232	-0.051	0.514	380	1.61	0.1079
SHAM: sev vs mild	**0.663**	**0.100**	**1.226**	**380**	**2.31**	**0.0212**
TRUE: mod vs mild	0.092	-0.184	0.369	380	0.66	0.5108
TRUE: sev vs mild	**0.535**	**0.035**	**1.036**	**380**	**2.10**	**0.0361**
Mild: sham vs true	-0.083	-0.177	0.011	380	-1.74	0.0829
Mod: sham vs true	0.056	-0.076	0.188	380	0.83	0.4055
Sev: sham vs true	0.045	-0.251	0.340	380	0.30	0.7669

Exhaled NO measurements did not differ by filtration status (β=-0.01 [95% CI: -0.09, 0.07], p=0.78) (Tables 11.2 and 11.3). These results did not change when data were restricted to participants who did not smoke, drink, exercise, or eat within an hour of having these measurements (not shown). Asthma severity did not significantly modify the association between filtration status and exhaled NO (p=0.17) (Table 11.4). Mean exhaled NO measurements (log-transformed) were higher in children with severe asthma compared to children with mild symptoms irrespective of filtration status (SHAM: β=0.66 [0.10, 1.23], p=0.02; TRUE: 0.54 [0.04, 1.04], p=0.04) (Table 11.5).

12. Compare Forced vital capacity (FVC) in sham vs. true filtration

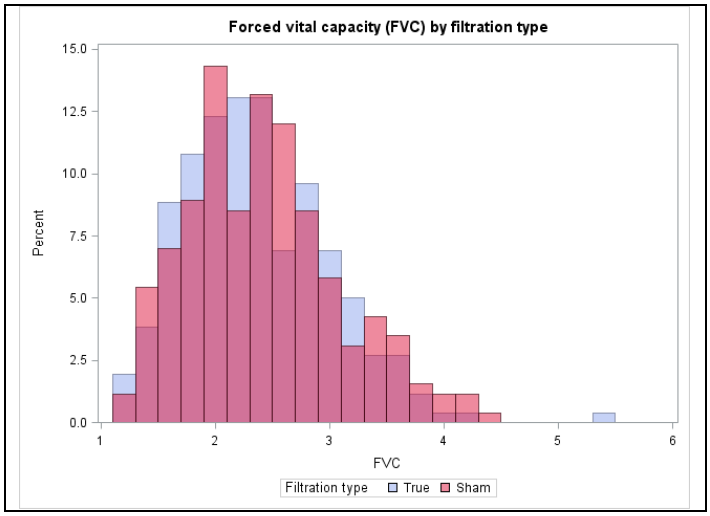


Figure 12.1: Distribution of forced vital capacity (FVC) measurements.

Figure 12.1 shows the distribution of forced vital capacity (FVC) by filtration status. Higher values indicate better health.

Table 12.1: Descriptive statistics for Forced Vital Capacity (FVC) during the sham and true filtration periods, stratified by study year, city, and season

			Forced Vital Capacity (FVC)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	15	2.4	0.52	2.5	1.9	2.7	30	2.2	0.56	2.1	1.9	2.5
		Spring	5	2	0.66	1.9	1.6	2	31	2.3	0.52	2.2	1.9	2.7
		Summer	12	2.2	0.7	2	1.7	2.6	35	2.5	0.52	2.5	2.2	2.9
		Fall	19	2.1	0.46	1.9	1.6	2.5	24	2.2	0.59	2.1	1.8	2.6
	Riverside	Winter	18	2.2	0.58	2	1.9	2.5	8	2.7	1.33	2.3	1.8	3.4
		Spring	10	2	0.44	1.9	1.5	2.3	20	2.2	0.56	2.3	1.7	2.5
		Summer	.	.	.	.	.	.	17	2.4	0.75	2.3	1.7	2.9
		Fall	4	2.7	0.54	2.5	2.3	3	22	2.3	0.59	2.2	1.7	2.5
Year 2	Fresno	Winter	33	2.4	0.68	2.3	1.8	2.8	12	2.9	0.57	2.9	2.5	3.3
		Spring	32	2.6	0.64	2.4	2.1	3	6	2.2	0.61	2	1.9	2.8
		Summer	23	2.5	0.71	2.4	2	3	15	2.3	0.79	2.1	1.8	2.5
		Fall	20	2.3	0.56	2.2	2	2.7	18	2.5	0.52	2.5	2	2.8
	Riverside	Winter	7	2.8	0.96	2.5	2	4	14	2.3	0.59	2.3	1.8	2.7
		Spring	19	2.7	0.78	2.5	2.3	3.4	6	2.5	0.57	2.4	2.2	2.7
		Summer	19	2.7	0.71	2.5	2.3	2.9	.	.	.	.	.	.
		Fall	22	2.5	0.63	2.5	1.9	2.9	2	3.4	0.27	3.4	3.2	3.6

Stratified by study year, city, and season, the mean FVC measurements were similar during the sham and true filtration periods (Table 12.1).

Table 12.2: Parameter estimates for linear mixed-effects model examining whether Forced Vital Capasity (FVC) differs by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	95% CI	
Intercept					2.6095	0.107	169	24.39	<.0001	2.3983	2.8207
true			Sham		-0.00153	0.0186	342	-0.08	0.9347	-0.03812	0.03507
true			True		0	.	.	.	.	.	.
season		Fall			-0.03969	0.02334	342	-1.7	0.09	-0.0856	0.006229
season		Summer			0.06942	0.1134	342	0.61	0.5409	-0.1536	0.2925
season		Winter			-0.01589	0.1128	342	-0.14	0.8881	-0.2378	0.2061
season		Spring			0	.	.	.	.	.	.
area	Fresno				-0.1196	0.1111	342	-1.08	0.2827	-0.3381	0.09897
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	-0.3191	0.02234	342	-14.29	<.0001	-0.3631	-0.2752
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 12.3: Arithmetic means of FVC by filtration type

Filtration type	Mean	95% CI	
SHAM	2.392	2.282	2.392
TRUE	2.394	2.282	2.505

Table 12.4: Type III tests of fixed effects for linear mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	340	0.05	0.8199
Severity	2	340	0.29	0.7485
true*Severity	2	340	0.32	0.7238
season	3	340	5.79	0.0007
area	1	340	1.32	0.252
VisitYr1	1	340	195.28	<.0001

Table 12.5: Contrasts in mean FVC for each level of the TRUE x SEVERITY interaction term in the linear mixed-effects model

Contrast	Estimate	95% CI		DF	t Value	Pr > |t|
SHAM: mod vs mild	0.09531	-0.1309	0.3215	340	0.83	0.4079
SHAM: sev vs mild	0.05695	-0.2549	0.3688	340	0.36	0.7197
TRUE: mod vs mild	0.06777	-0.1488	0.2843	340	0.62	0.5386
TRUE: sev vs mild	0.07297	-0.2705	0.4165	340	0.42	0.6763
Mild: sham vs true	-0.01225	-0.0632	0.03869	340	-0.47	0.6364
Mod: sham vs true	0.01529	-0.03749	0.06806	340	0.57	0.5692
Sev: sham vs true	-0.02828	-0.2378	0.1813	340	-0.27	0.7908

Forced vital capacity (FVC) measurements did not differ by filtration status (β=-0.002 [95% CI: -0.04, 0.04], p=0.93) (Tables 12.2 and 12.3). Asthma severity did not modify the association between filtration status and FVC (p=0.72) (Table 12.4). No differences in FVC were observed between sham and true filtration at any level of asthma severity (Table 11.5).

13. Compare Forced expiratory volume at 1.0 second (FEV1) in sham vs. true filtration

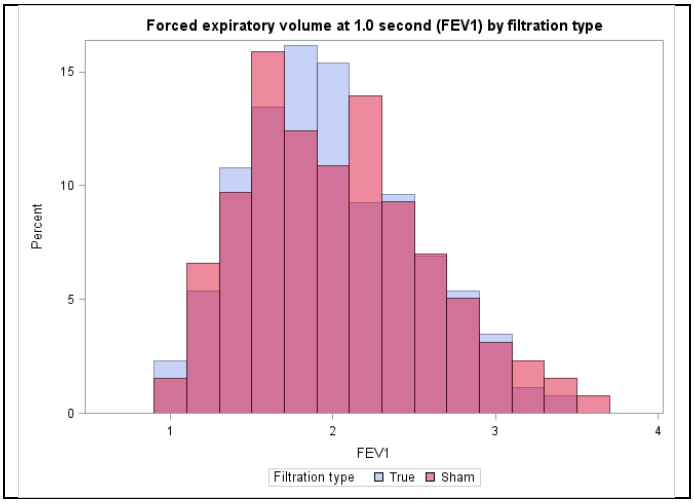


Figure 13.1: Distribution of forced expiratory volume at 1.0 second (FEV1) measurements.

Figure 13.1 shows the distribution of forced expiratory volume at 1.0 second (FEV1) measurements by filtration status. Higher values indicate better health.

Table 13.1: Descriptive statistics for Forced Expiratory Volume at 1.0 second (FEV1) during the sham and true filtration periods, stratified by study year, city, and season

			Forced Expiratory Volume at 1.0 sec (FVC)											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	15	1.9	0.46	2	1.4	2.4	30	1.9	0.48	1.8	1.5	2.2
		Spring	5	1.7	0.6	1.6	1.5	1.7	31	2	0.44	1.8	1.7	2.4
		Summer	12	1.9	0.54	1.8	1.5	2.3	35	2	0.51	2	1.7	2.5
		Fall	19	1.8	0.4	1.7	1.5	2	24	1.9	0.46	1.9	1.6	2.1
	Riverside	Winter	18	1.9	0.5	1.7	1.5	2.2	8	2.1	0.82	2.1	1.6	2.7
		Spring	10	1.6	0.39	1.5	1.3	1.8	20	1.9	0.51	1.9	1.6	2.2
		Summer	.	.	.	.	.	.	17	2	0.64	2	1.5	2.4
		Fall	4	2.3	0.4	2.2	2.1	2.6	22	1.9	0.49	1.8	1.4	2.3
Year 2	Fresno	Winter	33	2	0.64	1.9	1.5	2.4	12	2.3	0.51	2.3	1.8	2.8
		Spring	32	2.2	0.55	2.1	1.8	2.5	6	1.8	0.46	1.7	1.7	2.2
		Summer	23	2.1	0.61	2	1.5	2.6	15	2	0.65	1.9	1.6	2.1
		Fall	20	2	0.48	1.9	1.7	2.3	18	2.1	0.43	2	1.8	2.4
	Riverside	Winter	7	2.4	0.72	2.2	1.6	3.2	14	1.9	0.55	1.8	1.5	2.2
		Spring	19	2.2	0.62	2.2	1.8	2.6	6	2.1	0.57	1.9	1.7	2.5
		Summer	19	2.2	0.6	2.2	1.7	2.5	.	.	.	.	.	.
		Fall	22	2	0.51	2.2	1.7	2.4	2	2.8	0.15	2.8	2.7	2.9

Stratified by study year, city, and season, the mean FEV1 measurements were similar during the sham and true filtration periods (Table 13.1).

Table 13.2: Parameter estimates for linear mixed-effects model examining whether Forced Expiratory Volume at 1.0 second (FEV1) measurements differ by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	95% CI	
Intercept					2.1548	0.08694	169	24.78	<.0001	1.9832	2.3265
true			sham		-0.00944	0.02094	342	-0.45	0.6524	-0.05063	0.03175
true			true		0	.	.	.	.	.	.
season		Fall			-0.05238	0.02273	342	-2.3	0.0218	-0.09708	-0.00767
season		Summer			0.05167	0.08777	342	0.59	0.5564	-0.121	0.2243
season		Winter			-0.02493	0.08596	342	-0.29	0.7719	-0.194	0.1441
season		Spring			0	.	.	.	.	.	.
area	Fresno				-0.07837	0.08673	342	-0.9	0.3669	-0.249	0.09222
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	-0.2281	0.02311	342	-9.87	<.0001	-0.2735	-0.1826
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 13.3: Arithmetic means of FEV1 by filtration type

Filtration type	Mean	95% CI	
SHAM	1.986	1.899	2.073
TRUE	1.995	1.905	2.085

Table 13.4: Type III tests of fixed effects for linear mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	340	0.07	0.7937
Severity	2	340	2.34	0.0982
true*Severity	2	340	0.01	0.9868
season	3	340	6.32	0.0004
area	1	340	0.85	0.3580
VisitYr1	1	340	94.15	<.0001

Table 13.5: Contrasts in mean FEV1for each level of the TRUE x SEVERITY interaction term in the linear mixed-effects model

Contrast	Estimate	95% CI		DF	t Value	Pr > |t|
SHAM: mod vs mild	0.002927	-0.1744	0.1803	340	0.03	0.9741
SHAM: sev vs mild	**-0.2267**	**-0.4514**	**-0.00212**	**340**	**-1.99**	**0.0479**
TRUE: mod vs mild	0.008784	-0.1632	0.1808	340	0.1	0.9200
TRUE: sev vs mild	-0.2224	-0.487	0.04224	340	-1.65	0.0993
Mild: sham vs true	-0.00632	-0.05495	0.0423	340	-0.26	0.7983
Mod: sham vs true	-0.01218	-0.07382	0.04946	340	-0.39	0.6978
Sev: sham vs true	-0.01071	-0.2143	0.1929	340	-0.1	0.9177

Forced expiratory volume at 1.0 second (FEV1) measurements did not differ by filtration status (β=-0.01 [95% CI: -0.05, 0.03], p=0.65) (Tables 13.2 and 13.3). Asthma severity did not modify the association between filtration status and FEV1 (p=0.99) (Table 13.4). No differences in FEV1 were observed between sham and true filtration at any level of asthma severity (Table 11.5). During the sham period, children with severe asthma had significantly lower FEV1 measurements compared to children with mild asthma (-0.23 [-0.45, -0.002], p=0.048).

14. Compare FEV1/FCV in sham vs. true filtration

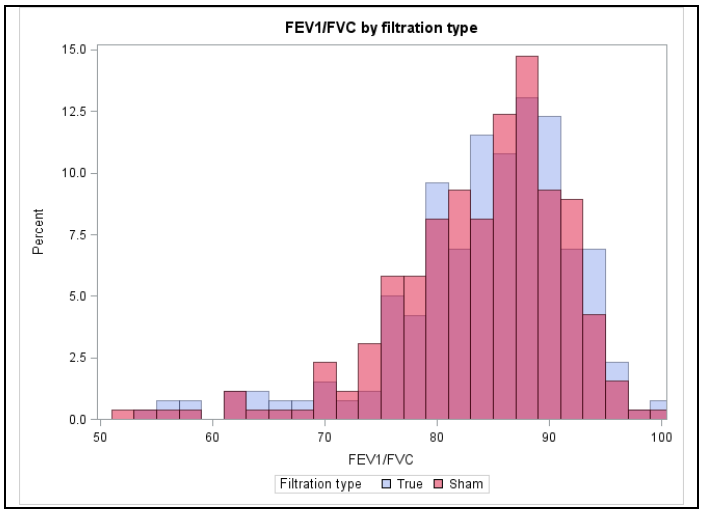


Figure 14.1: Distribution of FEV1/FVC % measurements.

Figure 14.1 shows the distribution of FEV1/FVC % by filtration status. Higher values indicate better health.

Table 14.1: Descriptive statistics for FEV1/FVC % during the sham and true filtration periods, stratified by study year, city, and season

			FEV1/FVC %											
			Filtration status											
			SHAM						TRUE					
Study year	City	Season	N	Mean	StdDev	Median	P25	P75	N	Mean	StdDev	Median	P25	P75
Year 1	Fresno	Winter	15	80.5	11.01	84.3	78.1	88.4	30	85.7	7.72	86.8	80.1	90.9
		Spring	5	86.7	5.54	87.5	87.3	89.2	31	86.8	5.57	86.9	84.5	91.5
		Summer	12	87.6	5	88.6	85.1	90.2	35	82	10.01	82.2	77.7	89.4
		Fall	19	85.5	6.46	87.7	82.1	89.2	24	85.8	6.74	87.7	82.5	90.3
	Riverside	Winter	18	84.1	6.16	86.4	81	87.1	8	82.9	10.73	81.9	76.4	92.9
		Spring	10	86.3	10.39	89.2	80.7	93.8	19	84.9	6.68	84.2	81.3	90.7
		Summer	.	.	.	.	.	.	17	84.8	8.92	86.2	80.5	92.6
		Fall	4	86.5	3.58	85.4	83.9	89.1	21	83.2	8.62	84.4	79.5	90.1
Year 2	Fresno	Winter	33	83.7	6.66	84.8	80.3	88.6	12	79.2	10.34	81.4	78.9	84.6
		Spring	32	85.2	7.18	87	81.9	89.1	6	84.2	3.95	84.3	80.5	88
		Summer	23	82.2	9.54	83.9	78.5	87.3	15	86.4	5.19	88.5	83.3	89.9
		Fall	20	84.3	6.32	84.5	81.6	88.3	18	84.4	5.8	86.5	85.1	87.1
	Riverside	Winter	7	86.4	6	85	81.2	92.3	14	80.8	9.05	81.7	76.2	87
		Spring	18	80.5	6.69	80.1	75.9	86.8	6	82.3	14.14	86	83.4	90.9
		Summer	19	83.5	7.78	83.7	79.4	90.6	.	.	.	.	.	.
		Fall	21	81.4	9.68	80.4	77.4	90.6	2	81.8	2.09	81.8	80.3	83.3

Stratified by study year, city, and season, the mean FEV1/FVC %'s were similar during the sham and true filtration periods (Table 14.1).

Linear Mixed-Effects Model: Is filtration status associated with FEV1/FVC %?

Table 14.2: Parameter estimates for linear mixed-effects model examining whether FEV1/FVC %'s differ by filtration type

Effect	City	Season	Filtration type	Study year	Estimate	SE	DF	t Value	Pr > |t|	95% CI	
Intercept					83.0867	1.3087	168	63.49	<.0001	80.5031	85.6704
true			sham		0.1229	0.3294	339	0.37	0.7093	-0.525	0.7707
true			true		0	.	.	.	.	.	.
season		Fall			-0.7982	0.4088	339	-1.95	0.0517	-1.6022	0.005817
season		Summer			-0.8635	1.2725	339	-0.68	0.4979	-3.3666	1.6396
season		Winter			-1.2729	1.2045	339	-1.06	0.2914	-3.642	1.0963
season		Spring			0	.	.	.	.	.	.
area	Fresno				0.708	1.2375	339	0.57	0.5676	-1.7261	3.1422
area	Riverside				0	.	.	.	.	.	.
VisitYr1				Year 1	1.8187	0.3546	339	5.13	<.0001	1.1213	2.5161
VisitYr1				Year 2	0	.	.	.	.	.	.

Table 14.3: Arithmetic Means of FEV1/FVC % by filtration type

Filtration type	Mean	95% CI	
SHAM	83.7394	82.5082	84.9706
TRUE	83.6165	82.3116	84.9214

Table 14.4: Type III tests of fixed effect for linear mixed-effects model with an interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	337	0.47	0.4949
Severity	2	337	9.34	0.0001
true*Severity	2	337	0.3	0.7396
season	3	337	1.78	0.1502
area	1	337	0.8	0.3731
VisitYr1	1	337	26.38	<.0001

Table 14.5: Estimates for each level of the interaction term in the linear mixed-effect model

	Estimate	95% CI		DF	t Value	Pr > |t|
SHAM: mod vs mild	-2.5232	-4.865	-0.1815	337	-2.12	0.0348
SHAM: sev vs mild	-10.6271	-16.4051	-4.8492	337	-3.62	0.0003
TRUE: mod vs mild	-2.2455	-4.5727	0.08174	337	-1.9	0.0586
TRUE: sev vs mild	-11.6441	-17.5347	-5.7535	337	-3.89	0.0001
Mild: sham vs true	0.1744	-0.6814	1.0302	337	0.4	0.6888
Mod: sham vs true	-0.1034	-1.0602	0.8535	337	-0.21	0.8319
Sev: sham vs true	1.1914	-2.1741	4.5569	337	0.7	0.4867

FEV1/FVC % did not differ by filtration status (β=0.12 [95% CI: -0.53, 0.77], p=0.71) (Tables 14.2 and 14.3). Asthma severity did not modify the association between filtration type and FEV1/FVC % (p=0.74) (Table 14.4). As expected, greater asthma severity was associated with lower FEV1/FVC

% irrespective of filtration type (Table 14.5). During the sham period, children with moderate and severe asthma had significantly lower FEV1/FVC % compared to children with mild asthma (moderate: -2.52 [-4.87, -0.18], p=0.03; severe: -10.63 [-16.41, -4.85], p=0.0003). Similarly, during true filtration, children with moderate and severe asthma had lower FEV1/FVC % compared to children with mild asthma (moderate: -2.25 [-4.57, 0.08], p=0.06; severe: -11.64 [-17.53, -5.75], p=0.0001).

15. Compare the number of clinic visits in the last 3 months in sham vs. true filtration only in study months 1-6 and 13-18 only, providing a balanced crossover design.

Study year covariate is not included in these models.

Table 15.1: Parameter estimates from Poisson Mixed-Effects Model examining the association between the number of clinic visits in the last 3 months by filtration status in a balanced crossover design (study months 1-6 and 13-18 only)

Effect	City	Season	Filtration status	Estimate	SE	DF	t Value	Pr > |t|
Intercept				-0.8025	0.2448	183	-3.28	0.0012
true			sham	-0.00798	0.1557	472	-0.05	0.9591
true			true	0	.	.	.	.
season		Fall		-0.219	0.2343	472	-0.93	0.3504
season		Summer		-0.3737	0.2326	472	-1.61	0.1088
season		Winter		-0.112	0.2262	472	-0.5	0.6207
season		Spring		0	.	.	.	.
area	Fresno			0.3155	0.2154	472	1.46	0.1436
area	Riverside			0	.	.	.	.

Table 15.2: Geometric mean number of clinic visits in the last 3 months by filtration status in a balanced crossover design

Visit	Log Mean	SE of Log Mean	Mean	SE of Mean
SHAM	-0.8289	0.12360	0.4365	1.13156
TRUE	-0.8210	0.13930	0.4400	1.14947

The number of clinic visits did not differ significantly by filtration status (p=0.96). The geometric means of the number of clinic visits during sham and true filtration periods were 0.44 [1.13] and 0.44 [1.15], respectively (Table 15.2).

Table 15.3: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × SEVERITY

Effect	Num DF	Den DF	F Value	Pr > F
true	1	470	0	0.9973
Severity	2	470	9.86	<.0001
true*Severity	2	470	0.44	0.6422
season	3	470	0.89	0.4464
area	1	470	2.64	0.1052

Table 15.4: Contrasts in log mean number of clinic visits in the last 3 months for each level of the TRUE × SEVERITY interaction term in the Poisson mixed-effects model

	Estimate	SE	DF	t Value	Pr > |t|
SHAM: mod vs mild	-0.00929	0.2453	470	-0.04	0.9698
SHAM: sev vs mild	1.3101	0.3333	470	3.93	<.0001
TRUE: mod vs mild	0.2778	0.2726	470	1.02	0.3087
TRUE: sev vs mild	1.3163	0.4427	470	2.97	0.0031
Mild: sham vs true	0.09713	0.2616	470	0.37	0.7106
Mod: sham vs true	-0.1899	0.2022	470	-0.94	0.3480
Sev: sham vs true	0.09095	0.4343	470	0.21	0.8342

Table 15.5: Log means of the number of clinic visits in the last 3 months for each level of the interaction term in the Poisson mixed-effects model

Filtration x SEVERITY		Log Mean	SE of Log Mean	Mean	SE of Mean
sham	moderate	-0.9818	0.18730	0.3746	1.20599
sham	severe	0.3376	0.29370	1.4016	1.34138
sham	mild	-0.9725	0.16790	0.3781	1.18282
true	moderate	-0.7918	0.17380	0.4530	1.18982
true	severe	0.2466	0.39050	1.2797	1.47772
true	mild	-1.0696	0.21430	0.3431	1.23899

The 2-way interaction term TRUE × SEVERITY (filtration status x asthma severity) was not statistically significant, indicating that asthma severity did not modify the association between the number of clinic visits and filtration status (p=0.64) (Table 15.3).

The number of clinic visits did not differ significantly by filtration status irrespective of asthma severity (Table 10.4). During the sham period, the number of clinic visits was significantly higher in children with severe asthma compared with children with mild asthma (β=1.31 [SE=0.33], p<0.0001); similarly, during the true filtration period, clinic visits were higher among children with severe asthma than mild asthma (1.32 [0.44], p=0.003).

The geometric means (GM) of days with asthma symptoms are presented in Table 10.5. During the sham period, the GMs of the number of clinic visits in children with mild, moderate, and severe asthma were 0.38 [1.18], 0.37 [1.21], and 1.40 [1.34], respectively. During the true filtration period, the GMs of the number of clinic visits in children with mild, moderate, and severe asthma were 0.34 [1.24], 0.45 [1.19], and 1.28 [1.48], respectively

16. Compare night waking due to asthma in sham vs. true filtration for air cleaner homes, modified by having the bedroom door open vs. closed.

Table 16.1: Number of days per week the child's bedroom door was kept open by filtration type, in households with air cleaners only

Filtration type	N	Mean	Std Dev	Median	Minimum	Maximum
Sham	425	3.976	3.265	6	0	7
True	462	3.965	3.250	6	0	7

In homes with air cleaners, the number of days per week the child's bedroom door was kept open was the same by filtration type, as expected (Mean=4.0, Median=6).

Table 16.2: Type III tests of fixed effect for Poisson mixed-effects model with interaction term TRUE × BEDROOM (households with air cleaners only)

Effect	Num DF	Den DF	F Value	Pr > F
true	1	739	5.14	0.0236
sd_dropen_n	1	739	0.25	0.6202
sd_dropen_n*true	1	739	4.72	0.0301
season	3	739	0.65	0.5848
area	1	739	0.07	0.7848
VisitYr1	1	739	6.88	0.0089

Table 16.3: Parameter estimates for Poisson mixed-effects model with filtration type x bedroom door interaction term (TRUE × BEDROOM), households with air cleaners only

Effect	City	Season	Filtration type	Visit	Estimate	Standard Error	t Value	Pr > |t|	Lower	Upper
Intercept					-1.0749	0.3488	125	-3.08	0.0025	-1.7651
true			sham		0.5597	0.2468	739	2.27	0.0236	0.07519
true			true		0	.	.	.	.	.
sd_dropen_n					0.0274	0.0418	739	0.66	0.5124	-0.05466
sd_dropen_n*true			sham		-0.0976	0.04492	739	-2.17	0.0301	-0.1858
sd_dropen_n*true			true		0	.	.	.	.	.
season		Fall			-0.2208	0.1968	739	-1.12	0.2622	-0.6072
season		Summer			-0.2166	0.2316	739	-0.94	0.3499	-0.6711
season		Winter			-0.2053	0.1809	739	-1.13	0.2569	-0.5604
season		Spring			0	.	.	.	.	.
area	Fresno				-0.07978	0.2921	739	-0.27	0.7848	-0.6532
area	Riverside				0	.	.	.	.	.
VisitYr1				Year 1	0.5264	0.2007	739	2.62	0.0089	0.1323
VisitYr1				Year 2	0	.	.	.	.	.

Table 16.4: Contrasts in log geometric mean days the child woke up due to asthma for each level of the filtration type x bedroom door interaction term in the Poisson mixed-effects model, households with air cleaners only

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	Lower	Upper
Door open 0 days per week: Sham vs True	0.5597	0.2468	739	2.27	0.0236	0.07519	1.0441
Door open 3 days per week: Sham vs True	0.2669	0.172	739	1.55	0.1213	-0.07089	0.6046
Door open 5 days per week: Sham vs True	0.07165	0.17	739	0.42	0.6736	-0.2622	0.4055
Door open 7 days per week: Sham vs True	-0.1236	0.2106	739	-0.59	0.5577	-0.5371	0.29
Diff in Mean diff: Door open 7 vs 0 days: Sham vs True	-0.6832	0.3145	739	-2.17	0.0301	-1.3006	-0.06585

In households with air cleaners, the number of days per week the child's bedroom door was kept open was the same by filtration type, as expected (Mean=4.0, Median=6) (Table 16.1).

*The 2-way interaction term TRUE × BEDROOM (filtration type x open/closed bedroom door) was **statistically significant**, indicating that the frequency of keeping the child's bedroom door open modified the association between days the child woke up due to asthma and filtration type (p=0.03) (Table 16.2). Specifically, the mean difference in the number of days the child woke up due to asthma (expressed as log counts) between sham and true filtration periods decreased by a factor of 0.0976 for each additional day per week that the bedroom door was kept open (Tables 16.2 and 16.3).*

For example, in homes that never kept the child's bedroom door open (0 days per week), the number of days the child woke up with asthma symptoms was, on average, 1.75 times higher during sham

compared with true filtration (β=0.56 [SE=0.25], p=0.02); and in homes where the bedroom door was left open 3 times per week, the number of days the child woke up at night was 1.31 times higher during sham (β=0.27 [SE=0.17], p=0.12). Meanwhile in homes that always kept the child's bedroom door open (7 days per week), the number of days the child woke up due to asthma was slightly lower during sham though not statistically significant (-0.12 [0.21], p=0.56). Furthermore, the difference in the mean differences for homes where the bedroom door was always open versus never was statistically significant (-0.68 [0.31], p=0.03), thus, demonstrating that the effect of filtration on the number of days the child woke up due to asthma depended on how often the child's bedroom door was kept open (Figure 16.4).

APPENDIX G: SOPS RELATED TO AIR QUALITY SAMPLING AND AIR CLEANERS

Contents ***Page***

STANDARD OPERATING PROCEDURE FOR CASCADE IMPACTOR (CI) CLEANING, ASSEMBLY, AND DISASSEMBLY

A. CLEANING OF SAMPLER HARDWARE

MATERIALS:

Ethanol, ACS reagent grade
Methanol, ACS reagent or pesticide grade
Dichloromethane (DCM), HPLC grade
Milli-Q water
Mild dish detergent (Dawn)
Kimwipes
Plastic trays
Beaker

A.1 FOR NEW SAMPLERS OR HEAVILY SOILED SAMPLERS

a) Wash hands thoroughly dry thoroughly before beginning cleaning protocol. Wear gloves.

b) Separate the filter holder part from the rest of the CI.

c) Remove the black O-ring from the filter housing part and the black O-ring from behind the support screen (keep these separate because the black one is greased and you don't want grease on the black support screen O-ring).

d) Wipe as much of the grease off the area where the black O-ring was on the housing.

e) Disassemble the filter holder part (top, bottom and screen).

f) Wash all parts with mild dish detergent (Dawn), rinse with Milli-Q water three times, and allow drying (covered with Kimwipes to protect from dust settling). An Ethanol rinse can be used to speed the drying procedure.

g) Place all the metal parts (not including screens) in a clean beaker.

h) Cover the parts with Milli-Q water and sonicate 5 minutes. Drain off the water using a watch glass to hold parts in the beaker.

i) Cover the parts with methanol and sonicate 5 minutes. Drain off the methanol using a watch glass to hold parts in the beaker. This needs to be done in a fume hood.

j) Cover the parts with DCM and sonicate 10 minutes. Drain off the DCM using a watch glass to hold parts in the beaker. This needs to be done in a fume hood.

k) Let the parts air dry on a Kimwipe.

l) Place screens into a beaker. Note that screens are cleaned separately from any other parts. One beaker can hold up to 15 screens at a time.

m) Clean the screens following the same procedures above, that is, sonicate in Milli-Q water for 5 minutes, in methanol for 5 minutes, and in DCM for 10 minutes, respectively. Let the parts air dry on a Kimwipe.

Important - DCM is very toxic and will go through nitrile gloves so if you get any of the solvent on your hands, remove the gloves immediately and put fresh gloves on. Always work with these solvents in a fume hood because the fumes are highly toxic. Just be very careful working with the solvents.

A.2 FOR ROUTINE CLEANING PRIOR TO ASSEMBLY FOR SAMPLING

The description of the cleaning is contained in this section so they can be viewed as a whole, however, the actual cleaning steps in A.2 occur as part of the loading process, as documented in section B.

a) Wash hands thoroughly and dry thoroughly before beginning cleaning protocol. Wear Nitrile gloves.

b) Use Kimwipes moistened with Milli-Q water to carefully wipe clean all surfaces of the sampler components. It is most important to clean the substrate holders and the backup filter holder. Also make sure that the slits in the impactor nozzles are cleaned well.

c) Use Kimwipes moistened with Ethanol to wipe the top of the screen and the part of filter holder that touches the filter ring. Wipe the top of the screen with a slightly water damp Kimwipe to remove any discoloration of screen.

A.3. CI GREASING

****USE GLOVED HANDS FOR GREASING****

MATERIALS:

Components (hardware) of 4 stage impactor
Kimwipes (large and small)
Silicone grease (Dow Corning High Vacuum Grease)

a) Wash hands thoroughly and dry thoroughly before beginning o-ring greasing and check. Put on gloves.

b) Apply a thin coating of silicone grease to the **nozzle O-rings** of the samplers marked as needing grease.

c) Check all bottom stage o-rings on all samplers to be loaded.

d) *Wash hands thoroughly after applying grease to o-rings and before any further assembly occurs.*

B. CI ASSEMBLY

***NOTE: AVOID BIG MOVEMENT, FOR EXAMPLE FURNITURE MOVING, IN THE LAB 1 HOUR BEFORE ASSEMBLING.

DURING ASSEMBLY, MINIMIZE EXPOSURE TIME OF FILTERS AND PUFS TO THE AIR TO REDUCE DEPOSITION. KEEP CIS COVERED OR IN A CONTAINER WHILE ASSEMBLING OTHERS***

****GLOVED HANDS ARE ALWAYS USED FOR ASSEMBLY****

MATERIALS:

Clean components (hardware) of 4 stage impactor
37-mm PTFE filters for Stage 4 (stored in labeled plastic Petri dishes)
Small PUF substrates for Stages 2 and 3 (stored in labeled plastic Petri dishes)- *PUF specifications in Appendix A*
Large PUF substrates for Stage 1
ID labels (for assembled impactors and field logs)
Drain discs (Whatman cat. no. 230800)
Magnetic Screw driver
Non-serrated stainless steel forceps (VWR cat no. 25718-088)
Deionized or distilled water in plastic spray bottle
Torque screwdriver (McMaster-Carr no. 8554A25; size 2 Phillips bit, McMaster no. 5750A14)
Kimwipes (large and small)
Quart size new resealable plastic bags
Plastic tray

a) Wash hands thoroughly and dry thoroughly before beginning assembly (loading). Put on gloves.

b) The assembled 4 stage cascade impactor is shown in Figure 1 below for reference:

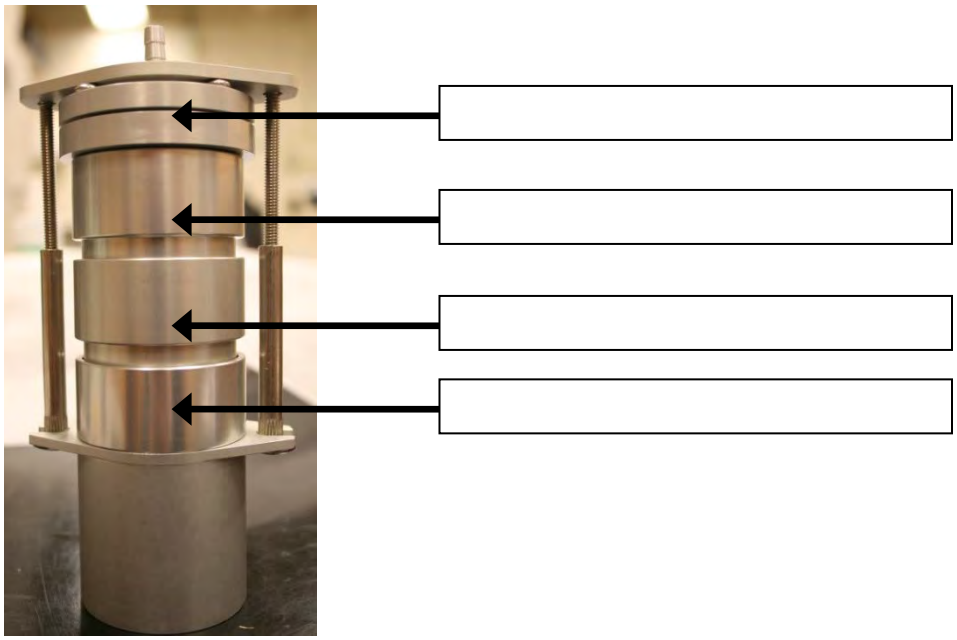


FIGURE 1. ASSEMBLED CASCADE IMPACTOR

c) Clean tray with milli-Q water and kimwipes. Make sure tray is completely dry. Then cover with kimwipes.

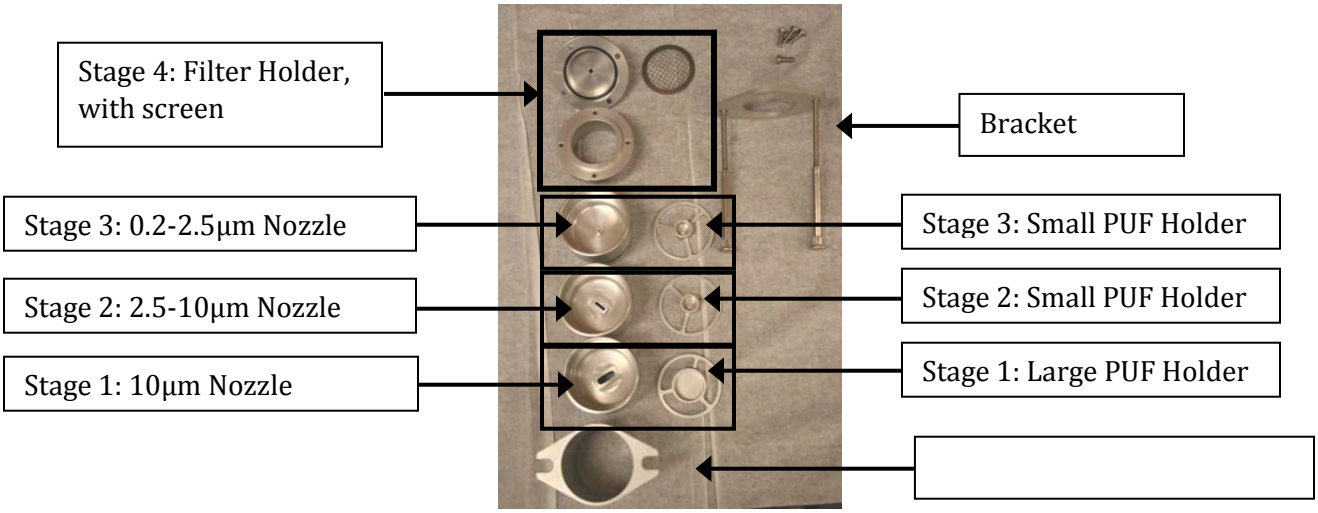
d) The impactor assembly (loading) is normally done on a clean tray covered with two large kimwipes. Care must be taken to minimize the contamination of the PUF substrates and filters from ambient dust during assembly (loading) of the impactor. ***Do not allow the PUF or filter to have contact with the work surface or any other surfaces.*** If a filter or Puf is dropped, do not use it. This is why each stage is cleaned and assembled one at a time.

e) All sampler components (hardware) are cleaned during assembly (see Section A1).

f) Clean 2 sets of forceps with a Kimwipe moistened with milli-Q water and lay on a Kimwipe to dry. Make sure the forceps are dry before using them.

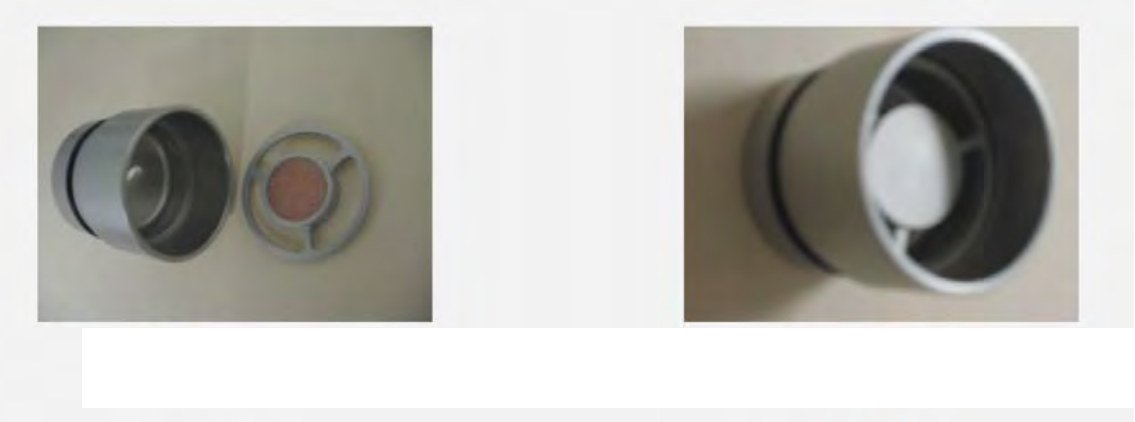
g) Stages 1 to 3 are in order of increasing nozzle size. All components are shown in Figure 2 below:

FIGURE 2. CASCADE IMPACTOR HARDWARE



STAGE 1: (10 µM IMPACTOR)

a) This nozzle (slit) size is the largest of all of the stages (Figs. 6a,b)
b) Clean all parts of stage 1, confirm they are dry before proceeding.
c) With forceps, place a LARGE (3/4") PUF substrate into the substrate holder.
d) Use the forceps to press the substrate down into the holder, spaced uniformly into the cylindrical cavity.
e) Place the substrate holder into the nozzle.
f) Place the loaded substrate holder into the barrel of stage 1 with the PUF substrate facing the nozzle (i.e. Puff down) (Fig. 6b).
g) There is no label for the large PUF, as it will be discarded after sampling.



STAGE 2: (2.5 µM IMPACTOR)

a) The nozzle (slit) size for stage 2 (the middle stage) is the next size smaller than stage 1 (the bottom one).
b) Clean all parts of stage 2, confirm they are dry before proceeding.
c) With forceps, place a SMALL (3/8") PUF substrate into the substrate holder.
d) Use the forceps to press the substrate down into the holder, spaced uniformly into the cylindrical cavity.
e) Place the loaded substrate holder into the barrel of stage 2 with the PUF substrate facing the nozzle (Puf side down). See Figure 4.
f) Place a label for the PUF on the outside of stage 2.
g) Place a label for the filter on the CI set-up field log as well as the CI lab log. Record the CI number (each CI has a number etched on the outside of the Stage 4 of the CI) on the CI set-up field log. Then, fill out the rest of assembly section of the CI lab log, including your initials, CI number, and assembly date. Do this for each filter and puf.
h) Slide the barrel of stage 2 into stage 1

Figure 4

STAGE 3: (0.2 µM IMPACTOR)

a) This stage, the top stage, has the smallest nozzle (slit) size.
b) Clean all parts of stage 3, confirm they are dry before proceeding.
c) With forceps, place a SMALL (3/8") PUF substrate into the substrate holder.
d) Use the forceps to press the substrate down into the holder, spaced uniformly into the cylindrical cavity.
e) Place the loaded substrate holder into the barrel of stage 3 with the PUF substrate facing the nozzle (facing down), Figure 4.
f) Place a label for the PUF on the outside of stage 3.
g) Slide the barrel of stage 3 into stage 2.

ASSEMBLE STAGE 4: THE BACKUP FILTER.

Note: Beginning in September 2014, the cleaning was conducted in the UC Davis laboratory, but the drain disk and filter were not inserted into the sampler. They were placed in a petri dish and placed in the bag with the sampler. This section was then repeated as needed to insert the filter in the field lab.

a) Remove the four screws in the filter holder (Fig. 3a).
b) Hold the filter holder.
c) The filter holder O-ring and clean stainless steel screen should be inside the bottom section of the filter holder. When first installing, make sure the O-ring is not nicked or cut from previous use and that there is no grease on this o-ring. Make sure the screen is not bent. Make sure the O-ring is seated properly in the base. Make sure the screen is seated properly on the O-ring.
d) Place a drain disc on top of the screen (done in field). A drain disk should always be placed between the filter and the stainless steel screen.
e) Place Teflon filter on the drain disk as shown in Figure 3b with the "ridge side" facing up (done in field).
f) Place drain disk in Petri dish with filter.
g) Seat the top and bottom sections together securely and screw together (Fig. 3c).
h) Tighten each screw a little at a time, to make sure that there is even tightness for all. Tighten across screws first.
i) Use the torque screwdriver to set tension more consistently. Adjust the torque setting to the maximum of 60 in-oz. Tighten each screw until it clicks (loosen the torque setting to the minimum for storage) (Done in field).
j) Place a label for the filter on the outside of Stage 4. Place loading date sticker on sampler.

FIGURE 3A. Fig.3a FIGURE 3B. Fig.3b FIGURE 3C. Fig.3c

a) Place a label with the loading date on the outside of the CI.
b) Place the impactor and CI set-up field log together in a re-sealable plastic bag for storage until deployed in the field. Put the Petri dish with the filter and drain disk in the bag. Put the long screws and plates in the bag.

C. DISASSEMBLY

MATERIALS

5 LPM samplers returned from the field (inside re-sealable plastic bags)
Labeled Petri dishes for PUF substrates and filters
Milli-Q water
Kimwipes
Non-serrated forceps
Paper label tape
Teflon tape
CI disassembly lab log
Philips screwdriver
Plastic trays

a) Make sure to wash hands thoroughly and dry thoroughly before disassembly. Put on Nitrile gloves.

b) CIs are transported from the field in re-sealable bags. Keep the CIs in their plastic bags until disassembly. The re-sealable bag of used CIs will have the take-down date and household ID written on them.

c) To prevent mislabeling of the PUF substrates and backup filters, process only one sampler at a time. Keep the substrates and the filters upright at all times when handling, such that the sampling side of the PUFs and filters don't touch a surface facing downward.

d) Clean tray with milli-Q water and kimwipes. Make sure tray is completely dry. Then cover with kimwipes.

e) Check O-ring for nicks or other damage while unloading. If there is damage, then replace with a new o-ring. Make sure all O-rings are properly installed in components. Note if the parts are difficult to separate, indicating that the parts need regreasing. Remember to note this on bag.

f) Clean two pairs of curved forceps with a Kimwipe moistened with Milli-Q water -- do this before handling **each** PUF substrate or filter. Make sure the forceps are dry before using them. Set screw driver out.

g) Locate the Petri dishes with the labels that match the filter and Puf labels that are on the outside of the used CI that is to be disassembled. Find the CI number (etched on the outside of the CI stage 4) and assembly date (from the label on the CI with "loading date") for the CI that is to be disassembled in the CI lab log. Confirm that the filter IDs on the CI and on the lab log match. If not, notify the project manager. Complete the remainder of the disassembly section of the CI lab log.

Make sure to mark if it was used as a "Blank". Record any additional notes from the bag into the lab log. "Duplicates" are not indicated in the lab log, only on the field logs.

h) Remove the sampler from the bag and set it out on a clean tray covered with large Kimwipes.

i) Start disassembly at the filter holder end of the sampler.

j) Unscrew top of filter holder (stage 4). Gently separate the top of filter holder from the base.

k) With the forceps, grasp the plastic outer ring on the filter and drain disk, and ***keeping the dirty side up,*** place it into the corresponding labeled Petri dish. Using two pairs of clean curved filters, gently separate the filter and drain disk. Place them back together and place in petri dish. Make notes in the comments section of the CI lab log for any unusual findings, such as filter dislodged, O-ring slippage, yellow-colored filters (indicates tobacco smoke-also inform lab manager), dropped filter, hole in filter, etc.

l) Re-install screws for filter holder. Remove filter holder.

m) Use large, straight forceps to remove the puf holder. Flip over and set on tray.

n) Remove the small PUF substrate using 2 clean curved forceps, and ***keeping it dirty side up***, place it in the corresponding labeled Petri dishes. Make notes in the comments section of the CI disassembly lab log for any unusual findings, such as filter dislodged, dropped filter, etc.

o) Repeat steps m and n until all stages have been unloaded.

p) Remove the large PUF and discard. The large (3/4" diameter) PUF substrate for the 10 µm stage is only used to remove particles larger than the cut point. There is no analysis of this substrate.

q) Tape all Petri dishes closed with Teflon tape. Place an "x" on the top of each petri dish to indicate media has been used. Put taped petri dishes in plastic box labeled with unloading date. Petri dishes should be stacked in groups of 10 by type of filter and bags should be placed inside plastic box.

r) Remove labels from sampler. Put dirty sampler back in plastic bag – label bag "dirty used sampler." If any stage needs regreasing, write "needs greese" on bag. Place in bin of dirty used samplers.

s) Proceed with unloading the next sampler, until all samplers have been unloaded.

D. STORAGE

a) Samplers should be stored in a climate controlled environment.

E. SHIPPING

a) Shipping of samples is done by priority overnight mail on either a Monday, Tuesday, or Wednesday. This is to prevent the samples from being warm over the weekend if the shipment is delayed.

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Reilly Foam Corporation

QUALITY FABRICATED FOAM PRODUCTS

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3696 WESTROADS DRIVE
W. PALM BEACH, FL 33407
(561) 842-8090
FAX (561) 845-3782

Polyurethane Foam Specification Sheet

Foam Grade:	4410 AS
TEST OR STANDARD[1]	SPECIFICATION
Density – PCF (pounds per cubic foot)	1.40 ± .05
IFD on 4" at 25 % deflection	37-45
Resilience - % minimum	40
Tensile Strength – PSI (lbs./in^2) minimum	
Elongation - % minimum	150
Tear Strength - lb./in., minimum	2.0
50% Compression Set - % maximum	10.0
Surface Resistivity[2] - OHM/SQ maximum	1.0×10^{11}
Static Dissipation[3] - Seconds	<2

[1] ASTM D-3574-91
[2] ASTM D-257
[3] Test Method 4046, Fed. Std. 101C Per Mil. B-81705B

Stock width = 54"

From web: density of polyurethane = 1.05
or about 65#/ft^3

$\frac{1.4}{65} = 0.022$

2.2%

STANDARD OPERATING PROCEDURE FOR PERSONAL ENVIRONMENTAL MONITORS (PEMS) CLEANING, ASSEMBLY, AND DISASSEMBLY

A1. PEM (1.8 AND 4.0 LPM) DEEP CLEANING (WHEN NEW AND WHEN OBVIOUSLY SOILED)

MATERIALS:

3 large beakers
Powder-free latex gloves
Distilled water
Milli-Q water
Ethanol – ACS Reagent Grade
Methanol, ACS reagent or pesticide grade
Dichloromethane (DCM), HPLC grade
Non-serrated forceps
Mild dish detergent (Dawn)
Large Kimwipes
O-ring tool
H-PEM O-rings
H-PEM tops
H-PEM bases
H-PEM impaction plates
Metal screens
4 to 5 plastic trays
Paper tape
Permanent marker
Brush
Sonication bath (VWR #97043-958)

A1.1 HARVARD PEM TOPS, BASES AND IMPACTOR PLATES:

**** WEAR POWDER-FREE LATEX GLOVES FOR CLEANING ****

a) Wash hands thoroughly dry thoroughly before beginning cleaning protocol. Put on gloves.

b) Fill beaker with Milli-Q water and add several drops of the mild dish detergent (Dawn).
c) Disassemble the PEM into bases, impactor plates (the collective term for both the substrate body and substrate support), and tops.

d) Wash all parts in the beaker with Dawn detergent and water, using a brush to ensure that the H-PEM inlets are clear. Make sure that brush used for washing parts is in good condition, with no metal support exposed that could scratch the part surfaces.

e) Rinse contents of beaker four times (or until water is free of soap) in clean Milli-Q water.

f) Allow drying (covered with Kimwipes to protect from dust settling). An Ethanol rinse can be used to speed the drying procedure.

g) Place all parts except the screens in a clean beaker and cover with Milli-Q water and sonicate 5 minutes. Drain off the water using a watch glass to hold parts in the beaker.

h) Cover the parts with methanol and sonicate 5 minutes. Drain off the methanol using a watch glass to hold parts in the beaker. This needs to be done in a fume hood.

i) Cover the parts with DCM and sonicate 10 minutes in the fume hood. Drain off the DCM using a watch glass to hold parts in the beaker.

j) Let the parts air dry on a Kimwipe.

k) Place screens into a beaker. Note that screens are cleaned separately from any other parts. One beaker can hold up to 15 screens at a time.

l) Clean the screens following the same procedures above, that is, sonicate in Milli-Q water for 5 minutes, in methanol for 5 minutes, and in DCM for 10 minutes, respectively. Let the parts air dry on a Kimwipe.

Important - DCM are very toxic and DCM will go through nitrile gloves so if you get any of the solvent on your hands, remove the gloves immediately and put fresh gloves on. Always work with these solvents in a fume hood because the fumes are highly toxic. Just be very careful working with the solvents.

A1.2 O-RINGS

a) To clean O-rings, use a kimwipe moistened with Milli-Q water to carefully wipe them clean, stretching them a little as you wipe. Allow O-rings to dry naturally.

A2. STANDARD CLEANING (DONE BETWEEN EACH USE DURING STUDY)

**** WEAR NITRILE GLOVES ******

A2.1 PEM BASES, TOPS, AND SUBSTRATE BODY:

a) Wash hands thoroughly and dry thoroughly before beginning cleaning protocol. Wear gloves.

b) Inspect samplers. If there is obvious soiling, follow deep cleaning protocol.

c) If no obvious soiling, wipe off bases, tops, and substrate bodies with a Kimwipe dampened with millie-Q water. The Kimwipe should only be damp enough to wipe the pieces without leaving drops of water on them, so there should be no time required to dry them.

d) Wipe surfaces that touch the filter with an ethanol dampened Kimwipe. Wipe the top of the screen with a slightly water damp Kimwipe to remove any discoloration of screen.

A2.2 SUBSTRATE SUPPORT (CLEANING AND REGREASING):

MATERIALS:

Harvard PEM
Small foam swab
Spatula
Silicone Grease (Dow Corning - High Vacuum Grease)

a) Using a small spatula, remove the grease that contains the deposited particles to an approximate 1/16" depth from the middle of the impaction surface, along with the collected particles. Remaining grease does not need to be removed. This prepares the impaction surface for re-greasing. If the grease appears dirty throughout, and it seems appropriate, remove all grease.
b) If grease touches any other surface, wipe with an ethanol dampened foam swab.
c) The impaction surface should be re-greased with Dow Corning – High Vacuum Grease, using a small spatula. The grease should be smoothed with a spatula so that it is evenly flat with the impactor surface. Make sure grease is very smooth. **Avoid getting grease on other parts of the unit.** Use small ethonal dampened foam swab to clean any excess grease from around impactor surface. Greased impaction plates (or substrate support) should be placed in a covered dish until ready for use. They can be prepared up to three months in advance.

B1. HARVARD PEMS ASSEMBLY (FOR USE WITH 37MM TEFLON FILTERS FOR PM 2.5)

***NOTE: RUN IQ AIR STAND-ALONE CLEANER 12 HOURS CONTINUOUSLY UNTIL 1 HOUR BEFORE ASSEMBLING. AVOID BIG MOVEMENT, FOR EXAMPLE FURNITURE MOVING, IN THE LAB 1 HOUR BEFORE ASSEMBLING.

DURING ASSEMBLY, MINIMIZE EXPOSURE TIME OF FILTERS TO THE AIR TO REDUCE DEPOSITION. KEEP PEMS COVERED OR IN A CONTAINER WHILE ASSEMBLING OTHERS***

****USE GLOVED HANDS FOR ASSEMBLY****

MATERIALS:

Clean tops
Clean Impaction plates
Clean bases
Clean metal screens
Clean O-rings
Harvard PEM screws (4 per PEM)
37-mm PTFE filters (pre-weighed) stored in labeled plastic Petri dishes)
Drain discs (Whatman cat. no. 230800)
Plastic trays
Torque screwdriver (McMaster-Carr no. 8554A25; size 2 Phillips bit, McMaster no. 5750A14)
Non-serrated forceps
Milli-Q water
Kimwipes
ID labels (3 per filter for assembled PEMs and field logs)
PEM lab log form
PEM set-up Field Logs

a) Wash hands thoroughly and dry thoroughly before beginning assembly. Put on gloves.

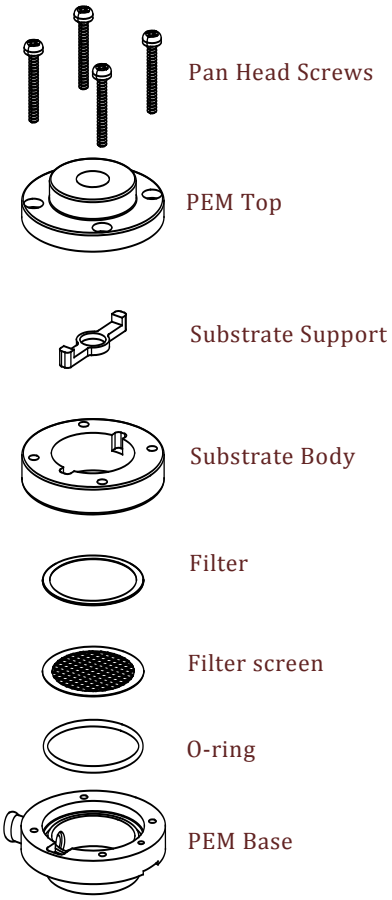


FIGURE 1. PEM PARTS AND CONFIGURATION

b) Components of a Harvard PEM are in Figure 1. (NOTE: Figure does not show that drain disk goes between screen and 37mm filter).

c) Clean tray with milli-Q water and kimwipes. Make sure tray is completely dry. Then cover with kimwipes.

d) Clean 2 sets of forceps with a Kimwipe moistened with milli-Q water and lay on a Kimwipe to dry. Make sure the forceps are dry before using them.

e) Clean all sampler parts, following instrauctions in A.2.1. The steps in A.2.2 will have already been completed.

f) At first assembly, using gloved hands, place the O-ring into the lip on the base of the Harvard PEM. Using clean non-serrated forceps, place a metal support screen for the filter into the base. Care should be taken to avoid using bent or warped screens. If fit is not completely flat and secure, obtain a new screen.

g) Place a new drain disk on the metal support screen (done in field).

h) Using clean non-serrated forceps, remove a 37-mm Teflon filter from the Petri dish by the plastic outer-ring. Place the filter on top of a drain disk in the PEM base with the ridged-ring side facing up. (done in field)

i) Inspect the impaction plate to make sure grease is smooth. If not, select another one. Tell the lab manger that one of the plates does not have smooth grease. Then place the substrate body on top of the filter holder, and place the substrate support in the appropriate slot in the substrate body with the greased side facing up.

j) Put a PM2.5 inlet on top of the impaction plate, and secure the top and base together using four screws and a Phillips screwdriver, ensuring that all four are tightened evenly. Torque screwdriver set to 60 in-oz. will be used.

k) In the lab, place a new drain disk in with the filter in the petri dish.

l) Place a filter label on the outside of the assembled PEM. Also, place a filter label on the PEM field log, AND on the PEM lab log, as appropriate. Record the PEM number on the PEM set-up field log, as appropriate (each PEM has a number etched on the outside of the PEM base). Then, fill out the rest of assembly section of the PEM lab log, including your initials, PEM number, and assembly date.

m) Place a label with the assembly date on the outside of PEM.

n) Place each prepared PEM in a resealable bag for transport to the field. Place the corresponding PEM field log in the resealable bag along with the PEM. Using a sharpie, label the bag with the assembly date (Example: "Assembly Date: mm/dd/yyyy"). Place the petri dish in the bag.

B2. INSERTING FILTER IN FIELD

a) Complete steps g and h from section B1 in the field laboratory. The filter will be in the zip-top bag with the sampler and field log.

C1. HARVARD PEMS DISASSEMBLY

**** USE GLOVED HANDS FOR DISASSEMBLY****

MATERIALS:

Labeled Petri dishes for filters
Plastic trays
Phillips screwdriver
Non-serrated forceps
Distilled water
Kimwipes
PEM lab log form
Milli-Q water
Teflon tape

a) Wash hands thoroughly and dry thoroughly before beginning disassembly. Put on gloves.

b) Clean tray with milli-Q water and kimwipes. Make sure tray is completely dry. Then cover with kimwipes.

c) Clean 2 sets of forceps with a Kimwipe moistened with milli-Q water and lay on a Kimwipe to dry. Make sure the forceps are dry before using them.

d) PEMs are transported from the field in resealable bags. Keep the PEMs in their plastic bags until disassembly. The resealable bag of used PEMs will have the take-down date and household ID written on them.

e) Disassemble one PEM at a time, keeping all other PEMS in their plastic bags.

f) Locate the Petri dish with the label that matches the filter label that is on the outside of the used PEM that is to be disassembled.

g) Find the PEM number (etched on the outside of the PEM) and assembly date (from the label on the PEM with "loading date") for the PEM that is to be disassembled in the PEM lab log. Confirm that the filter IDs on the PEM and on the lab log match. If not, notify the project manager. Complete the remainder of the disassembly section of the PEM lab log. Make sure to mark if it was used as a "Blank". Record any additional notes from the bag into the lab log.

h) Remove PEM from re-sealable bag and set it out on a clean tray covered with large Kimw. Unscrew PEM top and base.

i) With the forceps, grasp the plastic outer ring on the filter and drain disk, and ***keeping the dirty side up,*** place it into the corresponding labeled Petri dish. Using two pairs of clean curved filters, gently separate the filter and drain disk. Place them back together and place in petri dish. Make notes in the comments section of the CI lab log for any unusual findings, such as filter dislodged, O-ring slippage, yellow-colored filters (indicates tobacco smoke-also inform lab manager), dropped filter, hole in filter, etc.

j) Tape all Petri dishes closed with Teflon tape. Place an "x" on the top of each petri dish to indicate media has been used. Put taped petri dishes in plastic box labeled with unloading date. Petri dishes should be stacked in groups of 10 by type of filter and bags should be placed inside plastic box.

k) Reassemble sampler and remove labels from sampler. Put dirty sampler back in plastic bag – label bag "dirty used sampler." Place in bin of dirty used samplers.

l) Proceed with unloading the next sampler, until all samplers have been unloaded.

D. STORAGE

a) Samplers should be stored in a climate controlled environment.

E. SHIPPING

a) Shipping of samples is done by priority overnight mail on either a Monday, Tuesday, or Wednesday. This is to prevent the samples from being warm over the weekend if the shipment is delayed.

STANDARD OPERATING PROCEDURE FOR OGAWA SAMPLER (OZONE) CLEANING, ASSEMBLY, AND DISASSEMBLY

(MODIFIED FROM HSPH OZONE SOP)

The Ogawa samplers to be used in the California Asthma Intervention Study consist of a small plastic reusable badge with a diffusion end-cap, a glass fiber filter coated with nitrite-based solution for collecting ozone.

A1. CLEANING OF SAMPLER HARDWARE

MATERIALS:

Ethanol, ACS reagent grade
Milli-Q water
Kimwipes
2 plastic trays
6 beakers
Sonication bath (VWR #97043-958)
Sampler parts
- Cylinder bodies (with spacer disks and rings inside)
- End caps
- Stainless steel screens

CLEANING

THIS WILL BE DONE IN BETWEEN EACH SAMPLING EVENT

All sampler components (end caps, screens, and bodies) must be carefully rinsed with Milli-Q water and dried before each use following the instructions below. All components must be washed and dried ahead of time and should be stored in separate containers until assembly.

1) Wash hands thoroughly before beginning cleaning protocol.

2) Disassemble the samplers and separate the end caps, screens and cylinder bodies (with spacer disks and rings still inside). In old samplers sometimes the rings come out. When this happens, the plate should also be taken out, and the rings and plates cleaned separate from the bodies.

3) Place end caps in a beaker. Cover the end of the beaker with a watch glass. Rinse the end-caps 3 times with Milli-Q water, draining the water carefully between rinses, using the watch glass to hold the caps inside the beaker, and shaking gently to remove as much water as possible. Then set the end caps on Kimwipes to dry. Make sure to cover the parts with Kimwipes while drying to keep them clean. It may be necessary to tap the water out of the holes in the end-caps in order for them to dry completely.

4) Using clean forceps , dip and gently swirl the cylindrical bodies in a beaker filled with Milli-Q water. Do the same with a second and third beaker of Milli-Q water. Then dip and swirl the cylindrical bodies in a beaker

with ethanol. Shake off excess ethanol. and set the cylindrical bodies on a Kimwipe to dry. Cover the bodies with another Kimwipe to keep them clean while they are drying.

5) Place the stainless screens in a beaker, and fill the beaker with Milli-Q and place it in a sonication bath. Sonicate the screens for *5* minutes, then rotate the beaker a quarter turn; this procedure must be continued for a total of 15 minutes. Be careful not to damage or lose the wire mesh screens during handling. Rinse them three times with Milli-Q water, using a watch glass to hold the screens inside the beaker. Do a final rinse with ethanol, then cover the beaker with a Kimwipe and allow screens to dry in the beaker.

6) Once all parts are completely dry, place them in separate containers for storage until assembly. Clean parts can be kept in closed containers as long as it is necessary before loading the coated pads. All parts of the ozone passive sampler must be clean and completely dry before assembling the sampler.

C1. OGAWA BADGE ASSEMBLY

NOTE: CALIFORNIA STUDY IN "SUMMER" (MAY-OCTOBER) WILL USE 1 2-SIDED OZONE BADGE

MATERIALS:

Components of each 2-sided badge kit (see also Figure 1)

- 1 sampler body (with 2 spacer disks & 2 rings)
- 2 diffusion end-caps
- 4 stainless steel screens
- Vial of filters, use 2 filters for ozone.
- 1 re-sealable plastic bag (part of Ogawa Badge kits)
- 1 storage bottle (amber polystyrene)
- 1 Silica Gel dessicant pack

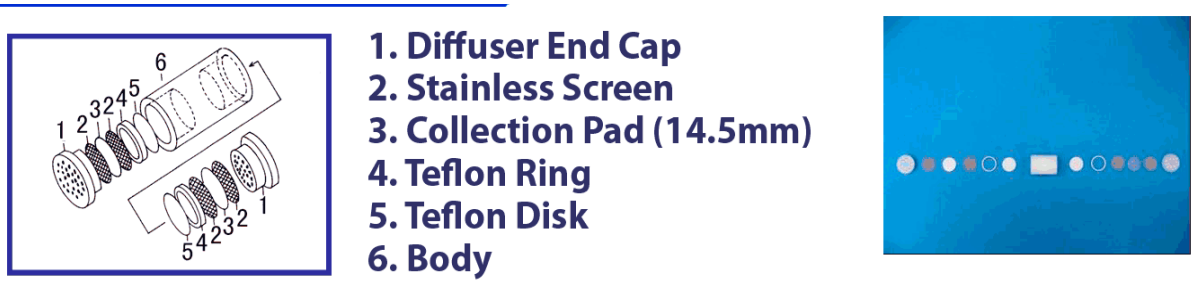


Figure 1. Components of badge.

Other items needed

- ID (identification) labels (4 per sample)
- forceps
- 1 modified glove-box (See appendix A)
- Coated cellulose Filter paper sheets for glove-box floor and sides (Coated with a solution of 2% $NaNO_2$ in water diluted 1:1 with ethanol (for ozone); supplied by Harvard)
- Kimwipes large & small
- 1 plastic squeeze bottle with Milli-Q water

STORAGE OF FILTERS BEFORE USE:

Pre-coated filters ("pads")are supplied by Ogawa & Co., USA, Inc. (www.ogawausa.com) in vials labeled with the batch number referring to the coating batch. Each vial contains 40 filters. Keep a laboratory record of the batch number and the date of assembly for each batch of samples and blanks. The pre-coated filters must be stored in their original containers in a cool, dark place, preferably at 5 ^{0}C before being loaded into samplers. If stored under these conditions they can be used up to a year. As a coated ozone filter ages, a slow conversion of nitrite to nitrate occurs. **All pads used for a designated batch (and corresponding field blanks) must be removed from the refrigerated vial and prepared at the same time.**

ASSEMBLY:

a) Wash hands thoroughly before beginning assembly.

b) All components must remain completely dry during the assembly. This requires that after forceps are wiped clean with a moist Kimwipe, **they must be completely dried before handling the filters and screens.** Use the blunt forceps whenever possible to prevent filter damage. Use the following assembly steps for each sampler (see also figure 2).

c) You should have two labels for each sampler (these labels will differ depending on the type of sampler that you are loading, either ozone.). Staff at the Harvard School of Public Health will provide the labels with the ID number as the labels that work best can only be printed on a dot matrix printer and UC Davis does not have such a printer.

d) At the start of the day, remove the coated paper from the resealable plastic bag and place the coated filter paper sheets on the floor and sides of the glove box, so that the floor and sides are completely covered with the filter paper. Tape the paper down.

e) Place a fresh large Kimwipe on the floor of the glove box, on top of the filter paper.

f) Place all clean parts for 5 badge samplers into the glove box (Remember, you will be loading both sides of the badge.) Also place 5 labels and 5 re-sealable bags (with desiccant packets in them) into the glove box at this time. Each sampler is assembled individually before moving on to the next one.

g) Place the cylindrical sampler body, with Teflon disks and rings still inside, upright on the clean Kimwipe in the glove box. **Avoid touching the inside of the ends of the body with fingers.**

h) Using the forceps (which should be clean and dry), add a stainless screen on top of the teflon spacer ring that is inside the cylindrical bodies. Make sure the screen is not bent. Be careful not to bend or damage the screen, and make sure that it sits flat on the Teflon spacer ring.

1. ***NOTE: The first of the two stainless steel screens should also be inserted before opening the vial of coated filter. This minimizes the time that the filters may be exposed.***

i) Take the vial of coated ozone filters out of the refrigerator and place them in the glove box. Open the vial containing each set of filters. Use the blunt forceps to gently grip one of the filters by its edge. Place the ozone filter in the end of the cylinder. Again, be careful not to damage the filter and watch that it sits flat on the stainless screen. If a filter is dropped, discard it and get another from the glass vial. Be careful not to contaminate the unused filters.

j) Place a second stainless screen over the filter, taking the same precautions as before.

k) Pick up a diffusion end-cap by its edge. Avoid touching its flat sides. Securely place an end-cap into the end of the body.

    1. ***NOTE: Sometime the end-cap fits quite tightly to the body. To get it to go all the in, it is sometimes necessary to put a small Kimwipe on the outside and push hard until it clicks in.***

l) Flip the sampler bodies over and load the other side of the sampler following steps g-j above.

m) Attach the sampler body to the sampler clip.

n) Put the label for ozone on the sampler clip lengthwise. Trim the ends of the label to fit if necessary.

o) Place the completed badge into a re-sealable bag along with a silica gel packet. Expel the air from the bag and seal it. Once all 5 samplers are in their bags, remove them from the glove box.

p) Place the matching ID label on the outside of the storage bottle. It is better to put the labels on the brown storage bottle, not the cap, to minimize confusion. Then make sure **that the ID label on the bottle is the same as on the badge that will be placed inside that bottle.** Place the sealed bag inside the airtight brown bottle and firmly seat cap on bottle.

q) Place a matching ID label on the both the set-up field log and on the Ozone Passive Sampler Loading Log, as appropriate. Fill out the remainder of the passive sampler loading log, including your initials, filter vial #, and filter batch #, as well as the loading date. Place the matching set-up field log in a re-sealable bag with the amber bottle containing the loaded sampler, then put these in the refrigerator.

r) **Remember: All pads used for a designated batch (and corresponding field blanks) must be removed from the refrigerated vial and prepared at the same time. Thus 20 samplers (including any blanks and duplicates) must be prepared per sitting. Repeat the steps above, loading 5 samplers at a time, until 20 samplers have been loaded.**

s) **A total of <u>1-2</u> of the 20 samplers loaded from a single vial must be labeled "Blank". This means that you will be alternating the number of Blanks prepared at every other preparation; so one time 2 of the 20 prepared samplers will be labeled as a "Blank" and the next time 1 of the 20 prepared samplers will be labeled as a "Blank". Be sure to label both the clip and the brown storage bottle as "Blank". Put the Blank and two regular samples into a re-sealable bag together. This will be a QA/QC sample bag.**

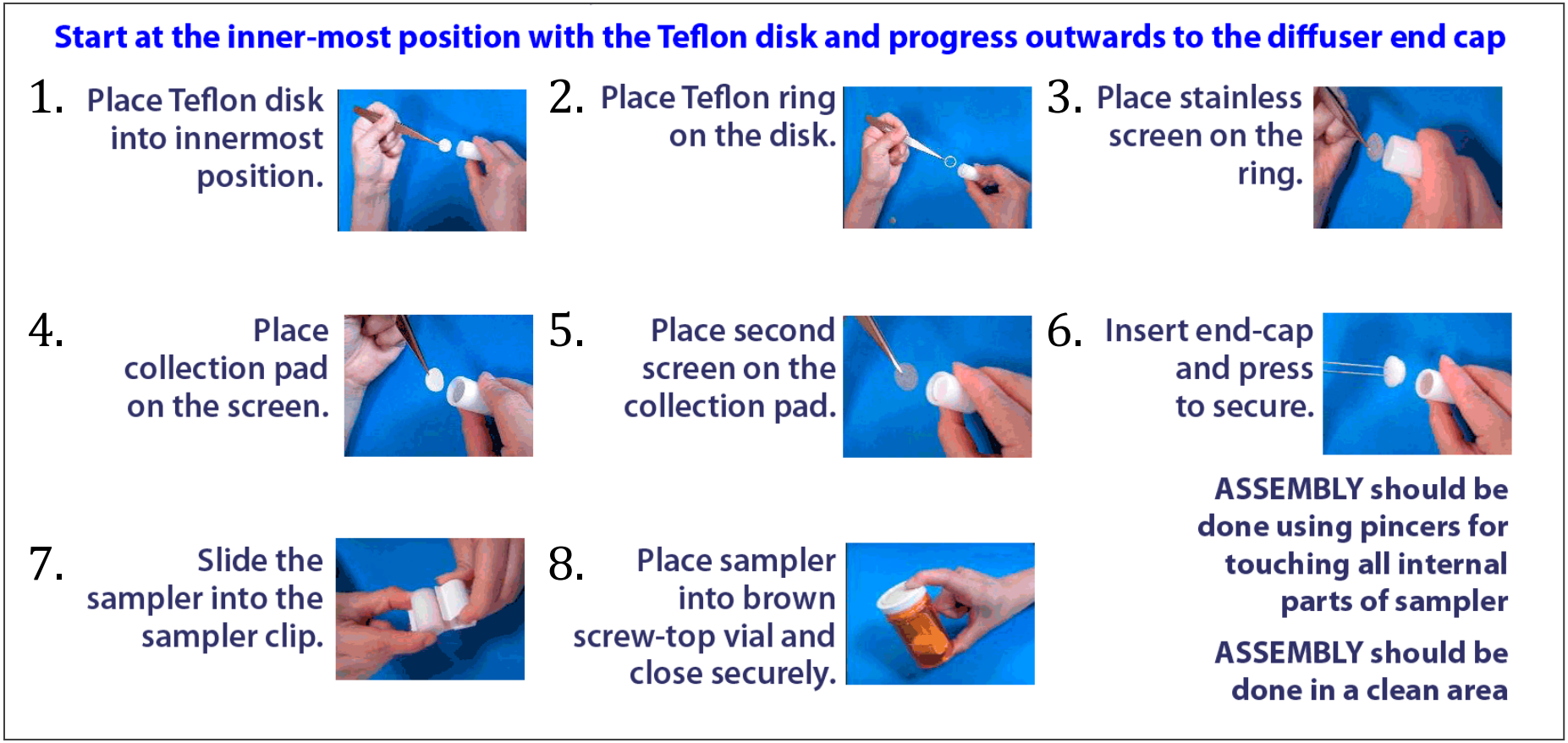


Figure 2. Assembly of badge, IMPORTANT NOTE: The figure leaves out the re-sealable plastic bag!! Most likely, steps 1 and 2 will not be necessary.

STORAGE OF ASSEMBLED BADGE (WITH COATED FILTERS)

The assembled badge, inside a re-sealable bag placed in the brown vial, can be stored in the refrigerator for at least ***one year from the date the coated filters were received***.

DISASSEMBLY

MATERIALS:

8 ml polyethylene vial, with self-sealing cap (from Ogawa USA)
Forceps
Kimwipes
Glove box, with coated filter paper

DISASSMEBLY OF OGAWA SAMPLERS:

ONLY UNLOAD ONE SAMPLER AT A TIME

a) Wash hands thoroughly before beginning disassembly.

b) All components must remain completely dry during the disassembly. This requires that after forceps are wiped clean with a moist Kimwipe, **they must be completely dried before handling the filters and screens.**

c) Remove 5 sample bottles, containing used Ogawa badges that are to be disassembled, from the refrigerator.

d) Do not open the bottles for 15 minutes while the badges are brought to room temperature.

e) Disassemble only one sampler at a time. Open the bottle and remove the re-sealable bag, containing the Ogawa badge from the bottle. Confirm that the label on the sampler matches the label on the bottle.

f) Place the label from the brown storage bottle on the Ozone Passive Sampler Unloading Log, as appropriate, and fill out the remaining sections of the unloading log, including the Household ID and take-down date (as recoded on the re-sealable bag that the sampler came back in). Make sure to mark whether the sample was used as a blank or duplicate.

g) Place the bag with sampler into the glove box. Also place an 8ml polyethylene vial in the glove box.

h) Remove the sampler from the re-sealable bag and place the sampler on one end.

i) Clean a watch glass with a kimwipe dampened with Milli-Q water.

j) Carefully remove the end diffusion cap from one end of the badge.

k) Carefully turn over the badge onto the middle of the clean watch glass, so that both screens and the filter are now on the watch glass. Use forceps to place the filter into an 8 ml polyethylene vial, with self-sealing cap. Make sure to push the filter all the down to the bottom of the vial.

l) Flip sampler over and repeat steps j and k with the other end of the sampler. Both filters from a single sampler should be placed in the same polyethylene vial.

m) When both filters are removed from the sampler, also remove the label from the sampler clip and place the label on the polyethylene vial.

n) Remove the vial from the glove box and place in the sample storage box in the refrigerator.

o) Go back to step "e" and process the next sampler. Repeat until all samplers have been disassembled.

STORAGE AND SHIPPING OF EXPOSED FILTERS AND BLANKS

a) The exposed and blank filters can be kept in the vial refrigerated for several months before shipping.

b) A group of samples (and blanks) that are intended to be analyzed together must also be shipped together, by the fastest shipping available.

NOTE 1: Use insulated coolers with frozen ice-packs for shipping. Ship with priority overnight service. Do not ship out on a Friday or Thursday (just in case the package is not delivered the next day for any reason.)

CHEMICAL ANALYSIS

The chemical analyses of the pads will be contracted either through the Research Triangle Institute in North Carolina. Details on the Passive flow rates are found in Appendix B.

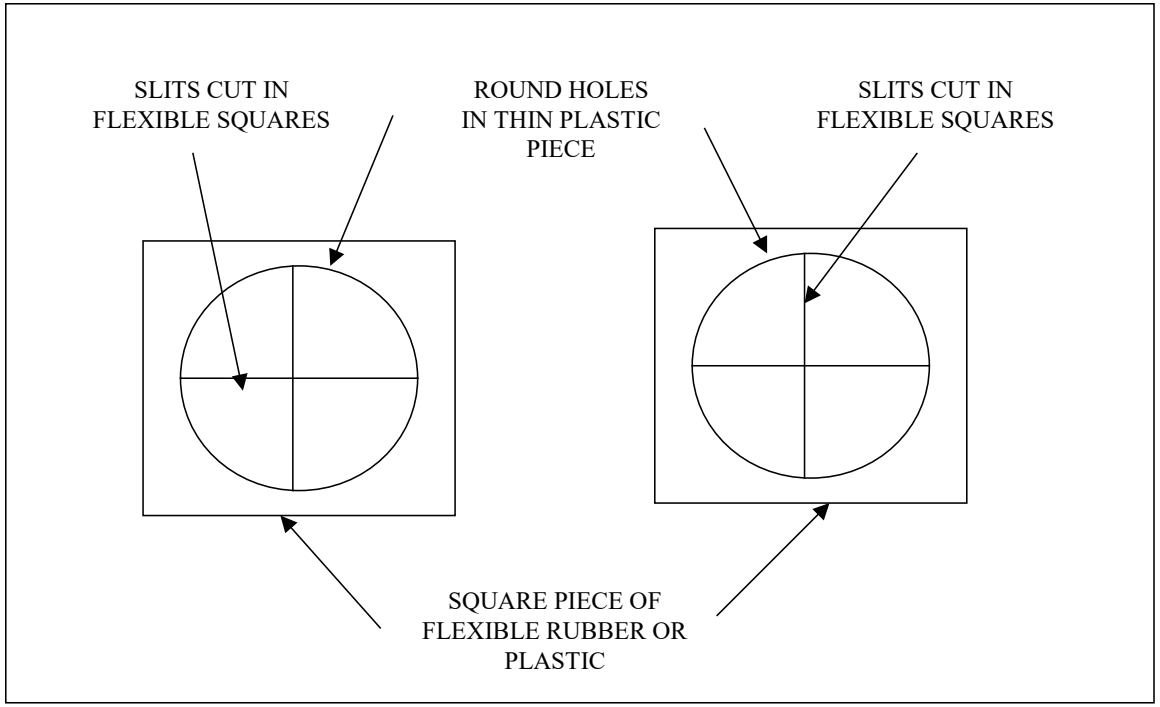
APPENDIX A

THE MODIFIED GLOVE BOX:

The modified glove box provides a chamber with a lower concentration of Ozone in the air than in the room air.

1. Use a glass aquarium, size 20x10x12.5" (length x width x height).
2. Obtain a rectangular piece of thin (1/8" or slightly thicker) clear plastic that fits well into the top of the aquarium (not too tight, not too loose). Probably available, cut to your dimensions, at a hardware store that sells Plexiglas window panes.
3. Cut out two round holes, placed toward the "bottom" (based on turning the aquarium onto one side – see figure below). These are to allow hands to be placed inside the box.
4. Cut out two squares (big enough to cover the round holes) of flexible material (rigid enough to not sag when the two perpendicular slits are cut to allow hands to go in and out). Cut slits as shown in the diagram.
5. Glue or tape the squares over the holes (clear plastic tape will allow good visibility into the box – and will allow easy replacement of squares, if necessary).
6. Use a piece of duct tape to make a hinge at the "top" of the box (again aquarium turned on side).
7. Place coated filter paper in the bottom of the glove box.
8. After placing samplers inside close the hinged front piece, and use temporary tape along sides and/or bottom to minimize contact with outside air.
9. Load and unload samplers in the glove box.

THIN PIECE OF CLEAR
PLASTIC TO FIT TOP OF
AQUARIUM



AQUARIUM TURNED ON

ONE SIDE TOP FACING OUT

APPENDIX C

PASSIVE FLOW RATES – HSPH DOCUMENT

PASSIVE SAMPLER REFERENCES

FOR COLLECTION RATES AND DIFFUSION COEFFICIENTS

TABLE OF EFFECTIVE COLLECTION RATES:

GAS	DIFFUSION COEFF.	DIFFUSION COEFF. REFERENCE	SAMPLING CONDITIONS	COLLECTION RATE in cc/min SINGLE FILTER	COLLECTION RATE REFERENCE
Ozone	0.15	1	outdoors/raincover	11.4	7
Ozone	0.15	1	indoors/fan	8.9	8
Ozone	0.15	1	Personal on chest without backing	5.2	8
Ozone	0.15	1	Personal on chest with backing	7.6	8
Ozone	0.15	1	Personal on shoulder with backing	8.0	8
Ozone	0.15	1	multi-pollutant sampler**	11.0	9
NO_2	0.154	2	outdoors/raincover	9.5	10
NO_2	0.154	2	multi-pollutant sampler**	13.3	9
SO_2	0.136	3	outdoors/raincover	9.8	10
SO_2	0.136	3	multi-pollutant sampler**	9.9	10
NH_3	0.236	4	(uncertain)	16.6	11
HNO_2	0.154	5	------	------	------
HNO_3	0.121	6	------	------	-----

** the single end of an Ogawa passive sampler is located in a side-arm attached to the elutriator used with a multi-pollutant sampler designed by HSPH

For our outdoor samplers, we will use the rate specified for outdoors/raincover. For the indoor one, we will use the indoor/fan rate.

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9. Chang, L.-T. (manuscript in preparation)
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11. Unpublished, incompleted study at HSPH (not recommended for ambient sampling)

Ozone Calculation

PSD Sampling rate for Ozone is constant, 22.8 ml O_3/min (outdoor) and 17.8 (indoor)

Outdoor Ozone concentration is calculated using the following equation.

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{22.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6}M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6\mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

To calculate the constant part of the equation, we get a constant, 17.30

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 17.30$$

Indoor Ozone concentration is calculated using the following equation.

$$O_3(ppmV) = \frac{Nitrate\ (\mu g)}{sampling\ time\ (\text{min})} \times \left[\frac{1}{17.8\ ml/min} \times \frac{1\mu mol\ O_3}{62\mu g\ NO_3} \times \frac{24.45\mu L\ O_3}{1\mu mol\ O_3} \times \frac{10^{-6}M^3\ O_3}{1000\mu L\ O_3} \times \frac{10^6\mu L}{L} \times \frac{10^6 mL\ O_3}{M^3\ O_3}\right]$$

To calculate the constant part of the equation, we get a constant, 22.16

$$O_3(ppmV) = \frac{Nitrate\ (in\ \mu g)}{sampling\ time\ (in\ \text{min})} \times 22.16$$

STANDARD OPERATING PROCEDURE FOR REFLECTANCE ANALYSIS

(MODIFIED FROM HSPH REFLECTANCE ANALYSIS SOP)

EEL MODEL 43M- SMOKESTAIN REFLECTOMETER

APPLICATION

This SOP is for measurement of the "blackness" of ambient $PM_{2.5}$ particles collected on 37mm Teflon membrane filters as a surrogate for Elemental Carbon [EC]. The Teflon membrane filters are mounted in a two-piece filter-holder to keep them flat for the analysis, and to minimize contamination from contact with other surfaces during measurements. For this revised version of the SOP, the same blank filter (Working Standard Blank) is used to determine the relative reflectivity of each test filter (both samples and field blanks). (37mm filters fit in the yellow holders).

For background on this method, see IS0 publication #9835, "Ambient air - Determination of a black smoke index", Reference number: IS0 9835:1993(E). Notes: 1) since there is a 1 to 2 mm spacing between the measurement head's "mask" and the filter, as well as several mm's between the filter and the background surface, these readings are not directly equivalent to traditional Black Smoke absorption readings as described in ISO 9835, and; 2) relationships of absorption to EC concentrations need to be empirically determined for different sampling locations and seasons using quartz filters and the thermal optical reflectance/absorbance methods.

EQUIPMENT

MATERIALS NEEDED

- The EEL Model 43M Smokestain Reflectometer
- EEL Calibration plate with white and grey surfaces
- 37 mm sample filters & blanks
- Yellow 37 mm filter filter holders, as required
- Grey PVC plastic ring ("mask") for 37mm filter holders (custom from Harvard)
- Fresh (not faded from exposure to light) white copy paper (92 brightness) for the white background mat
- Unserrated stainless steel Forceps
- Kimwipes (large & small)
- Milli-Q (ultrapure water)
- Plastic lab tray (ideal size 12" x 16") cleaned with Milli-Q water and Kimwipes
- Computer with Microsoft Excel and Reflectance Data Entry Log Excel spreadsheet
- Back-up flash drive for computer.
- Opaque case for storing Working Standard Blank

A. COMPUTER SET-UP AND DATA ENTRY

1) If this is the first time samples with this code (i.e. "UCD") are being measured, create a folder for the files in the C:\REFLECTANCE folder (ask for help to do this, if needed) on the back-up flash drive. To access the C:\REFLECTANCE folder, go to the external drive and open the C:\REFLECTANCE folder.

2) Click on the icon (blank) "Reflectance Data Entry Log" under the C:\REFLECTANCE folder. Save the data entry log with a new filename to the folder for this site code ("UCD"): **Use the following format: UCD_YYYYMMDD_A.**

3) The blank data entry log is protected to prevent accidental changes. The new file (UCD_YYYYMMDD_A) is a copy of the blank log and is still protected. Unprotect the new file as follows: Click on Tools, then on Protection, then on Unprotect Sheet.

4) Enter the following information in the new data entry log spreadsheet: File Name (UCD_YYYYMMDD_A); Operator (initials); Filter size (37mm); Session Date; Site Code (AAA).

5) It is also okay to rename an existing file by changing dates and file name. Only after the file has been renamed and saved should the existing data be deleted.

B. START-UP PROCEDURE

1) The Reflectometer power is left on all the time, with the lamp unplugged.

2) The optical head of the lamp should always be kept upright, resting on the analytical mat (white copy paper), when not in use. This is the same position it is in when measuring samples.

3) Avoid bright lights when measuring, such as direct sunlight or bright table lamps (make sure that the lamp above the desk is turned off). **This is VERY important.** If this is done in a room with a lamp or light is directly above, take the bulbs out before continuing.

4) At the start of a session, with the lamp unplugged, confirm the zero value displayed on the Reflectometer. If it does not go to zero, contact Rebecca Moran.

5) Plug in the lamp (hold the black plastic part of the plug firmly, and **gently** rotate the knurled metal cylinder to secure the plug) and allow it to warm up for a minimum of **1 hour** before proceeding with the Calibration Check.

C. FILTER PREPARATION

SHOULD BE DONE WHILE WAITING FOR THE LAMP TO WARM UP. IF LAMP IS WARMED UP, PROCEED THROUGH THE CALIBRATION STEPS WHILE DOING FILTER PREPAPATION.

1) Thoroughly wash hands before beginning filter preparation and measurements.

2) Make sure you have a clean, open space on the top of the desk next to the reflectometer **[free from any bright light source]** to accommodate the clean lab tray and all of the samples to be analyzed.

3) Create a "standard" white background mat for the lamp to rest on. This consists of three sheets of 92 brightness white copy paper taped to the desk. If this is set up already, just replace the top sheet of paper with a fresh sheet, and make sure that the 3 sheets remain taped to the desk.

4) Clean the lab tray with a Kimwipe moistened with Milli-Q water. Put one large Kimwipe on the clean lab tray. Use tape to stretch the Kimwipe so that it 0lies flat on the tray. Eliminating wrinkles in the Kimwipe prevents contact with the filter when the holder is placed on it. This tray will serve as a dedicated clean area for filters and other work items.

5) Use a small Kimwipe moistened with Milli-Q water to clean the stainless steel forceps. Put the cleaned forceps on the clean lab tray covered with the large Kimwipe.

6) Use Kimwipes moistened with Milli-Q water to clean the six yellow filter holders to be used for filter analysis. Use one Kimwipe for each holder. Line these cleaned filter holders ("tops" and "bottoms" separated) along the upper side of the tray, with the receded sides of the "tops" and the "bottoms" facing up, as shown below.

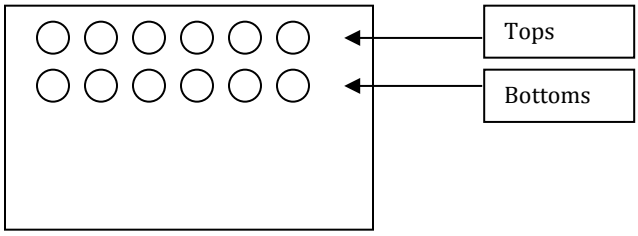

Figure 1: Diagram of filter holders on tray

7) While the lamp continues to warm up, mount the first six filters that will be measured. Place the Petri dishes containing 6 sample filters to be tested below their respective filter holders, as shown below (dark circles):

8) Enter the first set (of six) Sample IDs are into the data entry log for the first Set (#1) of measurements. **It is essential to keep the labeled Petri dishes for the filters in the same order as that they are listed on the data log. This allows replacement of the filters back into the same dishes they came out of, after measurements are made.**

9) Using a barcode scanner, scan the filters in numerical order into the section labeled "**Sample ID**". Make sure the filters are the in numerical order even if they are not in consecutive order.

10) Then, open each Petri dish and inspect each filter carefully. If there are any tears, holes, or other problems with the filter, mark the comments section "void……." and do not measure reflectance. It is not necessary to put void filters into filter holders. Set the void filters aside and select another filter to measure in its place so that you have six valid filters to measure.

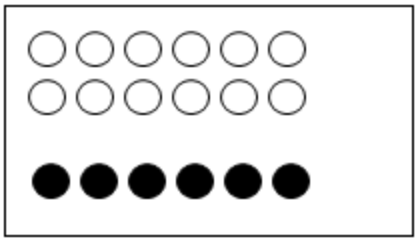

Figure 2: Diagram of filter holders on tray with petri dishes containing sample filters above tray.

11) Gently place the first filter into the recessed side of the bottom half of the adjacent filter holder so that the shiny surface of the outer ring of the filter is **facing down**. *Use the clean stainless steel forceps to help put the filter into the holder.* This is done so the side of the filter with the particle deposit will be facing the Kimwipe surface below the base (recessed half) of the filter holder. (If the filter was improperly loaded upside down when the sample was collected, place the filter so that the shiny side of the filter's outer ring faces up, and note this in the comment section of the spreadsheet) **Orienting the filter and placing it in the proper filter holder "half" is a critical step!** If unsure about this step, consult the Lab Manager. Be sure that the filter is directly in the center of the base before attaching the top half of the filter holder, or the filter may be damaged. Then **carefully (***do not touch the filter with fingers*) "snap" the lid of the filter holder into the base of the filter holder. **It is very important to close the filter holder completely to be able to get valid measurements.** Finally, flip the ring holding the filter, so that the shiny side with the particle deposit is facing up, ready for measurement.

12) Repeat step 11 for each of the six sample filters. Clean the forceps with Milli-Q water before contacting each filter only if the forceps touched inside the outer shiny ring of the previous filter. This is to ensure minimal contamination and accurate data analysis. Make sure the forceps are dry before contact with a filter.

13) For all 6 filters, each Sample ID should now be correctly entered into the Excel data entry spreadsheet, each filter installed in a filter holder, and ready for analysis.

14) Wait for the lamp to have warmed up for a full hour before proceeding to the steps below.

D. CALIBRATION CHECK

1) Remove the glass calibration plate from its protective cardboard box. Use a Kimwipe moistened with Milli-Q to clean the grey/white glass plate, making sure the plate is dry and free of streaks before use. The plate is 3" x 6", with a white circle on one side and a grey circle on the other.

2) *After the lamp has warmed up for at least 1 hour,* place the lamp assembly **(without the grey PVC ring attached)** over the center of the white circle on the calibration glass plate. To remove the grey PVC ring, unscrew the set screws and slide the ring off the lamp assembly.

3) Before any adjustments are made and when the reading has been stable for a count of ten, record the reading as the "**White Value: Before Gain Adjustment"** on the log. Then, pressing the blue button labeled 'CAL', adjust the calibration value on the meter to read 100.0.

4) When the reading of 100.0 has been stable for a count of ten, move the lamp to the center of the grey circle on the calibration plate.

5) The reading should gradually increase. After 3 minutes, record the value in the log as the "**Initial Grey Value".**

6) When finished with the calibration check, replace the calibration glass plate into its protective cardboard box.

E. FILTER MEASUREMENTS

GENERAL NOTE: SAMPLES ARE MEASURED IN SETS OF SIX. MEASUREMENT OF EACH SET STARTS WITH ADJUSTMENT OF THE WORKING STANDARD BLANK TO READ 100.0, AND ENDS WITH MEASUREMENT OF THE WORKING STANDARD BLANK. **RECORD EACH READING WHEN THE REFLECTOMETER DISPLAY HAS BEEN STABLE FOR 10 SECONDS (TO WITHIN 0.1 UNIT, I.E. "88.3")**

1) ***Remember:*** All filter measurements are made using the "standard" white background mat (three sheets of copy paper), not the white circle on the calibration plate.

2) Confirm that the Calibration Check for the instrument has been properly performed before analyzing any filters.

3) Clean the grey PVC ring (this was removed during the Calibration steps) with a Kimwipe moistened with Milli-Q water and attach it to the lamp assembly for measuring all filters. When attaching the PVC ring to the lamp assembly, **be careful not to strip the threads of the lamp assembly.** The screws should be recessed on the bottom of the assembly, so that no external light "leaks" under the PVC ring and so the filter holder will be flush with the white background mat (three layers of white copier paper) when taking measurements.

ADJUST THE GAIN WITH THE WORKING STANDARD BLANK FILTER

4) Place the filter holder containing the Working Standard Blank on the white analysis mat so that the flush side of the filter holder will now be facing up, and the recessed side of the 'bottom' part will be facing the white mat. This position ensures that the desired filter surface (deposition) to be analyzed is closest to the instrument's optical source. Place lamp assembly over the filter holder. Using the box containing the EEL Calibration plates, place the box below the lamp and move the lamp until the box is completely inside the white analysis mat. Then, place the box (with the longer side placed vertically on the table) to the left of the lamp and move the lamp until the box is completely inside the white analysis mat. This is to ensure that measurements are taken in the same spot on the white analysis mat with the same amount of external light (if any) entering the lamp.
    a. **<u>The same</u>** "**Working Standard Blank**" filter is used for testing before and after ***every set*** of 6 sample filters, and is kept permanently inside its own filter holder. When not being used for measurements, the blank is stored in plastic Petri dishes and kept in opaque containers. The container is kept on the table next to the reflectometer.
    b. Once a quarter the back-up blank will be measured along with the Working Standard Blank. **<u>On the first measurement event of the quarter</u>**, make sure to measure both the Working Standard Blank and the back-up blank, as noted below. Record the back-up blank measurements in a "blanks" log. *Make sure to adjust the gain for the measurement session with the Working Standard Blank only.* When not being used for measurements, the blanks are stored in plastic Petri dishes and are left on the table.

5) After ten seconds of a stable reflectance reading (+/- 0.1), record the value in the Blank Adjustment section of the data entry log as the "**Before Gain Adjustment**" reading.

6) With the Working Standard Blank still in place, adjust the instrument using the blue button labeled 'CAL', as appropriate, so the display reads 100.0, again for a period of five-ten seconds. If measuring back-up blanks during this session, *make sure to adjust the gain for the measurement session with the Working Standard Blank.*

7) Remove the Working Standard Blank from the white analysis mat and place it on the lab tray.

8) Record at the top of the sheet if you will be doing pre- or post- measurements in this session.

MEASUREMENT FOR SAMPLE FILTERS

9) Place the filter holder containing the first sample filter to be measured on the white analysis mat so that the flush side of the filter holder is facing up and the recessed side is facing the white mat. This position ensures that the desired filter surface (deposition) to be analyzed is closest to the instrument's optical source. Place lamp assembly over the filter holder.

10) After five-ten seconds of a stable reflectance reading (+/- 0.1), record the value in the excel spreadsheet under "Test 1". Confirm the value did not change while entering data. If it did, revise value.

11) Remove the sample filter from the analysis mat and place it back on the lab tray above its corresponding petri dish. **It is essential to keep the both the labeled Petri dishes and their corresponding filters in the same order on the lab tray that they are listed on the data log. This allows replacement of the filters back into the same dishes they came out of, after measurements are made.**

12) Repeat steps 9-11 until all 6 sample filters have been measured.

13) Measure the Working Standard Blank again just as if it were a sample filter and record the value in the data entry spread sheet. Make sure to adjust the placement of the lamp accordingly to ensure that the lamp is one box length above and one box length to the right on the white analysis mat. The reading must be between 98% and 102% for the measurements to be considered valid. If the reading is outside this range, the prior six readings will need to be repeated. The reading is rarely outside this range. If it is outside this range, please consult the lab manager before continuing. If the reading is inside this range and the reading was recorded, adjust the instrument using the blue button labeled 'CAL', so the display reads 100.0, again for a period of roughly five-ten seconds.

14) After measuring the set of six sample filters, do NOT remove the filters from their filter holders.

15) Repeat the measurement of the same set of six sample filters, including adjusting the gain with the Working Standard Blank, following steps **6-14** above. Record these values in the excel spreadsheet under "Test 2".

16) The data entry spreadsheet calculates the difference between the 1st and 2nd measurements for each filter and the Working Standard Blank at the end. If the two values agree with +/-.2, the results are acceptable. If not, for any filters that are outside this range, repeat the measurement (set Working Standard Blank to 100, measure filter(s), measure Working Standard Blank). Record data under "Test 3".

17) If more than 3 of the 6 filters require repeated measurements, the instrument is unstable, and the reflectance session will have to be postponed. Inform the lab manager.

18) While the template data entry spreadsheet has space for a maximum of 15 sets, if needed, the data entry tables can be copied to allow for more sets in the same file.

19) Once all measurements of the six filters have been made, return the filters to their petri dishes.

20) Reload the filter holders with another set of 6 sample filters, following the procedures in Section C: "Filter Preparation". Then, measure reflectance on these filters following the steps outlined above (Section E: "Filter Measurements").

F. REPEAT CALIBRATION CHECK

21) At the end the Reflectance measurement session, you must perform a modified calibration check. After the final Working Standard Blank value has been recorded, place it in its Petri dish, and put it inside the opaque plastic case. Remove the grey PVC ring from the lamp assembly, and place the lamp assembly on the white circle on the calibration glass plate.

22) After the reading stabilizes for five-ten seconds, record the value in the cell for "Before Gain Adjustment".

23) Then, pressing the blue button labeled 'CAL', adjust the calibration value on the meter to read 100.0.

24) Place the lamp assembly on the grey spot, and after 3 minutes, record this value as the "Final Grey Reading".

G. SAVE THE LOG:

1) After the REPEAT CALIBRATION CHECK has been completed, and all entries have been made, you must SAVE THE LOG!

2) To be careful about not losing data, the operator should save the current log at various times (i.e,., after every set of six filters) during the course of measurements, and it must always be saved after the last entries are made.

3) The log file can be saved by simultaneously pressing the "Control" and "S" keys on the keyboard.

4) After saving the final version of the log, the file must be copied to the external flash drive.

5) Go to the desktop display.

6) Double (left) click on the "Reflectance" icon to open this folder.

7) Double click on the folder ("UCD") for the current log.

8) Double click on the icon or filename for the current log ("UCD_YYYYMMDD_A").

9) Left click on "Copy".

10) Go to the desktop display.

11) Double click on the “Flash Drive” icon.

12) Move the mouse to the “Name” section of the window.

13) Left click on the mouse, and then Left click on “Paste”.

14) The icon or filename of the current log will now be shown in the window for the flash drive, and the file has successfully been backed up.

H. SHUTDOWN PROCEDURE

1) Unplug the lamp from the Reflectometer (hold the black plastic part of the plug firmly, and rotate the knurled metal cylinder to release the plug), but **leave the instrument power on**.

2) The optical head of the lamp should always be kept upright, resting on the analytical mat (white copy paper), when not in use. This is the same position it is in when measuring samples.

3) Cover the lamp assembly with a Kimwipe to keep out dust. Place something (like a roll of tape) on top of the Kimwipe to keep it from falling off.

4) Return the glass calibration plate to its cardboard box (keeping the white and grey surfaces out of the light will minimize fading over time).

5) Return the Working Standard Blank filter (inside filter holder, inside Petri dish) to the opaque box of Reflectance Blanks. This box is kept on the table next to the reflectometer at all times.

6) Store the empty filter holders in a clean plastic re-closable bag.

I. BACKUPS FOR WORKING STANDARD BLANKS

1) The Working Standard Blank for the project is selected by measuring reflectance of 42 filters and selecting the one with the highest reflectance value. One back-up filter is also selected.

    a. There is a possibility that the Working Standard Blank will be accidentally damaged during handling, with the result that the membrane gets torn or has a hole in it. Therefore “back-up” blanks must be prepared that can be substituted for the originals, in case the damage occurs. This is unlikely to occur.

    b. It is anticipated that the back-up blank will have a value greater than 97. If not, more filters will be measured until two back-up filters in this range are found.

2) For Quality Assurance, the Working Standard Blank will be compared with the back-up filter quarterly. This value will be recorded in the back-up log.

3) If the Working Standard Blank is damaged, do not proceed with measurements. Contact both the lab manager and the PI, who will instruct on steps to be taken.

ESS INO GENOP 260
Weighing Substrates for TECL Analysis

1. Scope and Application

1.1. This method outlines how to prevent trace element contamination while weighing several different types of substrates for the Trace Element Clean Lab (TECL). Often, pre-weights are taken on a cleaned substrate before it is sent to a client and gross weights are taken on it when it is returned to the lab. It is critical to obtain accurate and precise masses at each point, since final trace element concentrations are routinely reported on a per mass basis.

1.2. The use of mass control substrates allows for the correction of environmental variation in the weighing room, which can affect sample mass between the pre and gross weights.

1.3. Preferably, this method is performed using a computer-connected balance and barcode scanner to automatically record data. This helps prevent transcription errors. The balance used is identified on the bench sheet.

1.4. For instrument operating procedures, consult the appropriate instrument operating instructions.

2. Summary of Method

2.1. The preparation of the balance and connectivity of the computer, barcode scanner and balance in 215A are described.

2.2. Procedures are outlined for obtaining accurate masses while preventing trace element contamination when weighing different substrates.

2.3. Proper quality control, file and data management, and calculations for final mass (i.e., net mass) are also described.

3. Apparatus

3.1. MX5 or MT5 Mettler Microbalance or other balance as applicable
3.2. Non-metallic Forceps
3.3. Weight Table (optional)
3.4. Standard Weight Set
3.5. Computer (if connection to the balance is available)
3.6. Barcode Scanner (optional)
3.7. Square of Plastic to Cover Balance Pan
3.8. Antistatic Bars and/or Antistatic Gun

4. Preparing Any Balance for Weighing

4.1. If the balance is off, turn it on and let it warm up for 60 minutes before use. **DO NOT TURN OFF THE BALANCE.** If the balance is shut off the connection between balance and computer may be lost.

4.2. The balance should be in weighing mode.

4.3. The balance should be calibrated.

4.3.1. The MT5 microbalances in 215A, 116D and the Dark Room are set to automatically recalibrate as needed.

4.3.2. If the MT5 beeps and displays AUTOCAL on the screen during a weighing procedure, perform the available manual internal calibration. On an MT5 Mettler Microbalance, initiate this procedure by touching the Menu key on the middle left of the display screen, followed by pressing the ReZero bar.

4.3.3. Manual calibration is performed on the Sartorius after removing the large filter weighing rack and rezeroing the balance. Press the CAL button on the right of the screen.

4.4. The balance accuracy must be verified at three different weights and the weights recorded on each day of use.

5. Establishing Computerized Connection to the Microbalance

5.1. Log onto any available linked **c**omputer

5.2. If the balance has not been turned off, the computer connection should be active and can be opened by double clicking the balance.exe icon.

5.2.1. Under Set Up/Data String enter 0 for Horizontal Movement and 1 for Vertical Movement.

5.2.2. Open the Excel file of interest.

5.3. If the 215A balance has been shut off, go to: **START > Programs > Accessories > Communications > Hyper Terminal** Note: This is a program, not a folder

5.4. Open Hyper Terminal program by double-clicking

5.4.1. When first opening the program, choose **No** to make Hyper Terminal your default connection program.

5.4.2. Afterwards, choose a name of the connection (e.g., “balance”), and choose any icon (enter).

5.4.3. Lastly, choose “**cancel**” when “connect to” box appears to enter details for phone number

5.5. Once Hyper Terminal program is open, pull-down: **File > Open**

5.6. The default directory is probably wrong. Change the directory. Go to the directory under: **C:\program files\weights**

5.7. Open “**balance.ht**” by double-clicking (this is the program used to send commands to the balance).

5.7.1. Do you want to save it? = **Yes**.
5.7.2. You can also replace existing file (**Yes**).

5.8. Once this software widow is open (it looks like a blank screen), type in capital letters: **ST** (enter)

5.9. The balance should respond: ST A 1 (an incorrect response is ST A 0 or ST A).

5.10. If not, type: **ST 1** (enter)

5.11. If balance responds ST A *or anything other than* ST A 1, type ST (enter) and computer should respond ST A 1.

5.12. Type: **ST** (enter) to confirm. (You may have to repeat step 5.10 again).

5.13. The balance now should be properly sending weight data to the computer.

5.14. Close-out of Hyper Terminal program (i.e., you can disconnect = **yes**).

5.15. Open the main balance program ("balance.exe" on the desktop).

5.16. Enter the direction of cursor movement.

5.16.1. Set Up\Data String\ 0 horizontal\1 vertical.

5.17. Open the Excel file of interest from within the balance program to begin weighing.

6. Scanning Sample ID Numbers

6.1. Choose the appropriate cell of the spreadsheet

6.2. Place the center of the scanner slit over the bar code.

6.3. Click the button in the scanner handle to transfer the data.

6.4. Confirm that the number in the spreadsheet matches the number on the substrate.

7. General Procedures for Weighing Substrates

7.1. Equilibrate sample substrates along with appropriate mass control substrates in weighing room beforehand. Equilibration time varies for different substrates and for some isotope speciation.

7.2. Ensure Petri dishes are slightly open during equilibration time and a plastic sheet is covering the slightly open dishes to prevent particles from landing in the dishes or on the substrates.

7.3. Initial and Date the spreadsheet tab

7.4. Record the temperature and percent relative humidity at the beginning and end of each weighing.

7.5. **Relative humidity (RH) in the weighing room has marked effects on media weights.**

7.5.1. If the relative humidity exceeds 40%, no weighing should be performed other than Teflon split weights**.**

7.5.2. Harvard recommends weighing PUFs at 35% ±3% RH.

7.5.2.1. The 215a weighing room may average a slightly higher RH, especially in the spring and fall.

7.5.2.2. The Dark Room averages much lower than 35% RH. It is unadvisable for PUF preweights, but might prove to be the best environment for MCE media along with antistatic gun use.

7.5.2.3. Due to differences in room humidity it is advisable to try and weigh pre and post weights for a given substrate in the same room when possible, especially in the case of PUF substrates and substrates that are sensitive to RH.

7.6. Weigh three verification standards directly on the metal weigh pan and record on bench sheet. Record the verified weight of the standards used.

7.6.1. Avoid crushing, crumpling or dropping the weight.

7.6.2. Use a verification standard weight with a mass similar to the substrate if one is available.

7.6.3. Verification standards should agree with the posted mass within ± 5 µg.

7.7. If weighing a pre-cleaned substrate for metals analysis do not place substrate directly on the metal weigh pan. Place a small piece of clean plastic (cut a square piece out of a clean plastic bag) on the metal weigh pan.

7.7.1. The piece of plastic can be re-used for initial weights. Monitor plastic for particles when weighing samples and replace if dirty.

7.7.2. Tare the balance with the plastic square on the weigh pan.

7.8. Use a non-metallic forceps.

7.9. Tare (zero) the balance before each and every weight, regardless if it is sampling media, a control or check standard weight.

7.10. Remove static by holding substrate slightly over (but not touching) the ^{210}Po anti-static bars for a couple seconds.

7.11. If the weight "races" wildly up and/or down (much more than normal) when the substrate is placed on the weigh pan, this is probably due to static.

7.11.1. Remove the substrate immediately and don't record the weight.

7.11.2. Tare the balance again and repeat the static removal process.

7.11.3. It may be necessary to also remove the static from the small piece of plastic that has been placed on the weigh pan to prevent contact with metal.

7.11.4. An antistatic gun may be used if the ^{210}Po anti-static bars do not correct the instability problem.

7.12. To weigh the substrate and transfer data on an MT5 microbalance:

7.12.1. Choose the appropriate cell of the spreadsheet.

7.12.2. To open the glass draft shield of the weighing chamber press the **Select 1 or Select 2 key.**

7.12.3. Place the sample on the weigh pan and press the **Print key** to close draft shield.

7.12.4. The balance will need time to achieve equilibrium and will show a "○" in the upper left-hand side of the display window as long as the balance is unstable.

7.12.5. After the "○" has disappeared, the data will be automatically transferred into the outlined square of the spreadsheet.

7.13. If not using computer data collection, manually record the weight, and press Select 1 or Select 2 to open draft shield.

7.14. Remove the substrate.

7.15. Repeat steps 7.12 to 7.14 until all substrates, check standards and mass controls have been weighed.

8. Weighing and quality control (QC) for Teflon and polyvinyl chloride (PVC) Filters

8.1. Normally, equilibrate filters 12 hours before weighing.

8.2. For light sensitive samples, such as silver, platinum and vanadium, equilibrate 2 hours or as directed by the principal investigator. Dark plastic bags may be placed over the samples to reduce light exposure.

8.3. Before weighing, find the appropriate mass control filters and equilibrate all filters to room conditions simultaneously.

8.4. When pre weighing a substrate set, equilibrate "extra" clean filters without any ID numbers for replacement and lab blank purposes.

8.5. Handle filters gently by their edges to avoid puncturing the filters.

8.6. Visually inspect filters for holes and contaminants when preweighing.

8.6.1. DO NOT preweigh sample filters with holes or rips in them. Replace the filter with clean un-damaged filters

8.6.2. Filters with small holes may be used as lab controls or mass controls.

8.6.3. DO NOT preweigh filters with small fibers or particles on them. Remove the material or replace the filter.

8.7. Weigh each filter twice for the pre-weights and twice for sample mass post-weights.

8.8. Attempt to obtain the duplicate weights on the same day to ensure consistency in temperature and humidity conditions.

8.9. Quality Control Check Standards

8.9.1. A Check Standard should be weighed after every 10 filters.

8.9.2. Select a check standard with a weight similar to the filters.

8.9.3. Stop weighing if relative humidity exceeds 40% or if it varies by more than ± 3%.

8.10. Control Filters

8.10.1. The same mass control filters should be weighed with the pre-weights and the post-weights and in the same order to correct for environmental changes.

8.10.2. Mass control filters remain at the laboratory and should not be confused with field blanks or trip blanks, which are sent to a researcher.

8.10.3. Weigh mass control filters every tenth filter.

8.10.4. The same mass controls may be used for several batches of filters, but use several different mass controls per batch (i.e., don't keep weighing one mass control filter repeatedly for one batch).

8.10.5. If planning to use a mass control filter as an analytical blank, ensure it is not required to determine sample masses for any outstanding projects.

8.10.6. Lab Blank filters remain at this facility, but they are not preweighed. They may be analyzed to check for contamination and/or spike recovery in each batch of filters.

8.11. Data acceptability

8.11.1. The first and second substrate weight should be ± 5 µg within each weighing event.

8.11.2. If the difference between weights in an event is greater than ± 5 µg, a third weight can be taken.

8.11.3. If the difference is consistently over 5 µg, record the weight and the control filters will be used for correction.

8.11.4. If difference between filter weights in an event is regularly over 10 µg, contact supervisor.

9. Weighing and QC for Round Polyurethane Foam (PUF) substrates

9.1. Equilibrate PUFs at least 48 hours before weighing. Dark plastic bags may be used to reduce light exposure.

9.2. Before weighing, find the appropriate mass control PUFs and equilibrate all PUFs to room conditions simultaneously before weighing.

9.3. When preweighing a PUF substrate set, equilibrate extra PUFs without ID numbers for replacement and lab control purposes. Do not preweigh lab blanks.

9.4. Visually inspect PUFs when performing the first weighing.

9.4.1. Do not use PUFs with small fibers or particles on them.
9.4.2. Remove the material or replace the PUF.

9.5. Weigh each PUF once for the pre-weight and once for the gross (post) weight.

9.6. PUFs are very sensitive to environmental effects. Relative humidity should be between 32% and 40%.

9.6.1. Stop weighing if the relative humidity exceeds 40% or if it varies by more than ± 3% in a weighing session.

9.6.2. Store mass control and lab control PUFs out of direct lab lighting or sunlight.

9.7. Quality Control Check Standards

9.7.1. A check standard should be weighed for each 10 sample PUFs.
9.7.2. Use a 10 µg, standard weight for small PUFs.

9.8. Control PUFs

9.8.1. Intersperse the weighing of mass control PUFs before and after every 5 samples.

9.8.2. Weigh the same mass controls in exactly the same order for the pre-weights and gross weights.

9.8.3. The same mass controls may be used for multiple substrate batches.

9.8.4. Lab Blank PUFs may be analyzed to check for contamination in each batch of PUFs or used for spike recovery data.

9.9. Data Manipulation and Acceptability

9.9.1. Apply the average weight change of the bracketing mass control PUFs as a correction to the sample mass. This correction normally ranges between ±0.005 and ±0.040.

10. Weighing and QC for Polyurethane Foam Strips

10.1. Equilibrate PUF strips at least 48 hours before weighing.

10.2. Weigh each strip once for the preweight and once for the postweight.

10.3. To weigh long strips:

10.3.1. A 25 mm Teflon ring may be prepared by removing the Teflon filter membrane.

10.3.2. Tare the Teflon ring on the microbalance.

10.3.3. Wearing gloves fold the PUF strip in half and insert it into the ring.

10.3.4. Weigh the ring and strip.

10.4. Alternately, the strip may be sectioned and weighed in pieces or curled in a Petri dish.

10.5. Quality Control Measures

10.5.1. Mass control PUF strips are rarely available. Weigh periodically if they are provided.

10.5.2. Select a standard weight similar to the mass of the strips to weigh after each 10 strips.

10.5.3. Stop weighing if relative humidity exceeds 40%.

10.5.4. Stop weighing if relative humidity varies by more than 3% during a weighing session.

10.6. Data Acceptability and Manipulation

10.6.1. At the time of writing, there have been 2 studies involving PUF strip weights.

10.6.2. For 60 – 70 mg strips, a mass control weight variation of ± 0.120 mg is acceptable.

10.6.3. For 90 – 100 mg strips, a mass control weight variation of ± 0.200 mg is acceptable.

11. Weighing and QC for Zefluor Sheets on the Sartorius balance

11.1. Equilibrate sheets for 12 hours before weighing or an alternative time as directed by the principal investigator.

11.2. Perform the internal calibration and verify three check standards on the Sartorius Analytic Balance. Manually record the results.

11.3. Place the filter holder on the balance pan and tare out its weight.

11.4. Handle the sheets wearing gloves or use plastic forceps in each hand. Place the sheet into the filter holder and manually record the weight.

11.5. Weigh each sheet twice for preweights and twice for postweights.

11.6. The difference between the replicate weights from each event should not exceed ±0.0060 grams for an 8 inch by 10 inch sheet.

11.7. Quality Control Measures

11.7.1. Select a standard weight similar to the mass of the sheet to weigh after every 10 sheets.

11.7.2. Consider the expense of the media and the project requirements when preparing mass controls.

11.7.3. Stop weighing if the relative humidity exceeds 40%.

12. File Management

12.1. For preweights on new substrates

12.1.1. Open the folder Clean Room/FILTER WEIGHTS and choose the file for the year the filters are prepared or received from another source.

12.1.2. Make a copy of the appropriate weighing template from the first few sheets of the file and move to the end of the file.

12.1.3. Name the new sheet with the first media ID number and project name, if known.

12.1.4. Fill in the media numbers.

12.1.5. Connect to this file if using a balance linked to a computer and save periodically.

12.1.6. Print out the file if recording the weights manually and save the hard copy.

12.2. For postweights

12.2.1. Locate the appropriate preweight sheet or prepare a project weight sheet for the samples by combining the preweight data from several sheets.

12.2.2. Add any client identifiers in the appropriate column from the COC or scan in as the media is weighed.

12.2.3. Save periodically if working with the computer or save the hard copy if recording manually.

12.2.4. Save a copy of the postweight sheet, not the entire file, in the appropriate project subfolder.

13. Calculations

13.1. Gravimetric calculations on most substrates

13.1.1. Average the pre-weight for each filter (including controls).

13.1.2. Average the gross weight (after sampling has occurred) for each filter.

13.1.3. For mass control filters

13.1.3.1. Calculate the mass change (difference) between pre and gross weights for each mass control filter.

13.1.3.2. Average the mass changes of all mass control filters in the sample batch.

13.1.4. Final sample weight = average gross weight – average pre-weight ± average mass control change if greater than ± 5 in the last decimal place.

13.1.5. Uncertainty = standard deviation in the mass control changes X final sample weight.

13.2. Calculations for mass on PUF substrates.

13.2.1. Calculate the mass change between pre and gross weight for each mass control PUF.

13.2.2. Average the mass control PUFs bracketing each group of 5 PUFs

13.2.2.1. Apply this average mass control change to each individual sample weight between the bracketing controls.

13.2.2.2. Repeat for each group of 5 PUFs.

13.2.3. Final sample weight = gross weight - pre-weight ± average mass control correction

13.2.4. Uncertainty = standard deviation of all mass control changes X final sample weight.

14. References

14.1. 8½" x 11" manual called Operating Instructions METTLER TOLEDO AX and MX/UMX Balances, 2000.

14.2. 5⅞" x 8¼" manual called Operating Instructions METTLER MT/UMT balances, Mettler/Toledo AG 1993, ME-704791B.

Revision Tracking Table:

Revision number	Revision date	Changes Made	Revision author
2	Oct. 2012	Wording changes in sections 1, 2.2, 11, 12, 13 Added MT5 balance in section 3.1 In section 4.3 added balance calibration info In section 7.5 added relative humidity instructions In section 8.2 added instructions for light-sensitive samples. In section 9 added additional info for PUFs Updated NELAC reference, and added additional references Added a revision tracking table as a required element	James Swarthout

Signatures

Written by: ___Pamela S. Skaar_____ Date: _____10/18/12_____

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Title: ___Chemist - Supervisor_____

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Certification Statements received from:

Na Zhang

Christa Dahman

STANDARD OPERATING PROCEDURE FOR INDOOR/OUTDOOR AIR QUALITY FIELD SAMPLING

OVERVIEW

I/O PM sampling will involve use of a Cascade Impactor (CI), a PEM sampler, an Ogawa sampler, and a HOBO. The 5 LPM PUF cascade impactor was designed and evaluated at the Harvard School of Public Health. The major feature of this novel sampler is its ability not only to fractionate the particles with an aerodynamic diameter smaller than 10 μm into various size fractions, but also to collect them onto relatively small inert polyurethane foam substrates. It operates at a flow rate of 5 LPM and uses a 4-stage configuration, which consists of three impactor stages using slit-shaped acceleration nozzles plus a backup filter.

This configuration combines use of the 10 μm stage to remove particles above 10 μm, with the 2.5 μm stage to collect (coarse) particles between 10 and 2.5 μm ($PM_{10-2.5}$), and another stage for PM 0.2-2.5. The backup filter is placed downstream of the stage and is used to collect the particles with an aerodynamic diameter smaller than 0.2 μm. By adding the coarse and fine mass concentrations together, the total respirable mass (PM_{10}) is determined. This configuration has been successfully applied to extensive field studies, with results reported in several peer-reviewed publications.

PEM samplers for PM 2.5 monitoring will be set-up alongside the Cascade Impactors (both indoors and outdoors) and contained within the same sampling box (see Pump Box SOP for schematic). Identical boxes will be used for both indoor and outdoor sampling. The boxes will be set either on a tripod outdoors or a wooden base indoors. The tripod will keep them off the ground with the inlet at 72". The wooden base will keep the box off the floor, stable from tipping and at 45".

SAMPLING

FIELD MATERIALS FOR INDOOR/OUTDOOR SAMPLING

(2) Pump boxes – 1 indoor and 1 outdoor per home
(2) Pre-loaded PEMs in resealable bags with PEM set-up field logs
(2) Pre-loaded Cascade Impactors in resealable bags with CI set-up field logs
(2) Harvard calibration caps-*same type of calibration cap used for both PEM and CI*
Flow meter (s) (Bios Defender 520)
Tripod (outdoor)
Wooden base (indoor)
Cooler containing 2 ozone brown bottles with loaded Ogawa Badge samplers in summer
(1)HOBO

Tool box containing:
- Kimwipes
- Extra tubing
- Wire cutters
- Large plastic wire ties
- Large Phillips head screwdriver
- Ground fault interrupter
- Needlenose pliers
- Paper tape
- Pens
- Duct tape
- 3-prong and 2- prong extension cords
- Plastic wrap/bags to waterproof exten. cords
- Insulation for windows
- Electrical tape
- Plug adapters
- Towels or pads for furniture
- Labels for HOBOs (needed at take-down)

SELECTING SAMPLER LOCATIONS

THERE ARE TWO LOCATIONS FOR SAMPLE COLLECTION

- outdoors
- indoors

OUTDOOR APPARATUS LOCATION SELECTION

- The outdoor sampling box will be set-up on a tripod, which will be set up so as to elevate the inlet of the samplers 72" above the ground.

- Determine the best location for outdoor sampler placement. Preferably, the tripod should be placed in the backyard or otherwise blocked from view of the street. Take care to make sure outdoor sampler boxes are:

    - located **away** from:

        - Trees
        - Sprinklers or other water sources
        - Garage or driveway
        - Trucks, busses, cars, or other internal combustion engines
        - Walls or other surfaces. A distance of 1 m or more from vertical surfaces is adequate.

- In some cases, samplers may have to be set-up on a balcony, which may not meet the criteria listed above, if that is the only outdoor location available. In this case, locate the tripod and sampling box as far from the house as possible, try not to place it under a tree, near any sprinklers or other water sources, near a garage or driveway.

- The outdoor location must have access to power with the cord secured to ground. You may use an indoor outlet, with the cord routed out a window to obtain power, if necessary.

    - Check with the participant for a suitable power source for the pump. Plug in the ground fault interrupter and plug the extension cord into the ground fault interrupter. If no outdoor power is available, a power cord can be plugged in inside and run out a window. If running the cord through the window, consider security of the home and block airflow through the window. Make sure any extension cord connections outdoors are covered with plastic and secured with electrical tape to avoid electrical hazards. Do not cross walkways unless absolutely necessary, and use reflector tape if needed.

    - The electrical extension cord must include a ground fault interrupter device (at the source wall).

- The location selected must be easily accessible and useable for subsequent occasions.

INDOOR APPARATUS LOCATION SELECTION

- The indoor sampling box will be placed in a wooden base, which will elevate the inlet of the samplers 45" above ground, in the main living area of the home. This is the main room that the participant spends the majority of their awake time. Make sure to discuss with the participant's parent about where the child spends the majority of their awake time.

- Determine the best location for indoor sampler placement. Take care to make sure indoor sampler boxes are:

    - located **away** from:

        - combustion sources (i.e. fireplaces),

- devices that blow air or directly affect particle levels such as:
    - radiators,
    - vents,
    - baseboard heaters,
    - air conditioners,
    - windows,
    - ceiling fans
    - and TVs
- directly under a light
- gas stoves
- a door to a garage
- sources of water (bathrooms, kitchen sink, etc)
- behind furniture
- walls
    - sampler box should be at least 1 foot from the wall, if possible. This may not be possible in all homes (especially small homes), so samplers should be placed as far from the wall as possible, without causing a problem for the occupants of the home or causing a tripping or safety hazard.

- The location selected must be easily accessible and useable for subsequent occasions.

SET-UP SAMPLER

ONCE THE SAMPLE LOCATIONS HAVE BEEN LOCATED, FOLLOW THE DIRECTIONS BELOW FOR EACH PUMP BOX.

a) If summer, remove from the cooler both of the brown storage bottles containing the Ogawa Badge samplers. Leave these at room temperature for 20 minutes while the pump boxes are warming up. Do NOT open the brown storage bottles until the samplers have come to room temperature (after the 20 minutes).

b) Warm up the pump boxes for at least 20 minutes. Confirm that there is a pump box check sticker. The pump boxes can be warmed up in any convenient location, as such it can be done while selecting and setting up the sampling locations or in the sampling locations, after they are selected, depending on the home environment and space available.
    a. Plug in the pump box.
    b. Open the pump box and turn on the pump by pressing the “ON/OFF” button on the timer box 2 times. Close the pump box door while the pumps are warming up.

c) While the pumps are warming-up, insert the inlet tube into the Swagelok connector on the top of the pump box. Tighten Swagelok connector. See figure 1 below.

Figure 1.

NOTE: AVOID PUTTING FINGERS OVER INLETS ON ALL PEMS AND CIS DURING SET-UP, AS THIS CAN CAUSE BACK PRESSURE AND DISLODGE OR BLOW A HOLE IN THE FILTER.

d) Remove CI and associated set-up field log from resealable bag and place the CI on the plastic bag. Confirm that the ID labels on the sampler match the labels on the field log. Also confirm that the CI # on the CI (each CI has a number etched on the outside of stage 4 of the CI) and the CI # on the field log match. Fill out the Household ID, set-up date, and location information on the field log.

e) Repeat the directions above (d) for the PEM sampler.

f) After the pumps are warmed-up, turn off the pumps and unplug the pump boxes, so that CI and PEM samplers can be installed.

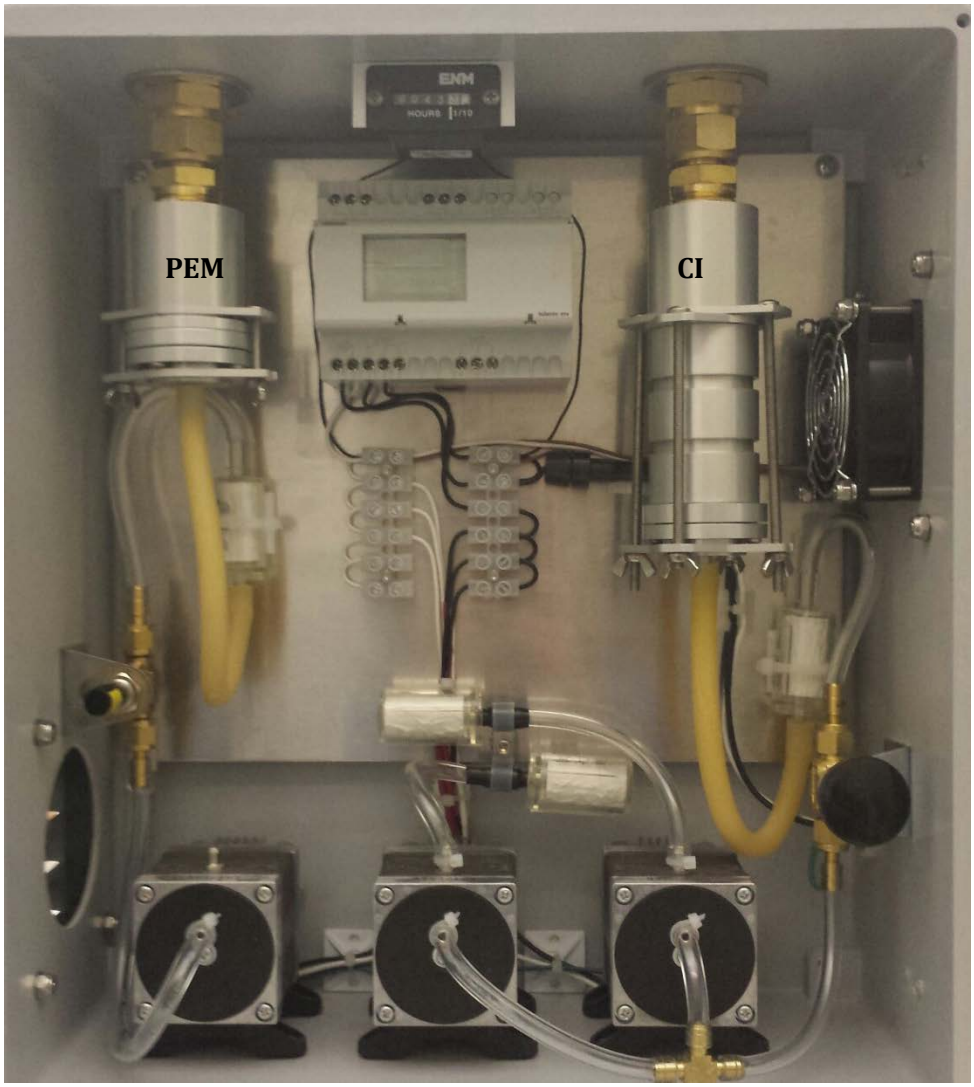

Figure 2.

g) Attach the cascade sampler to the pump. See figure 2 above.

h) Attach the PEM to the pump. See figure 2 above.

i) Plug pump box in and turn on the pumps. Record both the watch times and pump times for the CI and PEM on the respective field logs.

j) Attach a calibration cap to the inlet end of the CI sampler and measure the initial flows using the flow meter. Adjust the flow to between 5.0 and 5.25 LPM (left—looser, right—tighter). The flow meter is set to average three flows; measure the flow 3 times. Record the average adjusted flow.

k) Attach the calibration cap to the PEM and check initial flows. Adjust valves to bring flows to between 1.8 and 1.83 LPM (left—looser, right—tighter). The flow meter is set to average three flows; measure the flow three times. Record the average adjusted flow.

l) Remove the calibration caps from samplers and attach both samplers to the corresponding adapters in the pump box. Place screws through holder and plates to secure samplers in place.

m) Check over the field logs (PEM, CI,) and make sure that all details are completed, e.g., date, operator initials, and sample day.

n) Close and lock the pump box.

o) Place the pump box on tripod or wooden base, as applicable.

p) Attach HOBO, using Velcro adjustable strap, to one inlet tube on the top of the **indoor** pump box only. Record HOBO ID# on the CI field log.

q) If summer, open the brown storage bottles containing the Ogawa Badge samplers. Remove the badges from the bottles and then remove from the re-sealable bags. Attach ozone Ogawa badge sampler to one inlet tube on **both indoor and outdoor** pump boxes. See figure 3 below.

Figure 3.

r) Replace the re-sealable bag (with desiccant pack) in the brown storage bottle and tape the storage bottle to the bottom of the inlet tube

s) Fill out the remainder of the Ogawa Badge set-up field log, including the pump box number, and start watch time.

t) Upon returning to the field office, place field logs in the participant file. Place all participant files in the lockbox.

REMEMBER THAT THERE ARE 2 SAMPLING BOXES AT EACH HOME, ONE INDOORS AND ONE OUTDOORS. TAKE THE PUMP BOXES DOWN ONE AT A TIME FOLLOWING THE INSTRUCTIONS BELOW.

a) If summer (a-e), remove the Ogawa sampler from inlet tube. Using a sharpie, make an "x" on the label on the sampler to indicate that the sampler has been used.

b) Fill out the Ogawa sections of the take-down field log, including the sample ID and the end watch time.

c) Place the Ogawa sampler in the re-sealable bag that is contained in the brown storage bottle that was taped to the bottom of the inlet tube. Record the Household ID, the take-down date, and whether the sample was used as a blank or duplicate, on the re-sealable bag.

d) Double check that the label on the brown storage bottle matches the label on the Ogawa badge sampler and mark an "x" on the label on the brown storage bottle to indicate that it contains a used sampler. Place the re-sealable bag, containing the sampler, in the brown storage bottle and screw the cap on tightly.

e) Place the brown storage bottle a cooler with frozen ice packs for transport back to the field office.

f) Open pump box and check that fan and pump are running (**do not turn off pumps yet**). Check elapsed timer. Loosen and remove screws holding samplers to adaptors in pump box.

g) Remove samplers from adapters.

h) Attach calibration cap and measure off flows for both samplers. The flow meter is set to average three flows; measure the flow 3 times and record the average for each sampler. Record flows on field log.

i) Turn off the pumps by pressing the "ON/OFF" button 2 times, then un-plug the pump box and then remove the samplers from the pumps. Record the end pump time and end watch time on the take-down field log.

j) Place the samplers in the re-sealable bags for transport. Record the Household ID and the take-down date on the re-sealable bags.

k) Place the samplers (in bags) in the cooler for transport back to field office.

l) If you are taking down the indoor samplers, then remove the HOBO from indoor sampling box write the take-down date on the HOBO label. If you are taking down the outdoor samplers, skip this step.

m) Upon returning to the field office, place all field logs in the participant file. Place all participant files in the lockbox.

n) If the field log indicated that the pump is off for unknown reason or the sampling equipment appears damaged, notify the project manager.

a) If the home you are visiting is scheduled for blank and duplicate sample collection, then be sure to have a total of 4 CIs, and 4 PEMs . If this house is scheduled as QA/QC house, then be sure to grab a QA/QC Ogawa bag along with a single Ogawa sampler, so that you have a total of 4 Ogawa badges going out into the field with you. Also be sure that you know whether this house is scheduled for an indoor or outdoor blanks and duplicate. Blank and duplicate households will be dispersed between indoor and outdoor locations.

DUPLICATES

a) If home is scheduled for duplicates, treat the same as primary samplers and set-up a second pump box, either inside or outside, as specified.

b) Make sure to fill out the field log as a duplicate for these samples.

BLANKS

OGAWA BADGE SAMPLERS:

SET UP:

a) When the Ogawa field samplers are deployed, do NOT take the "Blank" Ogawa samplers out of the brown storage vials. The bottle containing the blank sampler must be kept closed and the whole bottle, containing the sampler, should be taped to one of the inlet tubes on the indoor or outdoor pump box as specified, so that the "Blank" sampler is kept at the same temperature and field conditions as the field sampler.

b) Fill out an Ogawa set-up field log for the blank sampler.

TAKE DOWN:

a) Untape the bottle containing the blank sampler from the inlet tube. Open the bottle and mark the Household ID and the take-down date on the re-sealable bag that contains the sampler.
b) Remove the sampler from the bag and mark an "x" on the label to indicate that it was used. Replace the sampler in the re-sealable bag, place the bag in the bottle and secure the bottle cap. Place an "x "on the label on the bottle as well.
c) Place the blank sampler in the cooler along with the primary field sampler for transport back to the field office.
d) Make sure to fill out a take-down field log for the blank samples.
e) When the exposed samples are returned, put both blank and primary field sample bottles into the refrigerator at the same time. The total time out of the refrigerator (at room temperature, more or less) should be the same as that for the field sample. Then all the blanks will be comparable, and can all be pooled for the analysis. The blanks are stable after sampling only when kept refrigerated.

CI AND PEMS:

a) Take the blank out of the bag, leave on plastic bag while assembly is occurring, then place back in bag. Write the Household ID and the set-up date on the bag.
b) Make sure to fill out the field log as a blank for these samples.
c) Take back to field office and place in refrigerator.

STANDARD OPERATING PROCEDURE FOR PUMP BOX

PUMP BOX DESCRIPTION

The pump boxes house all PM samplers to prevent access by children who may take an interest in the samplers (Figure 1). Indoor pump boxes are placed on a wooden base, and outdoor pump boxes are supported by a tripod.

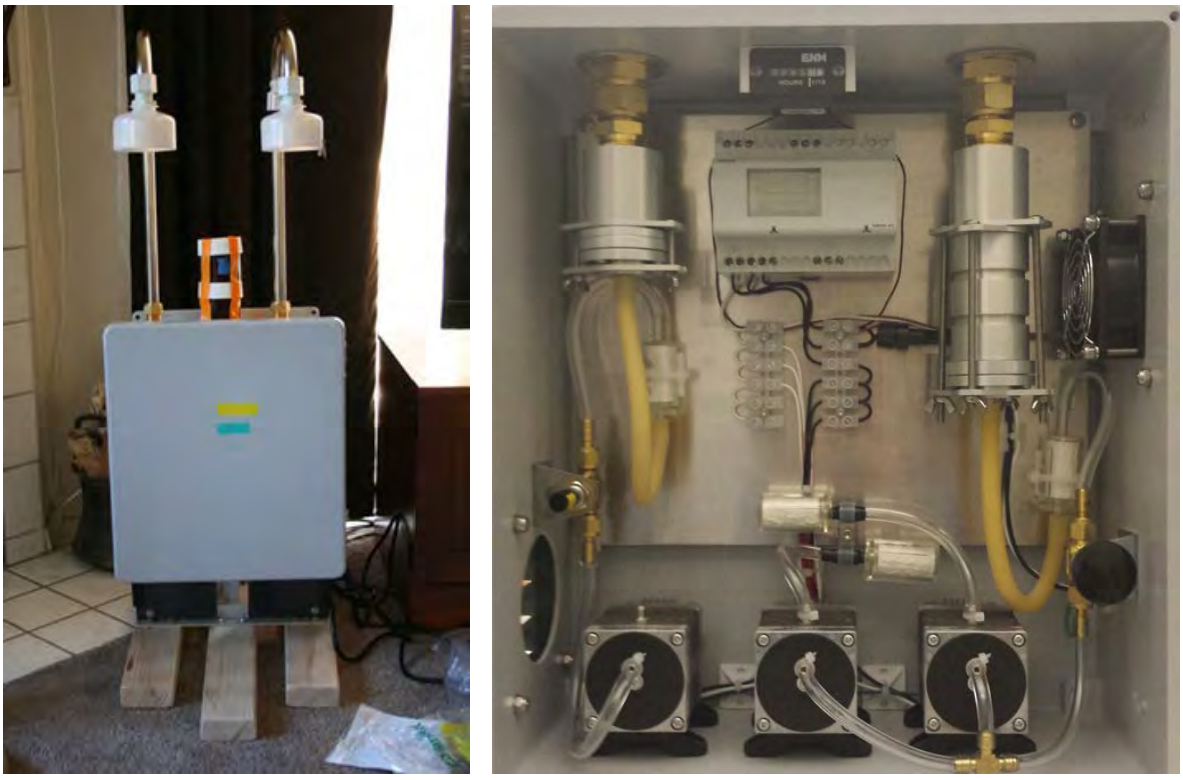

Figure 1. Outside and inside view of a pump box

The pump boxes were designed to hold one 5 LPM Cascade Sampler with two Medo pumps VPO125- 7 LPM (MEDO, Roselle, IL), one 1.8 LPM PEM with one Medo pump VPO140 -3 LPM (MEDO, Roselle, IL), and connect them to the sampling inlet. Each sampler has its own inlet tube. The pump boxes are also equipped with a flow control valve Milli-Mite 1300 Series 1315G4B (Hoke, Spartanburg, SC) for each sampler, a two-channel timer Talento 992+ (RS, Northamptonshire, UK), and an exhaust system. When the timer is launched with the launching program, in the case of a power outage, the pumps would turn back on once the power comes back on with this control timer. There is an hour meter to record elapsed time that the pumps ran for. Identical boxes and inlets are used indoors and outdoors.

SPECIFICATIONS

Dimensions of the box: 18" High x 14" Wide x 5" Deep

Tubing configuration: The metal tubing connecting to the sampling inlets will be in the shape of a candy cane, with a gentle, swept 180º turn near the top. For the latex tubing connecting pumps and impactors inside the pump box, the inside diameter is 3/16 inch and the thickness of the tubing is 1/8 inch.

Inlet configuration: The inlets are 0.625 inch inside diameter, made of aluminum. **Height:** Indoor- 36", Outdoor- 62". The indoor height is based on the breathing height for children in the older portion of our age range. The outdoor height is the standard height for collection of outdoor samples.

Flow control valve: Hoke number 1315G4B. Product description is attached.

Name and model number of pumps: 5 LPM Cascade Sampler- 2 Medo VP0125- 7 LPM (nominal life -
3,000 hours), 1.8 LPM PEM- Medo VP0140 -3 LPM (nominal life - 3,000 hours). Product description is attached.

Pump timers and hour meters: A two channel Talento control timer will be used. The time will be set for 9 days. In the case of a power outage, the pumps will turn back on when the power comes back on with this control timer. Sampling schedule will be adjustable with this timer. Each pump will have its own hour meter to record elapsed time. Product description is attached.

CLEANING

MATERIALS

Pump box
Kimwipes
Flashlight
Distilled Water
Isoproanol (Isopropyl alcohol)

CLEANING PROCUDURE

- Cover one end of the inlet with your hand and use a flashlight to look down the other end of the inlet. If obviously soiled, rinse with Isopropyl alcohol, by rinsing the inside of the inlet tube using the alcohol in a squeeze bottle and squirting the alcohol on the inside of the inlet, making sure all sides get rinse, then repeat from the other end of the inlet to ensure through rinsing.

- Wipe down pump box with a dry kimwipe. If box is heavily soiled a kimwipe damped with distilled water can be used, as needed.

MAINTENANCE

- Prior to doing maintenance check, remove old date check tapes of field labels from the pumpbox.

To make sure pump boxes are working well:

- Plug in pump and check the fans on the pumps box. Fans can get rattley. If you hear a whirring noise, unplug and re-plug in. If the fan is not operating or rattley noise is so loud that it will disturb the participant, put a piece of tape on the box that says “Do not use”. Notify Rebecca Moran.

- Check to make sure that the noise level of the pumps has not increased, as this is an indication that the pump is becoming worn out. If the pump sounds louder than normal, put a piece or RED tape on the front of the box that says “PUMPS BAD” and the date. Don’t use this box. Notify Rebecca Moran.

- Check that all the screws are tight and that wires are secure by touching each one. If a screw is loose, tighten it. If a wire is loose, put a piece of tape on it that says “Do not use” and notify Rebecca Moran. Tighten the screw securing the three wires regardless of whether or not it is loose.

- Visually check that the tubes are all connected and zip ties are on the tubes. Additionally, shake each tube to confirm a secure connection. If any tubing is loose or off, fix it. Replace zip-ties if needed.

- Touch timer to confirm it is securely fastened.

- Make sure the sampler adaptors have both wing nuts AND lock nuts on the screws.

- Make sure the pump box has a lock.

- Once the box has been cleaned and checked and all the maintenance items have been checked, place a white piece of tape on the front of the box that says “Date checked: xx/xx/xxxx”

HOKE

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Spartanburg, SC 29303

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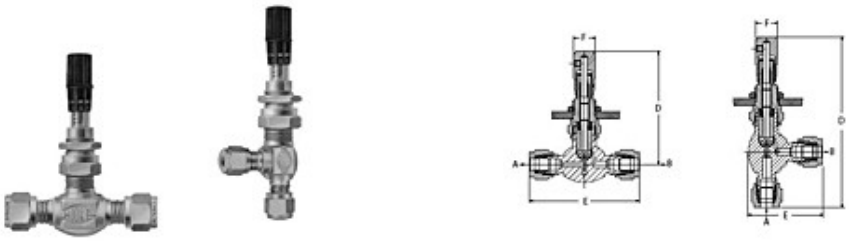
Item # 1315G4B, Milli-Mite 1300 Series

List Price QUOTE

Forged Metering Valves

Typical Applications

- Fine metering in medical and biochemical gas or vapor analysis
- Sampling and analyzing water and air pollution
- Chromatographs, mass spectrometers and other instruments where fine metering is required



SPECIFICATIONS

Connections - Inlet	1/4" Gyrolok
Connections - Outlet	1/4" Gyrolok
Flow Pattern	Globe
Body Material	Brass
Operating Pressure Range	3000 psig at 70° F (207 bar at 21° C)
Operating Temperature Range	-65 to +400 ºF -54 to +240 ºC
Cv	0.024 in
Stem	3° STEM
Orifice	0.047 in 1.19 mm

D	3 1/4 in 83 mm
E	2.38 in 60 mm
F	0.50 in 13 mm
Panel Hole	0.52 in 13 mm
Panel Thickness	0.16 in 4 mm
Features &Benefits	• Metering accuracy - 18 turn displacement of stem provides unparalleled performance and repeatability • 1° and 3° stems provide a wide flow range with ultra fine metering control • Panel mounting is standard for all valves • Precision orifice and close thread tolerances minimize hysteresis • Micrometer vernier handle provides visual control and repeatable stem settings • Dyna-Pak wafer packing below the stem threads provides leak tight service

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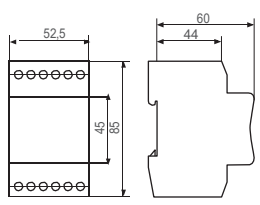
Technical data

	talento 891 plus talento 892 plus	talento 991 plus DCF talento 992 plus DCF
	45 x 52,5 x 60	45 x 52,5 x 60
Dimensions H x W x D (mm)		
Distributor cut-out (mm)	46 x 54	46 x 54
Weight (g) approx.	180	250
Connection voltage	230V 50-60 Hz	230 V 50-60 Hz
Power consumption at 230 V AC	5 VA	5 VA
AC switching capacity		
– ohmic load (VDE, IEC)	16 A / 250 V AC	16 A / 250 V AC
– inductive load cos. φ 0.6	10 A / 250 V AC	10 A / 250 V AC
– Incandescent lamp load	2600 W	2600 W
– Halogen lamp load	2600 W	2600 W
– Fluorescent lamp, compensated	1000 W	1000 W
– Fluorescent lamp, uncompensated	1000 W	1000 W
– Rated load AC1	3700 VA	3700 VA
– Rated load AC15	750 VA	750 VA
DC switching capacity 24 V DC/50 V DC/220 V DC	800 mA / 300 mA / 150 mA	800 mA / 300 mA / 150 mA
Switch contacts	1 changeover contact (talento 891 plus) 2 changeover contacts (talento 892 plus)	1 changeover contact (talento 891 plus) 2 changeover contacts (talento 892 plus)
Ambient temperature	-10°C ... +55°C	-10°C ... +55°C
Protection class	II	II
Accuracy	typ ± 1 s/day at +20°C	typ ± 1 s/day at +20°C
Power reserve	3 years from factory at +20°C	3 years from factory at +20°C
Shortest switching time	1 sec	1 sec
Programmable every	min	min
Memory spaces	800	800
Manual switch	automatic / preselection Fix ON/Fix OFF	automatic / preselection Fix ON/Fix OFF
Block formation of weekdays	free assignment	free assignment
Date range	yes	yes
Random generator	up to 30 min	up to 30 min
Switching state display	yes	yes
Pulse switching commands	yes: sec, min	yes: sec, min
Cycle switching commands	yes: sec, min, h, days	yes: sec, min, h, days
Hour counter with service function	yes	yes
Summer/winter time changeover	automatic / freely selectable / off	automatic / freely selectable / off
External output	yes	yes
– Override	yes	yes
– Countdown	up to 90 min/with 30 sec intervals	up to 90 min/with 30 sec intervals
Max. Terminal capacity	4 mm²	4 mm²
Connection type	captive ± screw terminals	captive ± screw terminals

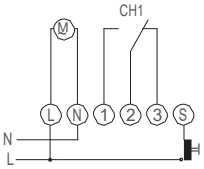
Communication between talento 89x/99x plus, talento CE plus and talento LAN plus via Grässlin Powerline protocol.

Dimensional drawings/ circuit diagrams:

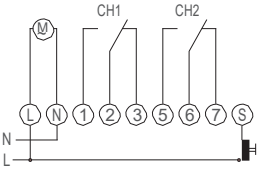
talento 89.. plus, 99.. plus DCF



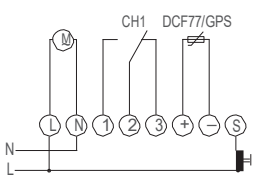
talento 891 plus



talento 892 plus



talento 991 plus DCF



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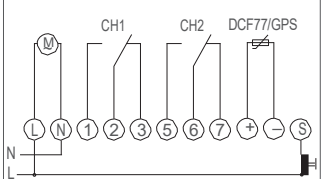


STANDARD OPERATING PROCEDURE FOR HOBO U23/U10 DEPLOYMENT AND MAINTENANCE

SUMMARY

The HOBO U10-003 and HOBO U23-001 are Temperature/Relative Humidity Data Loggers. Each logger can record up to 52,000 measurements. The HOBO U10 logger uses a direct USB interface for launching and data readout by a computer. The U23 logger uses an optical USB communications interface via a compatible shuttle or base station for launching and reading out the logger. The optical interface allows the logger to be offloaded without compromising the electronics. The USB compatibility allows for easy setup and fast downloads. Two different model numbers are used as we have a number of each in the Bennett Exposure Laboratory.

TO LAUNCH THE DEVICE:

1) Before launching the HOBO, check the status of the battery. If you are using the U10 HOBO, check the battery before connecting the device to the computer. If you are using the U23 HOBO, check the status of the battery after connecting the device to the computer.

    - U23 HOBO: Battery status can be viewed in the Launch Logger screen (Figure 6). If the battery status is not "Good," then the battery should be replaced before deployment.

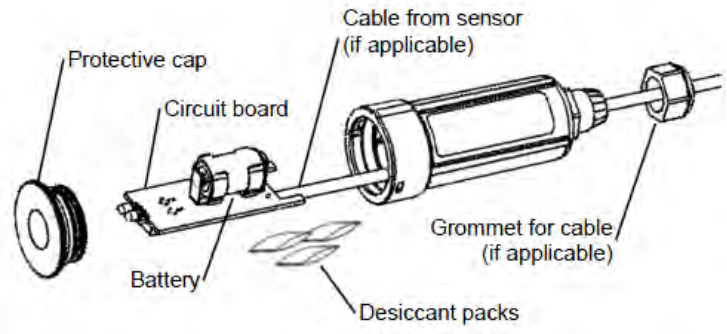


FIGURE 1

1. Turn slightly counter-clockwise and pull to remove the protective cap.
2. Carefully pull out the circuit board containing the battery.
3. Examine the desiccant packs that were packed into the case. If the desiccant is not bright blue, put the desiccant packs in a warm, dry place until the blue color is restored.
4. Install a new **1/2 AA, 3.6 Volt lithium battery**. The positive end of the battery should face towards the communication LEDs.
5. Use a clean, dry cloth to wipe away any moisture inside the case.

6. Push the board and the desiccant packs back into the case, taking care not to bend the communication LEDs. Align the board with the grooves inside the case. (If you try to put the board in upside-down, the battery will get in the way.)

7. Make sure o-ring on the protective cap is still in place. It should not be pinched, twisted, or trapping dirt or lint, which could interfere with the protective cap.

8. Line up the bumps on the protective cap with the notches in the logger's case. Push and turn the cap slightly clockwise.

- U10 HOBO: Open the case by unsnapping the side cover. Lift the circuit board and carefully push the battery out with a small blunt instrument, or pull it out with your fingernail. Use the battery tester to measure battery voltage. If the battery falls below 3.3 V, the battery must be replaced.

    1. Open the case by unsnapping the side cover.

    2. Lift the circuit board and carefully push the battery out with a small blunt instrument, or pull it out with your fingernail.

    3. Insert a new **3-Volt CR-2032 lithium battery**, positive side facing up.

    4. Carefully realign the logger in the case and re-close it.

2) Launch the HOBOware software on the computer.

3) Connect the HOBO to the computer

- **HOBO U23**: Place the coupler on the Optic Base Station and insert the HOBO into the coupler. Plug the Base Station into the USB port on the computer.23

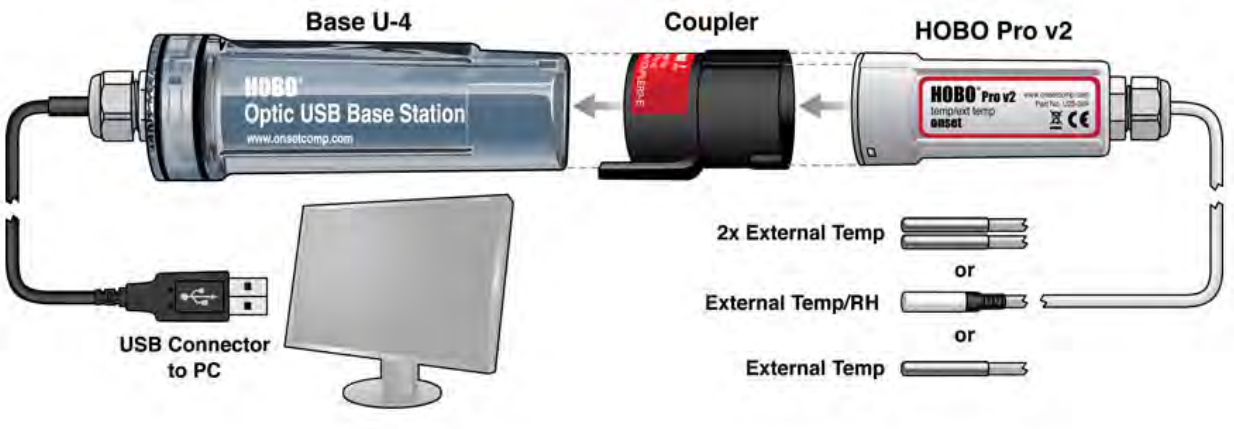


FIGURE 2

- **HOBO U10**: Plug the USB directly into the HOBO itself (base station and coupler are not required)

FIGURE 3

4) Click the Launch Device button in the task bar illustrated below.

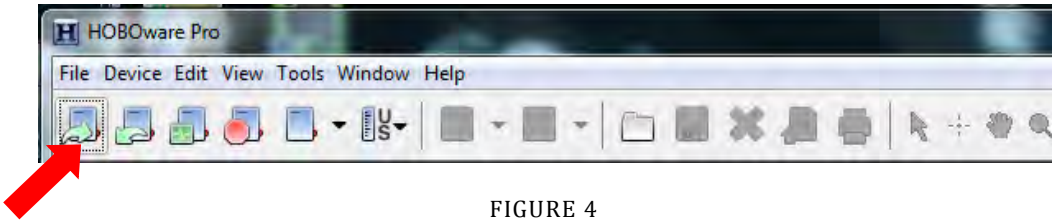


FIGURE 4

5) Select the communication preference.

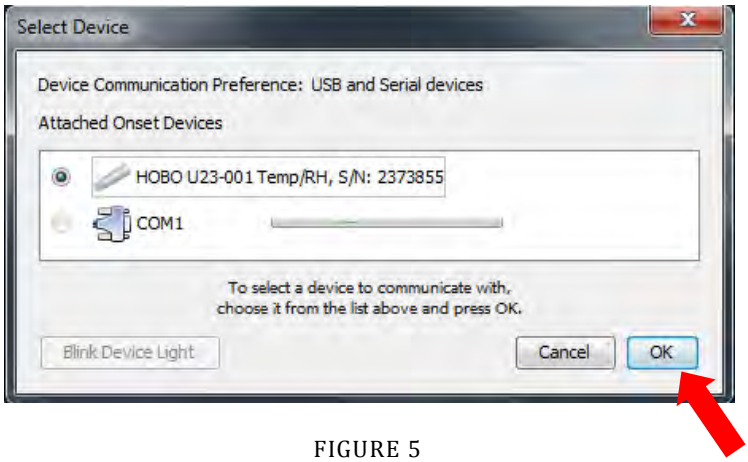


FIGURE 5

6) Confirm that the logging interval is set to 1 min, that the description is set to the serial number of the HOBO, and that you are recording the temperature relative humidity and battery voltage. Set the launch option "Start Logging" to now.

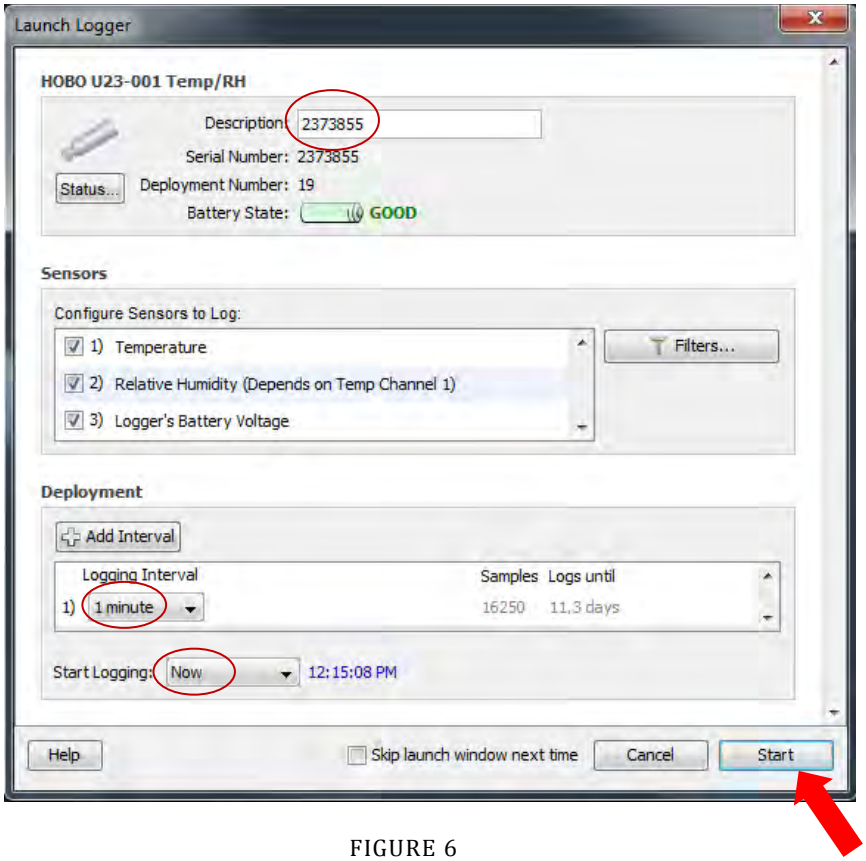


FIGURE 6

7) Launch the logger by pressing start.

8) Unplug the HOBO and begin collecting data.

9) A light (LED) in the communications window of the logger confirms logger operation. When the logger is logging, the LED light will blink once every 1 to 4 seconds (the shorter the logging interval, the faster the light blinks). If the logger is awaiting a start because it was launched in "Start At Interval" or "Delayed Start" mode, it will blink once every 8 seconds until logging begins.

TO READOUT DEVICE AND SAVE DATA:

To retrieve data recorded by a logger, you must read out the logger. Reading out the logger copies data from the logger to your computer, allowing you to save the data in a data file and view the plot. During readout, the logger continues to record data unless you have stopped the logger or the logger is full.

1) Launch the HOBOware software on the computer.

2) Connect the HOBO to the computer

- **HOBO U23**: Place the coupler on the Optic Base Station and insert the HOBO into the coupler. Plug the Base Station into the USB port on the computer.

- **HOBO U10**: Plug the USB directly into the HOBO itself (base station and coupler are not required).

3) Click the Readout Device button in the task bar illustrated below.

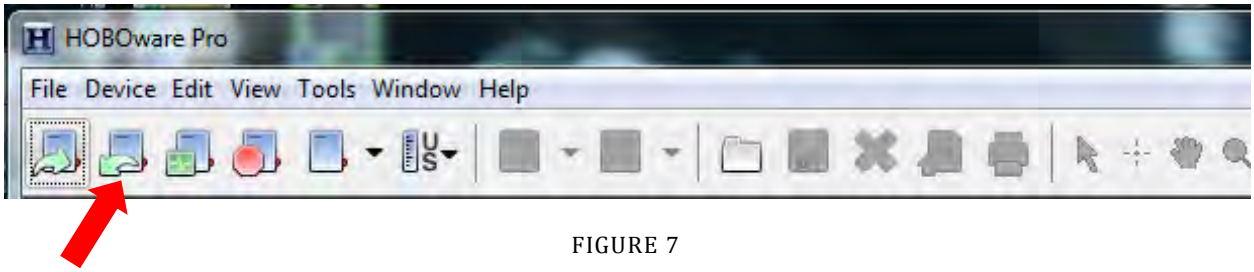


FIGURE 7

4) Select the communication preference.

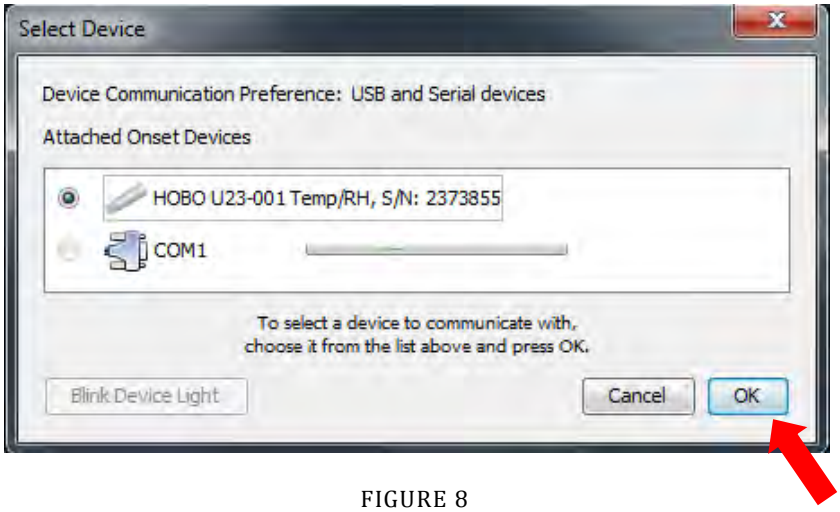


FIGURE 8

5) Stop logging in order to read out the logger.

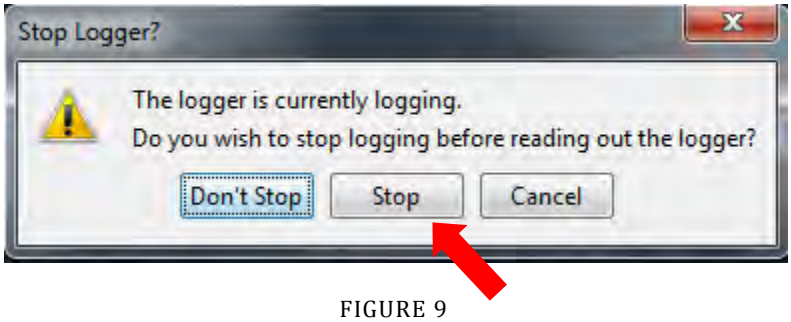


FIGURE 9

6) Save the HOBO file in the following format: [household ID]_[2 digit HOBO ID]_[takedown date] (ex: 50000_16_05122013). There will be a sticker on the HOBO that states the household ID and the takedown date. The HOBO ID is permanently marked on each HOBO.

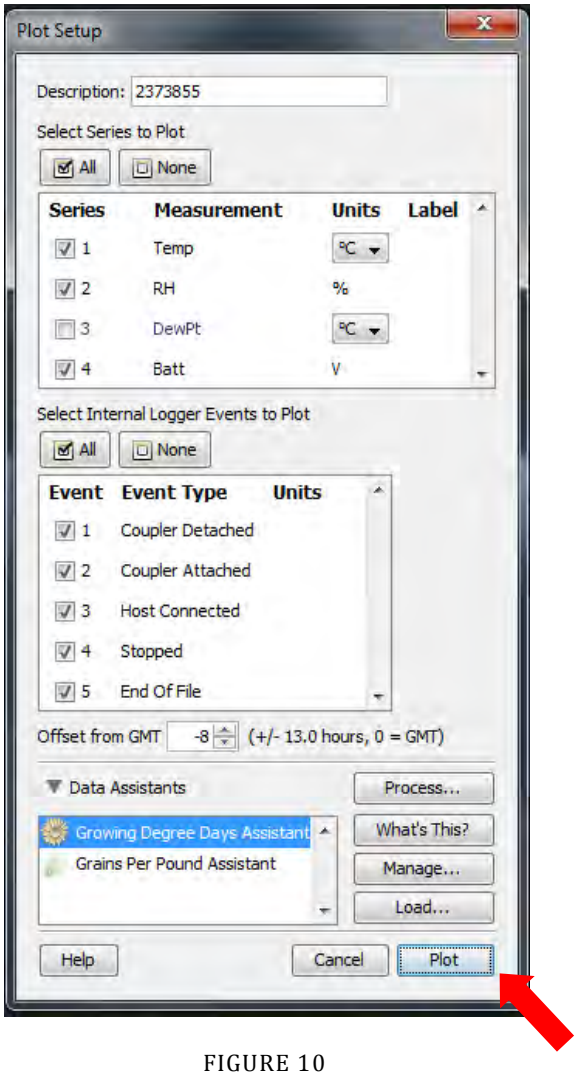


FIGURE 10

7) A plot setup screen will display. Set units to degrees centigrade (°C). Confirm that the offset from GMT is -8 as shown in Figure 10. Select the "Plot" option to load the results.

8) After selecting plot, you will be taken to the results page (Figure 11).

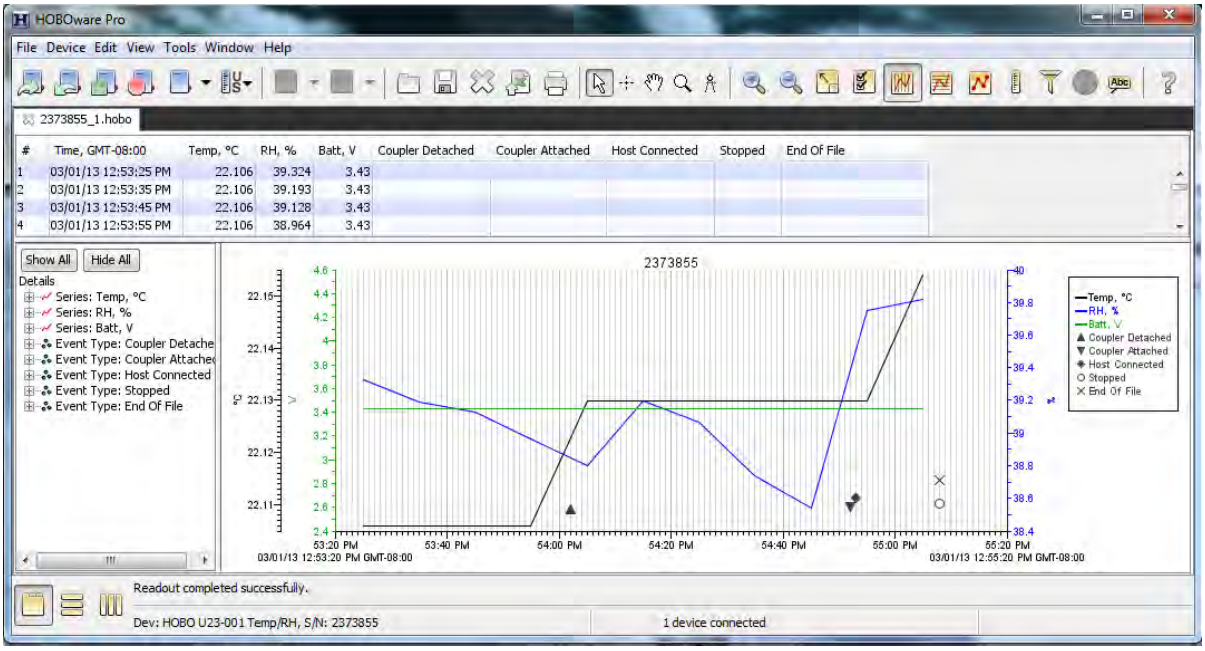


FIGURE 11

NOTE: The logger records two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (ex: the temperature every minute). Events are independent occurrences triggered by logger activity. Examples of events recorded during deployment include: when the logger is connected to the host, when the battery is low, end of a data file once the logger is stopped, and button pushes.

NOTE: If the battery falls below 3.1 V, the logger will record a "bad battery" event in the data file. If the data file contains "bad battery" events, or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and should be replaced before the next deployment.

NOTE: Once a logger is read out, the data will remain in the logger memory until the next time the logger is launched. Therefore, logger memory is never empty.

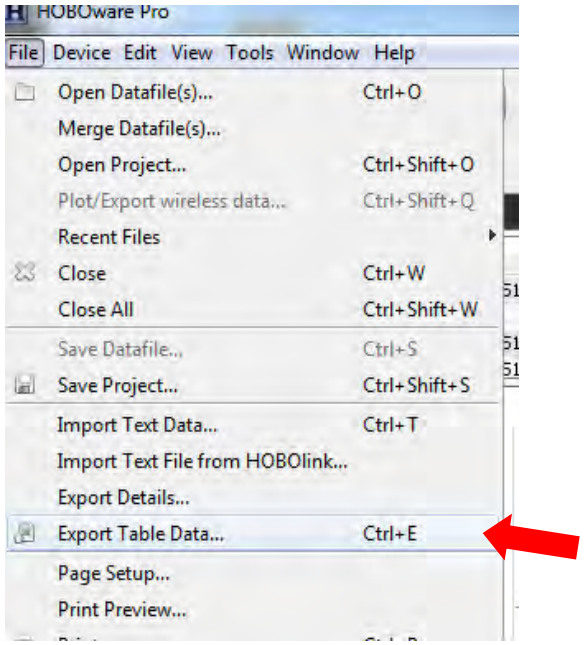


FIGURE 12

9) From the result page, select File → Export table data.

10) Make sure all measurements are checked. Select Export.

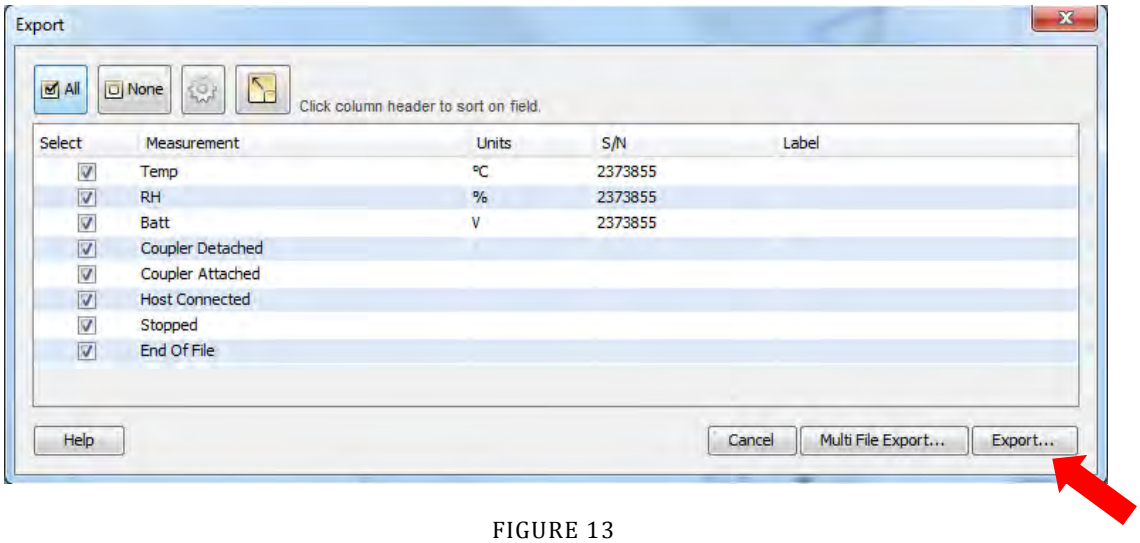


FIGURE 13

11) You will now save the exported data as a .csv file. Use the same file name that you used to save the HOBO file within the HOBO software: [household ID]_[2 digit HOBO ID]_[takedown date] (ex. 50000_16_05122013). This file should be saved on the secured shared network drive under Asthma Study → HOBO csv files.

12) Upload this data file to the study database.

13) After saving the data, check the HOBO battery.

STANDARD OPERATING PROCEDURE FOR STAND-ALONE AIR CLEANER

Description of the Air Cleaner

- Two sizes of stand-alone air cleaner have been prepared for this study, and are called the Large Air Cleaner and Small Air Cleaner. The surface of the air inlet is larger for the Large Air Cleaner than the Small Air Cleaner, and thus the Large Air Cleaner is quieter at a given air flow. Therefore, the Large Air Cleaner is much preferred whenever possible because it provides better air cleaning performance AND lower noise. The Small Air Cleaner should only be deployed in situations where the Large Air Cleaner would not be able to fit.
- Principles of operation: air is drawn into the system through decorative grille vents on the front, passes through a combined particle filter and gas phase filter, and is returned to the room via the diffuser on top of the system.
- In placebo mode, the filter is by passed. Air is drawn through grills in the back of the device. The air flow and sound level are indistinguishable from operation in the true mode.

Figure 1: Stand-Alone Air Cleaner

Using the Control Panel – General Information

The stand-alone air cleaners are operated and controlled via the electronic control panel, which is located at the base of the left side panel.

For the purposes of the study, the operation of the stand-alone air cleaners will be pre-programmed to operate at a specific airflow, and the control panels locked to prevent tampering. A phone number will be placed just above the control panel. If the participant has any problems with the air cleaner, they can call and we will assist them.

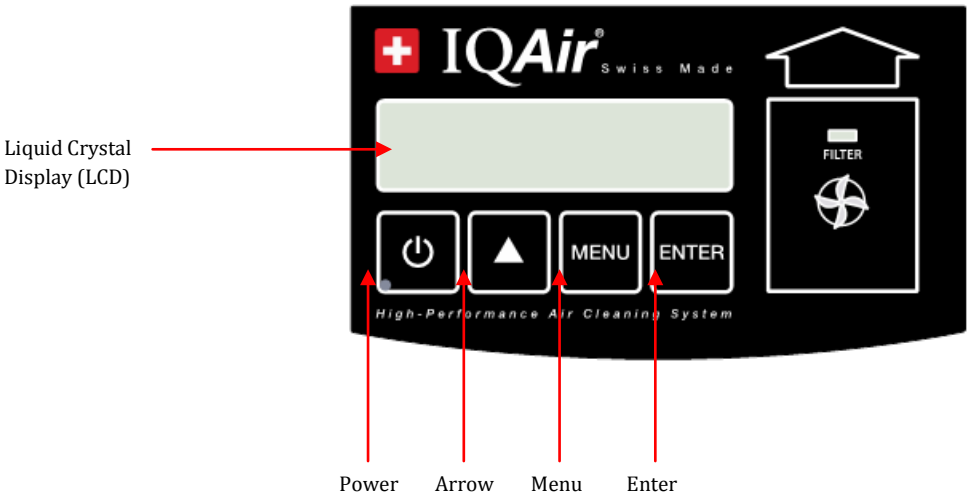


Figure 2: Control Panel

- The **Power** key switches the IQAir system on and off.
- When the system is switched on, the **Arrow** key or **UP** key allows the adjustment of the fan speed. In the enter mode, indicated by the appearance of a black flashing cursor (see "Enter Key" below), the **UP** key is used to modify the selected setting in the display window. Confirmed with the **Enter** key, the enter mode is automatically terminated. The LCD will then display the current menu settings for another 15 seconds before reverting to the main window display
- The **Menu** key allows access to any of the menu options. Pressing the **Menu** key once allows access to the first menu function. Pressing the **Menu** key twice allows access to the second menu function, and so on.
- The **Enter** key, if pressed for 3 seconds, allows the modification of a setting. The enter mode is indicated by a flashing cursor on the modifiable setting.

Locking/unlocking the Control Panel

The control panel keys can be locked to avoid tampering with the settings. To lock or unlock the control panel keys, the **Menu** and the **Enter** key have to be pressed down simultaneously for 3 seconds. The activated locking function is indicated with a star symbol in the control panel display. The locking function is not cancelled by disrupting the power supply. If the air cleaner is ever unplugged or if there is a loss of power, the air cleaner will simply start up in the selected fan speed when power is restored and the control panel lock will remain active. If after holding the buttons for three seconds the control panel is not locked or unlocked, this indicates that the staff pressed the two buttons one after the other rather than simultaneously. Release the buttons and try again.

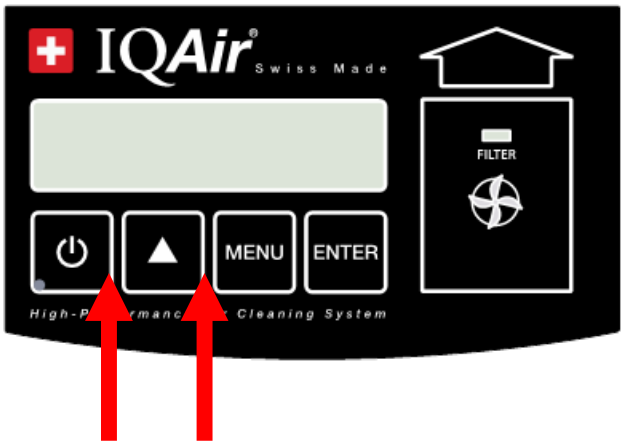


Figure 3: Locking/Unlocking the Control Panel

Regulating Fan Speed

The Large Air Cleaner can be set to run at four different fan speeds which correspond to four different air flow rates, while the Small Air Cleaner can be set to run at three different fan speeds which correspond to three different airflow rates. Speed 1 is the lowest speed, and speed 4 or 3 is the highest fan speed, for the Large and Small Air Cleaners, respectively. The different fan speed settings correspond to airflows as follows:

Air Cleaner Airflows

Fan Speed	Large Air Cleaner	Small Air Cleaner
Speed 1	120 cfm	120 cfm
Speed 2	175 cfm	175 cfm
Speed 3	300 cfm	240 cfm
Speed 4	400 cfm	n/a

To change the fan speed, do the following:

- Unlock the control panel by pressing and holding the **Menu** and **Enter** buttons simultaneously for three seconds, so that a star is no longer shown in the control panel display.
- (If the IQAir is switched off (standby mode), press the **POWER** key on the far left of the control panel.
- The LCD now displays the fan speed and the corresponding air flow rate.
- To change the fan speed, press the **UP** key.
- After the desired fan speed has been set, lock the control panel by pressing and holding the **Menu** and **Enter** buttons simultaneously for three seconds, so that a star is shown in the control panel display.

Additional information on how to select the speed for a particular room in a residence is described in the section below, "*Placement of Air Cleaner and Choosing Appropriate Fan Setting.*"

Placement of Air Cleaner and Choosing Appropriate Fan Setting

1. Select the best location for the air cleaner in the room. Confirm that this location is acceptable with participant. Ask if the nearest outlet is working and if it is on a switch.

   The air cleaner should ideally be positioned on the floor in such a way that it is:
   - Placed discreetly out of the way, with its backside towards a wall
   - Near a power outlet, with the power cord positioned in a way that it does not present an obstacle that could be tripped over. Do not cover the cord with a rug or other covering, per manufacturer's instructions.
   - The power cord is away from heated surfaces

   Do not:
   - Obstruct the air inlet or air outlet of the air cleaner.
   - Place next to a humidifier if possible.
   - Place the appliance on a soft surface such as a bed or other soft furnishings.
   - Operate this appliance if it has a damaged cord or plug, if the motor fan fails to rotate, if it is not working properly, if it has been dropped or damaged, or dropped into water.

2. Determine the acceptable fan speed setting for the main living area. The Large Air Cleaner has four fan speeds of which fan speed 3 is generally quiet enough for large rooms. Place it in the room, set to level 3 and then ask the parent whether the sound is acceptable. Unless there is noise concern, we recommended setting to level 3. If there is any noise concern, select fan speed 2. Record the selected fan speed on the usage log.

3. In the participant's bedroom, fan speed 2 is the default. Due to the smaller size of these rooms, less airflow will still be sufficient to provide a high level of air cleaning at a low sound. In cases where there is exceptional sensitivity to sound, fan speed 1 will be chosen. Record the selected fan speed on the usage log. Only if there is absolutely no space, the Small Air Cleaner may be deployed; however, the Large Air Cleaner is recommended whenever possible.

4. Mark the speed selected on a piece of tape and attach to control panel.

5. Follow the directions in the next section for recording the usage to get the initial hours, as the air cleaners were run ahead of any sampling to be aired out.

6. Lock the control panel by pressing the **Menu** and **Enter** buttons at the same time and holding for three seconds. The control panel can be unlocked in the same manner. If the air cleaner is ever unplugged or if there is a loss of power, the air cleaner will simply start up in the selected fan speed and the control panel lock will remain active.

7. The general instruction to the parent is to simply have the air cleaner running at all times, day and night 24/7. This will ensure that the house is constantly cleaned and rid of air pollutants. This will ensure that less dust will settle over the day as it enters the home from outdoors or is generated indoors through activity, such as cleaning.

8. If there is any concern at any time during the study about the sound or any other concern, telephone number is listed above the control panel. Point this out to the participant and tell them to contact us if they have any problems. In this case instructions can be given via telephone to unlock the control panel, adjust the fan speed down, and relock the control panel.

Obtaining Data on Run Time

Note: data will be collected at each visit, including initial visit and each subsequent visit

The air cleaner records usage in two ways: 1) it records operating hours, and 2) it records weighted hours. **"Weighted hours" are counted down from a nominal 30,000 hours, and are decreased in proportion to the amount of air that moved through the system.** In other words, it allows the calculation of the amount of air cleaned since the last time the data was collected, regardless of what fan speed(s) were actually used.

Here is a procedure to record usage:

1. Mark the visit, both the time period and visit type. Mark size of air cleaner on field log.

2. Check if the air cleaner is in the correct room and in a reasonable location.

3. Check whether the air cleaner is still plugged in.

4. Check which fan speed is currently being used. This is displayed on the LCD. Record current fan speed on field log. Compare to speed listed on sticker and if different, mark flag on the field log.

5. Unlock the control panel by pressing and holding the **Menu** and **Enter** buttons simultaneously for three seconds, so that a star is no longer shown in the control panel display.

6. Set the fan speed to the top speed setting (i.e., Speed 4 for the Large Air Cleaner, and Speed 3 for the Small Air Cleaner) using the **UP** button.

   It is important to set the fan speed setting to the maximum speed prior to obtaining the weighted hours, since those values will dynamically change depending upon the *current* fan speed setting.

7. Press the **Menu** button until the "weighted hours" is displayed, and record the value (XXXXh)

8. Press the **Menu** button until "operating hours" is displayed, and record the operating hours. (XXXXh)

9. Set the fan speed back to the desired setting using the **UP** button.

10. Relock the control panel by pressing and holding the **Menu** and **Enter** button simultaneously for three seconds, until a star is shown in the control panel display.

11. Ideally, over a 6 month period, the air cleaner should log approximately 4300 operating hours, which corresponds to continuous operation 24/7. If the hours operated is less than 3000 operating hours at the first 6 month visit, flag "low usage" and confirm with the participant that they like the current fan speed and if there are any problems. Offer to change the fan speed if they think it is too loud.

12. Always remind the participant to use the air cleaner in each visit.

Calculating the Average Airflow

Average Airflow (When The Device Was Used During the Test Period)

While the control panel does not log the fan speed of the device at any given moment, it is possible to calculate the average airflow over the test period as follows:

1) Determine the volume of air that passed through the device during the test period.

   Top fan speed = 400 cfm for the Large Air Cleaner or 240 cfm for the Small Air Cleaner

   Weighted hours used (hour) = weighted hours at beginning (hour) – weighted hours at end (hour)

   Volume of air (cubic feet) = top fan speed (cfm) * weighted hours used (hour) * 60 (minutes/hour)

   Here, the volume of air is expressed in terms of cubic feet.

2) Calculate the number of hours the device was used since the last visit by comparing the operating hours at the beginning and the end of the test period.

   Hours device used = ending operating hours - beginning operating hours

3) Calculate the average airflow (while the system was on) as the volume of air that passed through the device during the test period divided by the operational hours during that time period

   Average airflow (cfm) = volume of air (cubic feet) / (hours device used (hour) * 60 (minutes/hour))

   Here, the average airflow is expressed in terms of cubic feet per minute (CFM).

   This calculation then takes into consideration the possibility that a speed setting other than the top speed may have been utilized during the test period, or that the speed setting may be different from what we set.

   The parameters needed for calculation are recorded on the field log during field visits. After field data are input into the database by lab staff, these calculations will be conducted by data analyst.

Changing the Filter

The stand-alone air cleaners have been specially prepared for the Asthma Study. The filter is expected to last for a full year, and thus should not need to be changed unless we need to switch filters for true or sham filtration. The following procedure describes the filter change process.

Disconnect the power from the air cleaner by unplugging the power cable before adding or removing parts and before cleaning.

1. Remove the air cleaner's top panel by reaching in through the centermost grille vane opening and giving it a quick tug. Note: this panel is held in place by a magnet in the top center of the unit.

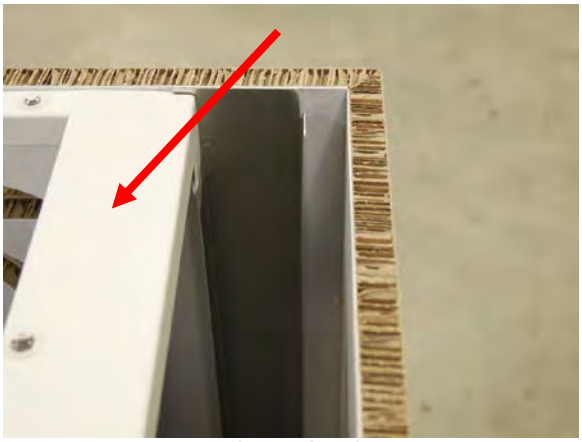
Grasp top panel through outlet grille

Top panel removed

2. Gently remove the used filter. Place it in a plastic bag and label with the data and household ID.

Remove used filter

3. Insert a new filter in the metal filter guide rails. The airflow arrow should point towards the inside of the air cleaner



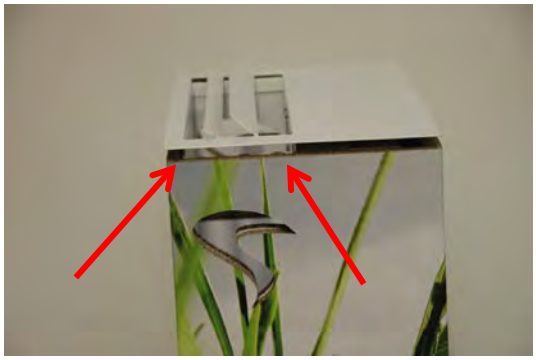
Filter guide rail

4. Slide the filter down until the top edge is level with the top support brace.

Flush-seated filter

5. Replace the top panel, taking care to align outlet grille vanes with the outlet plenum. The top panel is held in place magnetically. Afterwards adjust as necessary to ensure the top cover panel does not protrude over the sides of the air cleaner.

Outlet grille alignment

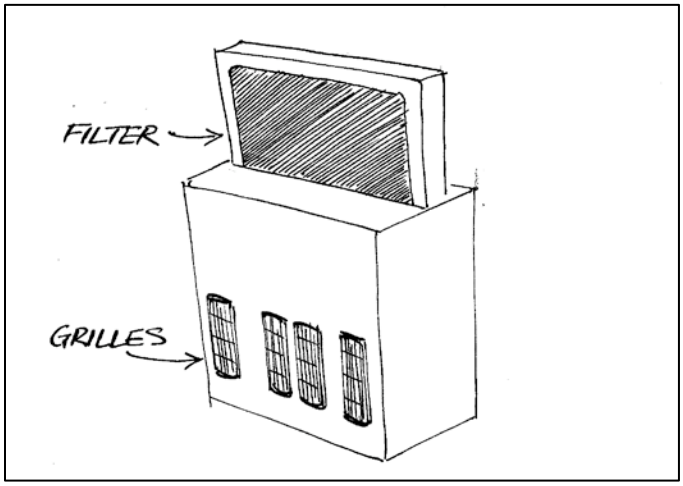


Fine-tuning the alignment

Top panel in place

Converting Placebo Air Cleaners into Fully Functional Versions

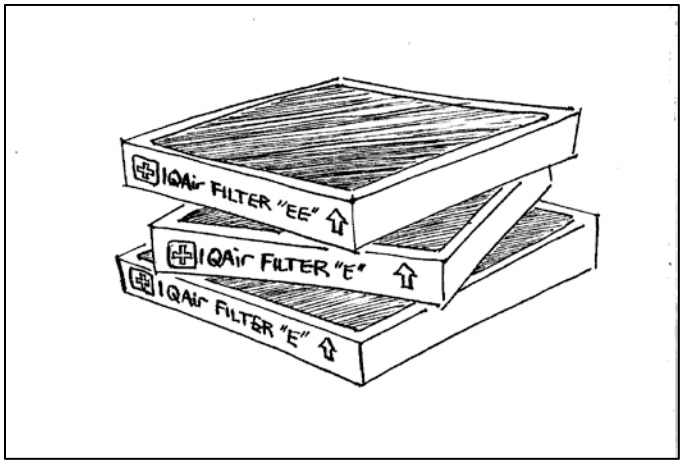
Converting between placebo and fully functional versions of the stand-alone air cleaners involves the replacement of both the filters and the backside grilles.



Both the filter and backside grilles are replaced when converting between placebo and functional versions of the air cleaner

<u>Placebo Filters</u>

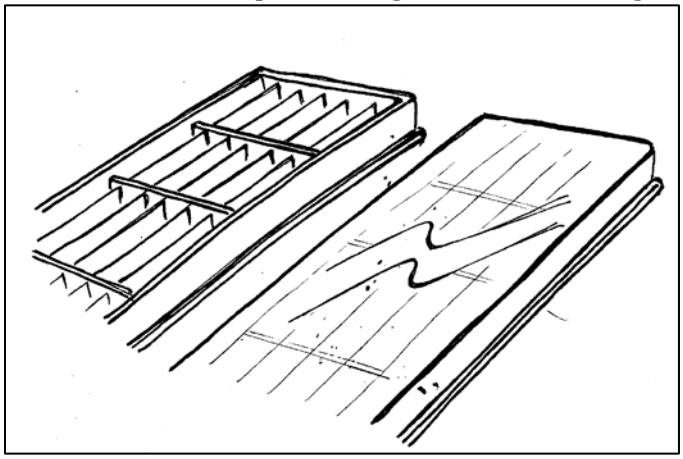
Placebo filters for the stand-alone air cleaners look identical to functional filters; however, they are internally occluded to prevent any air from passing through the filtration media. Placebo filters are identified by an "EE" product code as compared to the "E" code for functional filters.



Placebo and functional filters look identical, but are distinguishable by their labeling ("EE" and "E", respectively)

Backside Grilles

Backside grilles for the stand-alone air cleaners look similar from the outside; however, placebo grilles are open to allow for air to bypass the placebo filter. The backside grilles for the functional versions have a transparent film covering the inside surface, preventing air from entering through the grille.



Backside grilles for placebo (background) and functional (foreground) air cleaners

The backside grilles on the air cleaners must be replaced when converting between placebo and functional air filters. This is necessary to regulate the airflows through the two versions of the system.

Below are the steps to convert placebo Air Cleaners into Fully Functional Versions:

1. Always disconnect the power from the air cleaner by unplugging the power cable before adding or removing parts, and before cleaning.

2. Backside grilles are secured in place with two retaining pins located on each grille. Remove these with a pair of needle-nose pliers. Once the retaining pins are removed, the grille can be popped out and replaced with the alternate grille type. Insert the replacement grille, and secure in place with the two retaining pins.

3. Replace placebo filters just like functional filters, per the instructions in the previous section.

4. Record data and info on log sheet.

	Placebo Air Cleaner	Fully Functional Air Cleaner
Filter Code	EE	E
Backside Grilles	Open (without clear film)	With clear film

Comparison of differences between placebo and functional air cleaners

APPENDIX H: SOP'S RELATED TO HEALTH MEASURES

Contents ***Page***

STANDARD OPERATING PROCEDURE FOR SPIROMETRY AND ANTHROPOMETRY

A1. OVERVIEW

Spirometry is a medical test that measures various aspects of breathing and lung function. It is one of the simplest, most effective tests available for the assessment of lung function. Spirometry tests will be performed using an SDI Diagnostics AstraTouch Spirometer which will be used to measure the amount of air a subject inhales or exhales and the rate at which the air is exhaled. Spirometry testing requires that the subject exhale as forcefully as possible after taking a full, deep breath. The subject's effort is called the forced expiratory maneuver. Spirometry will be collected at the pre-intervention visit and every 6-months directly following each air-monitoring period.

We will use standard measures of spirometry in the pulmonary function analyses. These measures will be collected in the participant's home. Absolute measures of pulmonary function will be used to classify asthma severity at baseline. Sensitivity is further increased in that each subject will serve as his/her own control in this cross-over design. For spirometry, we will record actual volume-time tracings. From the volume-time tracing, we can calculate the best FEV_1, FVC, FEV_1/FVC and FEF_{25-75}. spirometry data will be reported as a percentage of predicted.

The SDI Diagnostics AstraTouch Spirometer is compliant with the American Thoracic Society spirometry standards. In addition to be being portable, it will print a hard copy of the spirometry results that can be given to the study subject. This instrument is integrated with a screen that displays results that can be seen by the participant as they are performing spirometry. There are "games" for children to encourage them to completely exhale, for example, one option is a screen with a rocket that the child tries to "lift". Because the results of the spirometry test are used to determine respiratory health status, the measurement must be performed according to strict standards by staff that have been properly trained and certified in how to conduct the maneuver. These strict standards include regular cleaning and calibration checks of all the equipment used.

In addition to spirometry testing, we will record height and weight every 6 months when collecting spirometry. To measure height and weight, a stadiometer and a scale is used.

There are some problems for quality control in measuring spirometry in children. Asthma itself has the potential to increase the variability of lung function measures at a given test session (e.g., post-inhalation bronchoconstriction). It is also well know that young children cannot maintain a forced vital capacity maneuver for 6-seconds, the minimum duration criterion for adult testing. Based on epidemiologic studies of children, including the FACES study, we will make modifications of the acceptability criteria for spirometry in children. For example, the acceptable duration time for spirometry in children will be at least 2-seconds, provided that all other ends of test criteria were met and the curve passed visual quality control. Dr. Kenyon will review the tracings for acceptability.

SUMMARY OF SPIROMETRY MEASURES

The following will be obtained through spirometry testing:

- Forced Vital Capacity (FVC) is the total volume of air exhaled in a forced expiratory maneuver (the act of exhaling as hard and fast as possible after maximal inspiration). The FVC is useful for detecting restrictive diseases, since lower than expected results may be a sign that the lungs cannot inflate as fully as normal. The FVC is reduced in people with obstructive and restrictive disorders.

- Forced Expiratory Volume at One Second (FEV_1) is the amount of air that a person breathes out during the first second of a forced expiratory maneuver. This is reduced in people with airflow obstruction.

- The ratio of FEV_1 to the FVC (FEV_1/FVC) is the most sensitive and specific index of airways obstruction measured by a spirometer. It is obtained by dividing the FEV_1 by the FVC, and is usually expressed as a percent (i.e. 100 x FEV_1/FVC).

- Forced Expiratory Flow 25-75 ($FEF_{25-75\%}$) is the mean expiratory flow rate over the middle half of the forced vital capacity.

REFERENCE VALUES

To interpret spirometric results, the results must be compared either to a subject's previous results or to a published set of "predicted reference values." Such predicted reference values typically describe the average lung function for an individual of a given age, height, and gender. Such equations have been published for a variety of racial groups.

The AstraTouch Spirometer offers a number of published predicted values tables for children, allowing comparison of the measurement results, listed below. This study will use the predicted values from the NHANES study.

1. NHANES lll: Hankinson, Odencrantz, Fedan, 'Spirometric Reference Values from a Sample of the General U.S. Population', Am J Respîr Crìt Care Med, Vol. 159, 1999, p 179-187.

2. Knudson, Ronald J., Michael Lebowitz, Holberg Catherine J., Benjamin Burrows, "Changes in the Normal Maximal Expiratory Flow-Volume Curve with Aging" , American Review of Respiratory Disease, Vol. 127, 1983, p.725-734.

3. Polgar, Promadhat, Pulmonary Function Testing in Children: Techniques and Standards, W.B. Saunders Co., Philadelphia, 1977.

A2. CALIBRATION OF SPIROMETER

Calibration checks MUST be performed at the beginning of each day and then every 4 hours on the day that the spirometer is used. The standard 3 speed calibration procedure will be used.

MATERIALS

3L Calibration Syringe
Calibration adaptor
AstraTouch Spirometer
Turbine transducer

CALIBRATION CHECK

CALIBRATION CHECK MUST BE PERFORMED AT THE BEGINNING OF EACH TESTING DAY AND THEN EVERY 4 HOURS ON THE DAYS IT IS USED

1) Connect the spirometer to the 3L calibration syringe using an adapter (Figure 1). Make sure the plunger is extended.

FIGURE 1

2) Turn on the AstraTouch Spirometer by pressing the ON/OFF button for 5 seconds.

3) Press Q Cal Check.

4) Enter the technician's initials.

5) Press ENT.

6) Insert 3L at FAST (1 second), MEDIUM (3 seconds) and SLOW (6 seconds) speeds. Each must meet the ±3.5% accuracy requirement, which equals a 2.90L – 3.10L acceptability range.

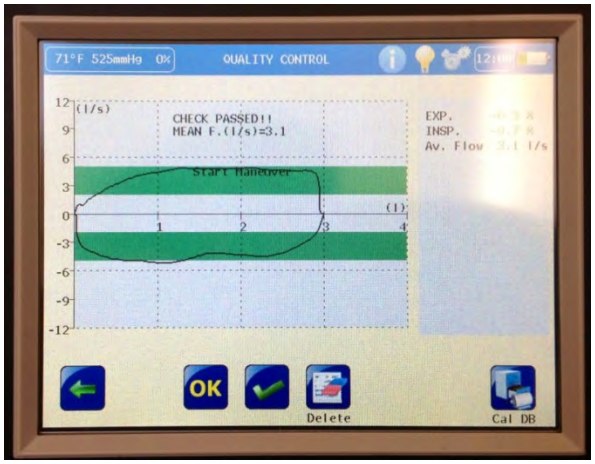


FIGURE 2

7) The "CHECK PASSED" screen will come up if the calibration is acceptable. Press the button with the check mark to accept it. See Figure 2. If there is a desire to redo the test, press the delete button. This decision is based on the spirometry training gained in the training class.

8) If the session is correct, the results will be automatically saved to the calibration record. Press Cal DB to see the data of the record.

9) At the end of the operation, press OK to see the results of the calibration maneuvers performed.

10) If the calibration check is not successful, notify Rebecca Moran or Maryam Shahin and they will contact SDI for trouble shooting assistance and re-calibration instructions.

WEEKLY LINEARITY CHECK

LINEARITY CHECK MUST BE PERFORMED WEEKLY

1) Connect the spirometer to the 3L calibration syringe using an adapter (Figure 1). Make sure the plunger is extended.

2) Repeat the 3 speed calibration routine described in the Calibration Check section, **three times** successively. All must meet the ±3.5% requirement. If an individual check does not meet the ±3.5% requirement, redo the test.

3) Print results and place in binder, saving a copy meets a new OSHA requirement. When analyzing data, one can go back and check for any difference over time.

A3. ANTHROPOMETRY MEASURES

GLOSSARY

- Stadiometer: a device for measuring height that consists of a vertical ruler and a sliding horizontal measuring arm which is adjusted to rest on the top of the head.

MATERIALS

Scale (HCG-R7 EatSmart)
Stadiometer (Seca 213)
Small Folding Stool

MEASURING HEIGHT

Height is measured in inches using the Seca 213 stadiometer. Participant should wear loose-fitting, comfortable, indoor clothing and no shoes during the measurement. If the participant refuses or the technician cannot obtain the participant's height, please make a note on the Field Log. Any unusual conditions should be noted on the Field Log.

1) Remove the stadiometer pieces from its carrier and construct the stadiometer against a wall, positioning the measuring arm at the top of the stadiometer. It should look like Figure 4. Use the folding tool if you are too short to read the measurement off the stadiometer.

   Logistics Note: Have the Air Sampling Technician set-up the stadiometer.

   NOTE: *Watch for ceiling fans while setting up.*

   NOTE: Use a longer extender to adjust if needed, due to the thickness of baseboard. If extender does not quite reach the wall, it is okay to proceed anyway.

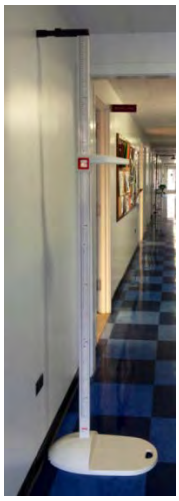


FIGURE 4

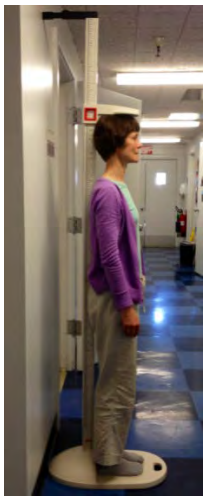


FIGURE 5

2) Ask the participant to remove their socks and shoes, empty their pockets, and remove any hair ornaments, jewelry, buns, or braids from the top and back of the head.

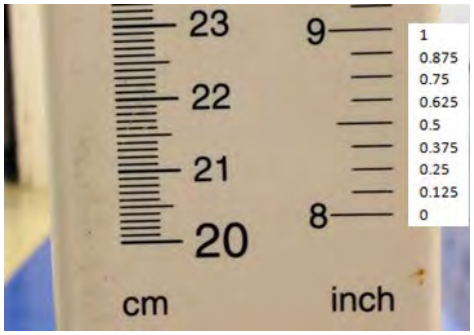
3) Ask the participant to stand with their back to the wall and look directly forward. The back of their head, back, buttocks, and heels should be in a straight line. Their heels should be together. Arms should be relaxed and hanging loosely at their sides. Shoulders should be relaxed. They should be positioned directly underneath the measuring arm.

   NOTE: Make sure that the participant is facing straight ahead and that the participant maintains this position during measurement.

4) Have the participant inhale deeply without altering his/her position. If this direction is difficult for the child, you can instruct the child to keep their feet on the ground and pretend to look over a fence.

5) Lower the arm of the measuring rod so it just touches the top of the participant's head, without bending.

6) Before exhalation, record the measurement in inches to the nearest 1/8th of an inch and record as a decimal (record value as shown in Figure 6, with up to three decimal places) on the Field Log.



7) Have the participant step off the stadiometer. Then, repeat steps 3-6 to obtain a second measurement.

8) If the 2 measurements are not within 0.5 inches of each other, take a third measurement and record it on the Field Log.

9) Calculate the average of 2 measurements that are within 0.5 inches of each other. Then, round the average measurement to the nearest inch (if average ends with 0.5, then round up) and record the rounded average measurement on the Field Log.

10) Remove the stadiometer columns from the base plate and pack it following the steps depicted in the figures below.

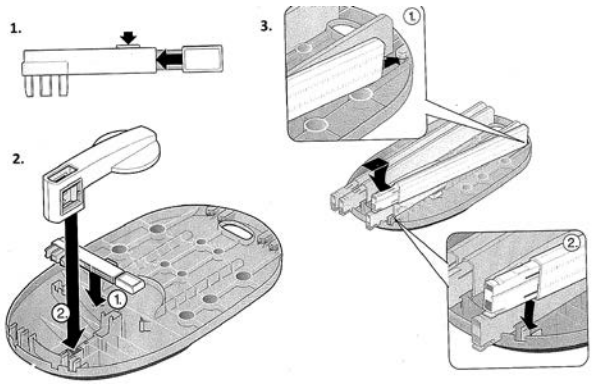


FIGURE 7

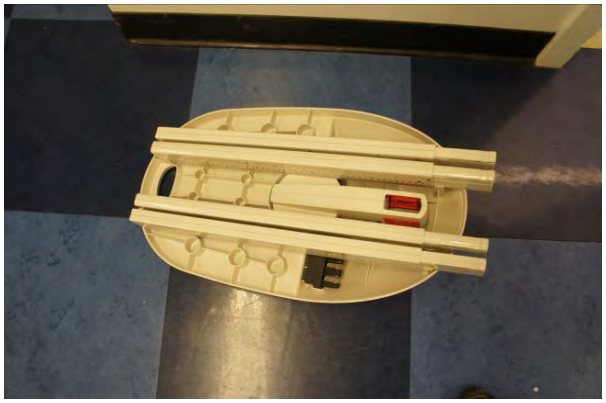


FIGURE 8

MEASURING WEIGHT

Weight is measured in pounds using a digital scale (HCG-R7 EatSmart Precision Digital Bathroom Scale). Participant should wear loose-fitting, comfortable, indoor clothing and no shoes during the measurement. Participants should be asked to empty their pockets and remove jackets, sweaters, shoes, and heavy jewelry. If the participant refuses or the technician cannot obtain the participant's weight, please make a note on the Field Log. Any unusual conditions should be noted on the Field Log.

FIGURE 9

1) Unpack the portable scale and place it on a flat floor surface.

2) Turn the scale on and 0.0 will appear on the display.

3) Ask the participant to empty their pockets and remove jackets, sweaters, shoes, and heavy jewelry.

4) Have the participant stand on the center of the platform, facing away from the digital display, with their weight equally distributed on both feet, and not touching or supporting their weight on anything.

5) Record the weight to the nearest 0.1 of a pound on the Field Log.

6) Have the participant step off the scale. Then, repeat steps 4-5.

7) If the 2 measurements are not within 0.5 a pound of each other, take a third measurement and record it on the Field Log.

8) Calculate the average of 2 measurements that are within 0.5 a pound of each other. Then, round the average measurement to the nearest pound (if average ends with 0.5, then round up) and record the rounded average measurement on the Field Log.

9) Pack the scale into its storage case.

TROUBLESHOOTING

TABLE 1

Problem	Possible solutions
No weight display comes on?	• Is the scale switched on? • Check the batteries.
0.0 does not appear before weighing?	• Switch off the scale with the Start button and start the scale again – there must not be any load on the scale – and only its feet should be in contact with the floor
The display shows 	• Battery voltage is running low. Change the batteries at the end of the day.
bAtt appears in the display?	• Batteries are empty. Put in new batteries.
STOP appears in the display?	• Maximum load (550 lbs) has been exceeded.
The display flashes?	• If there has been no activation of a function beforehand, remove the load from the scale and wait until 0.0 is displayed, then weigh again.
The display tEMP appears?	• The ambient temperature of the scale is too high or too low. Place the scale in an ambient temperature between +10 °C and + 40 °C. Wait about 15 minutes for the scale to adapt to the ambient temperature and then weigh again.
The display E and a number appear?	• Switch off the scale with the Start button and start the scale again. The scale will then work normally again. • If this is not the case, disconnect the power supply by briefly removing the batteries. If this measure is equally unsuccessful, inform Rebecca Moran who will contact the manufacturer's Service department.

1) Use a Scientific Calculator (TI-30X IIS) to calculate the participant's BMI using the following equation:

$$\text{BMI} = \frac{\text{Weight in pounds} \times 703}{\text{Height in inches} \times \text{Height in inches}}$$

2) Record BMI on field log.

3) Use the graphs in Figure 10 to identify which percentile the participant is in.

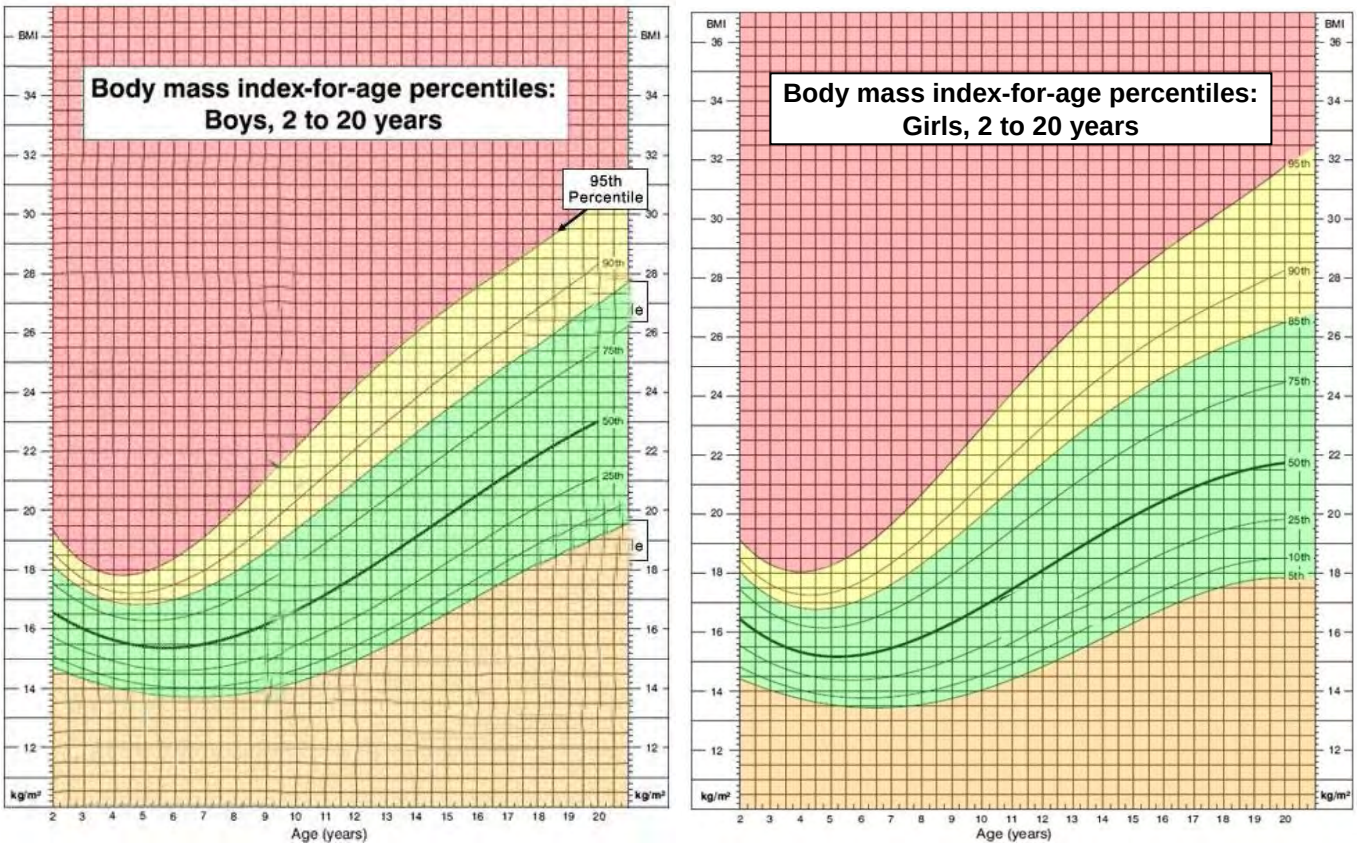


FIGURE 10

4) A participant in the 95th percentile or greater is in the obese category and a blood pressure measurement must be taken and recorded. If the participant is below the 95th percentile, skip to A4 and begin spirometry testing.

5) Take blood pressure measurement using the blood pressure machine. Wrap cuff snuggly around upper arm and press the start button on the machine (this will both turn the machine on and take the blood pressure measurement.)

6) Record the participant's blood pressure on the Field Log.

7) Use Tables 2 and 3 below to determine what percentile of height the participant is in for their age, selecting the lower percentile value when the height is in between two values.

8) Use Tables 4 and 5 below to determine if the participant's blood pressure is above the 95th percentile for their height and age. Find their age and the percentile of height on the table to determine what the 95th percentile value is for a child of that age and height.

9) If the participant's blood pressure is above the 95th percentile, do **NOT** conduct spirometry at this visit. Make a note in the Field Log.

TABLE 2: Height-for-age percentiles: **Boys**, 6-17 years

Age (Year)	Height (inches) ← Percentile of Height →						
	5th	10th	25th	50th	75th	90th	95th
6	42.1	43	44.1	45.5	46.9	48	48.7
7	44.5	45.3	46.5	48	49.5	50.7	51.5
8	46.8	47.5	48.9	50.4	52	53.3	54.1
9	48.7	49.6	51	52.6	54.3	55.8	56.7
10	50.5	51.4	52.9	54.7	56.4	58	59
11	52	53	54.7	56.5	58.5	60.1	61.1
12	54	55	56.7	58.7	60.7	62.5	63.7
13	56.3	57.5	59.4	61.5	63.5	65.5	66.5
14	59.1	60.3	62.3	64.5	66.5	68.5	69.5
15	61.5	62.8	64.8	66.9	69	70.7	71.7
16	63.2	64.5	66.3	68.2	70.2	72	73
17	64.1	65.2	67	69	71	72.6	73.6

TABLE 3: Height-for-age percentiles: **Girls**, 6-17 years

Age (Years)	Height (inches) ← Percentile of Height →						
	5th	10th	25th	50th	75th	90th	95th
6	42	42.7	43.9	45.1	46.6	48	48.7
7	44.5	45.2	46.5	48	49.2	50.7	51.5
8	46.7	47.5	48.8	50.2	51.9	53.3	54.2
9	48.5	49.3	50.8	52.4	54	55.6	56.7
10	50.1	51	52.7	54.4	56.1	57.9	58.9
11	52	53.1	54.9	56.7	58.7	60.3	61.5
12	54.7	55.9	57.7	59.5	61.5	63.2	64.2
13	57.5	58.5	60	62	63.8	65.3	66.4
14	59	59.9	61.4	63.1	64.9	66.5	67.5
15	59.6	60.5	62	63.8	65.5	67	68
16	59.9	60.8	62.3	64	65.8	67.3	68.3
17	60	60.9	62.5	64.1	65.9	67.5	68.4

TABLE 4: 95th Percentile Blood Pressure Levels for **Boys** by Age and Height Percentile

Age (Year)	Systolic BP/Diastolic BP (mmHg) ← Percentile of Height →						
	5th	10th	25th	50th	75th	90th	95th
6	109/72	110/72	112/73	114/74	115/75	117/76	117/76
7	110/74	111/74	113/75	115/76	117/77	118/78	119/78
8	111/75	112/76	114/77	116/78	118/79	119/79	120/80
9	113/76	114/77	116/78	118/79	119/80	121/81	121/81
10	115/77	116/78	117/79	119/80	121/81	122/81	123/82
11	117/78	118/78	119/79	121/80	123/81	124/82	125/82
12	119/78	120/79	122/80	123/81	125/82	127/82	127/83
13	121/79	122/79	124/80	126/81	128/82	129/83	130/83
14	124/80	125/80	127/81	128/82	130/83	132/84	132/84
15	126/81	127/81	129/82	131/83	133/84	134/85	135/85
16	129/82	130/83	132/83	134/84	135/85	137/86	137/87
17	131/84	132/85	134/86	136/87	138/87	139/88	140/89

TABLE 5: 95th Percentile Blood Pressure Levels for **Girls** by Age and Height Percentile

Age (Year)	Systolic BP/Diastolic BP (mmHg) ← Percentile of Height →						
	5th	10th	25th	50th	75th	90th	95th
6	108/72	109/72	110/73	111/74	113/74	114/75	115/76
7	110/73	111/74	112/74	113/75	115/76	116/76	116/77
8	112/75	112/75	114/75	115/76	116/77	118/78	118/78
9	114/76	114/76	115/76	117/77	118/78	119/79	120/79
10	116/77	116/77	117/77	119/78	120/79	121/80	122/80
11	118/78	118/78	119/78	121/79	122/80	123/81	124/81
12	119/79	120/79	121/79	123/80	124/81	125/82	126/82
13	121/80	122/80	123/80	124/81	126/82	127/83	128/83
14	123/81	123/81	125/81	126/82	127/83	129/84	129/84
15	124/82	125/82	126/82	127/83	129/84	130/85	131/85
16	125/82	126/82	127/83	128/84	130/85	131/85	132/86
17	125/82	126/83	127/83	129/84	130/85	131/85	132/86

A4. SPIROMETRY

GLOSSARY

- Maneuver: a single attempt (1 maneuver)
- Test: 3 acceptable maneuvers (6 maneuvers maximum)

MATERIALS

AstraTouch Spirometer
Turbine transducer
Transducer holder
Scissors
Mouthpieces
Noseclips
Thermal paper for the internal printer

PRE-EXAMINATION QUESTIONS

First check the activities to be conducted at this visit. If both spirometry and eNO are to be conducted, conduct the eNO first and the spirometry second.

Prior to performing a spirometry test, all participants or their parents must answer a few questions. The technician will sit with the parent or participant, and ask the questions below (these questions are also listed on the Spirometry Field Log form). Although the parent's presence is not required during the actual testing, **make sure the parent is present while asking questions**. The participant may require assistance in answering some questions. Mark the answers on the field log. The answers determined by these questions will facilitate the process of evaluating whether a participant can participate safely without jeopardizing their health, and any factors that may influence the results obtained during testing.

QUESTIONS FOR EXCLUSION FROM SPIROMETRY TESTING

THE SPIROMETRY TEST SHOULD **NOT** BE PERFORMED IF THE PARTICIPANT ANSWERS YES TO ANY OF THE FOLLOWING QUESTIONS.

1) Has your child had an injury to the chest or surgery (operation) on his/her lungs, chest or abdomen, in the last 3 months?

2) Has your child had a detached retina or an operation (surgery) on his/her eyes, in last 3 months?

3) Has your child been hospitalized for any other heart problems, in the last 3 months?

4) Is your child currently using medicine for tuberculosis?

Ask the following questions to determine if spirometry should be conducted, or if any modifications to the protocol are needed:

1. Has your child done (spirometry/the breathing test where they breathe a really long time, sometimes the nurse will say "keep going, keep going, keep going" while the child is breathing)?

   If no, proceed to Question 2.

If yes, ask the following:

1a. Has your child ever had a problem with shortness of breath, wheezing, or an asthma attack related to performing breathing tests or lung function tests?

If yes, check the box "participant was excluded due to medical reasons" and write "participant's asthma is exacerbated by lung function testing" in the area for notes. Also check the box "Participant's asthma is aggravated by spirometry and it should not be attempted in the future" to ensure spirometry will not be conducted with this participant in the future.

If no, ask the following:

1b. Is your child able to perform lung function tests without their rescue inhaler, or do they always need to use their rescue inhaler before even doing the first attempt at the lung function test?

If yes, proceed to Question 2.

If no, ask the following:

1c. Would your child like to use their rescue medication now and then do the spirometry/lung function test?

If yes, the participant should be observed taking their normal prescribed dosage (puffs of inhaler) of their rescue medication. Wait for 15 minutes, and then perform spirometry.

If no, do not conduct spirometry on this participant, also check the box "Participant needs to use bronchodilator prior to performing spirometry" to ensure spirometry will not be conducted with this participant without bronchodilator in the future.

2. Is your child currently having asthma symptoms?

If yes, do not conduct spirometry on this participant. Check the box "participant was excluded due to medical reasons" and write "participant experiencing asthma symptoms" in the area for notes. Please note on the visit checklist to try spirometry in one week at the next visit.

If no, proceed to the following section.

QUESTIONS FOR ALL INTERVIEWED PEOPLE WHO DO NOT MEET THE EXCLUSION CRITERIA AND THEREFORE MUST DO SPIROMETRY TESTING

THE SPIROMETRY TEST SHOULD BE PERFORMED AND CIRCUMSTANCE NOTED ON THE FIELD LOG IF THE PARTICIPANT ANSWERS YES TO ANY OF THE FOLLOWING QUESTIONS. If the answer in no, it will also be recorded in the field log.

1) Has your child had a respiratory infection or a cold in last the 3 weeks?
   If Yes:
   a. Note in Field Log.

2) Has your child used any medicines to help your breathing (inhaled bronchodilator), like aerosols, nasal sprays or a nebulizer, in last 3 hours?
   If Yes:
   a. Postpone test until end of visit. Note in Field Log.

3) Has your child done any hard physical exercise, like gymnastics, a long walk or jogging, in the last hour?
   If Yes:

a. Postpone test until end of visit. Note in Field Log.

4) Has your child smoked any type of tobacco product in last 2 hours? (only ask if the participant is 13 years old or older)
If Yes:
   a. Postpone test until end of visit. Note in Field Log.

SPIROMETRY EXAMINATION PROCEDURE

The accuracy of the spirometry examination largely depends on a coordinated effort exerted by the examinee and the conscientiousness of the technician. Consequently, it is crucial that the examination protocol be observed consistently, and that the examinee is prepared and "coached" for this examination.

The spirometry technician should explain that spirometry is a lung function test and it measures how hard and fast the participant can blast air out. Emphasize that, although the procedure doesn't hurt, in order to get useful and valid results the participant must breathe as hard and as fast as possible when told to do so, and that they will need to repeat the procedure a few times. Depending on the cultural setting in which the testing is done, participants may need repeated assurances that spirometry does not hurt them, or damage anything.

If they have never had spirometry done, explain the test to them and the small risk of bronchospasm. Ask if they want to have their rescue asthma medication on hand in case they notice any breathing difficulties after the test.

SET UP THE SPIROMETER/ENTER PARTICIPANT DATA

FIGURE 11

1) Remove the AstraTouch Spirometer from its storage bag.

2) Connect the turbine transducer and spirometer by inserting the plug of the turbine transducer into the socket located in the rear of the spirometer.

3) Connect the external power supply to the socket located in the rear of the spirometer and to the main AC power outlet if power is low.

4) Turn on the AstraTouch Spirometer by pressing the ON/OFF button for 5 seconds.

5) Press the FVC icon.

6) Enter the participant's data by touching the screen in the area you wish to enter information in and a keyboard display will appear.

    a. Use data from the Spirometry Field Log to enter the ID, participant's first name, age, height, weight, sex, ethnicity and smoking status **(if child is under 13 years of age, always check no)**. Leave last name blank. Verbally verify the age, ethnicity, and smoking status (if child is under 13 years of age, always check no) with the participant.

    b. Record the birth date listed on the STS tracking form in the participant folder on the Field Log. Verify the birth date on the Field Log with what is reported on the STS tracking form. If a discrepancy arises, please verbally verify the birth date with participant and make a note of it on STS tracking form.

    c. If the participant has completed a prior spirometry test while in the study, their data may still be entered into the machine. Select "See DB" to determine if and retrieve the participant's details from memory. Scroll using the sidebar arrows to select the participant. Once a participant is selected, the participant's ID will appear at the top of the screen.

7) After all participant data is entered, touch the checkmark symbol to go to the testing screen.

PERFORMING THE SPIROMETRY TEST

1) If applicable, instruct participant to loosen any tight clothing, since it might otherwise tend to restrict maximal inspiration.

2) Have the participant sit down in a chair (without wheels) so that their feet are flat on the ground (go to the car and get the small chair if needed).

3) Use the scissors to cut the bag containing a new mouthpiece. Allow the participant to remove their mouthpiece from this bag.

4) Briefly explain what you will be asking the participant to do. Tell the participant that they will need to take the deepest, deepest, breath that they can possibly take and then BLAST the air out hard and fast, and to keep going until you tell them to stop.

5) Now, demonstrate how to use the mouthpiece. Lay the tube on your tongue, like a tongue depressor, and wrap your lips tightly around it.

6) Demonstrate the actual maneuver with the mouthpiece in your mouth.

7) Show and explain the testing screen to the participant. Ask the participant if he or she would prefer the Rocket or the Dolphin game to help them perform the maneuver. Click on the game graphic in the middle of the screen to change between the rocket and the dolphin game.

8) Verify that the Flow-Volume graph will be displayed during the maneuver.

9) Instruct the participant to sit up straight, shoulders back, and chin slightly elevated. Ask the participant to place the mouthpiece in their mouth and instruct them to breathe normally through the mouthpiece before taking a very deep breath. Then instruct the participant to take a deep, deep breath and then BLAST and keep going out until you instruct them to stop. Encourage the participant to keep blowing, never re-breathing by telling them to "Keep going, keep going, blow out a little more air" repeatedly.

   NOTE: Watch for body language from the participant as he/she is blowing into the AstraTouch Spirometer. Make sure the participant is always sitting erect, never leaning forward, with his/her feet flat on the floor. If participant is not sitting erect, you will need to remind participant (i.e. a touch on the shoulder) to sit upright. If participant sniffs air through the nose at the end of the test, use a nose clip during their next try.

   Ordinarily, spirometry testing should pose little risk to the safety of the participant. If you see evidence that a participant feels faint, you can coach them to do a more relaxed expiratory effort during the latter phase of the maneuver (e.g. "O.K. BLAST!" "Now keep blowing, keep blowing…o.k. now keep blowing but not so hard, keep blowing but not so hard…). It is possible to coach participants to avoid lightheadedness or fainting.

   If the participant experiences shortness of breath or wheezing, cease spirometry and check the field log box "Participant was not able to complete the test",. Then write "participant's asthma was exacerbated during the procedure" in the area for notes. Also check the box "Participant's asthma is aggravated by spirometry and it should not be attempted in the future" to ensure spirometry will not be conducted with this participant in the future. Be particularly mindful if the participant has never conducted spirometry in the past. Ask if the participant would like to take their asthma inhaler medication before proceeding with the rest of the visit. If the participant's symptoms don't improve by the end of the visit, ask if they want to call their regular doctor or call our study physician.

10) The participant should blow out air for a minimum of 2 seconds. Coach the participant to continue as long as their lung capacity allows, even if they have already reached the game end point.

11) Read the AstraTouch Spirometer monitor screen to determine if the maneuver was completed successfully. If not, explain to the participant what the computer window indicated and what was the problem that resulted in an unsuccessful maneuver. When errors occur, review common errors with the participant before proceeding with additional maneuvers.

12) In between maneuvers, tap the graph to change which graph is displayed. Use the Volume-Time graph to check for the following maneuver errors:

    - Poor initial blast
    - Hesitation, slow start, large extrapolated volume
    - Cough in first second
    - Incomplete inhalation
    - Inconsistent effort
    - Partially blocked mouthpiece
    - Glottis closure or breath holding
    - Leak
    - Extra breaths

13) Continue administering the test until 3 acceptable maneuvers are achieved (up to a maximum of 6 maneuvers) assuming that the subject is able to continue.

14) Three acceptable maneuvers are needed to determine repeatability. **Repeatable** tests give the validity to the test. Of the 3 acceptable tests, the largest and second largest FVC and FEV_1 values must be within 150 ml. It is not necessary that the values come from the same maneuver. If the three acceptable maneuvers do not meet the criteria for repeatability, continue with additional spirometry maneuvers until the repeatability criteria is met or the participant has conducted the maximum six maneuvers.

15) After all test procedures are completed, and the test was complete, mark that the test was complete. If the test was not complete, document any problems in completing a successful trial, document any information about a participant's inability to complete a successful exam, e.g. refused test, unable to hold breath, etc. These comments should be recorded in the box located on the back of the Spirometry Field Log.

16) Print a hardcopy of the participant's 3 best maneuvers by pressing the print symbol with the number 3 on it.

17) Discard the mouthpiece used during spirometry testing.

EXPLANATION OF RESULTS TO PARTICIPANT

Participants may ask how they did on this test. Explain to them that we are only researchers and that we can not accurately tell them how they did on the test. Hand a copy of the results to the participating child's parent so they can give them to their doctor.

ACCEPTABLE AND REPEATABLE MANEUVERS

A valid test requires that there be a minimum of 3 **acceptable** maneuvers. An **acceptable** test consists of the following:

- Good start: deepest breath and a big blast out (hard and fast with maximal effort).
- Smooth, continuous exhalation with proper posture: upper torso upright and chin up.
- Satisfactory length of maneuver: 2 seconds or longer maneuver.

In order for a test to be considered **acceptable**, it must not have any of the acceptability errors listed below.

Acceptability errors:

1) Slow Start (Extrapolated Volume Error)
2) Coughing during the first second
3) Premature termination of effort
4) Extra Inhalations/Hesitations/Valsalva Maneuver (glottis closure)
5) Leaks around the mouthpiece
6) Obstructed mouthpiece
7) Evidence of an extra breath being taken during the maneuver

The goal during testing is to obtain 3 maneuvers without any of the 7 conditions listed above. This is considered an **acceptable** maneuver. If the curve meets conditions 1 and 2 only but fails the other acceptability criteria, it may be considered **useable**. However, efforts to obtain 3 **acceptable** maneuvers should be continued up to a maximum of 6 maneuvers.

Three acceptable maneuvers are needed to determine repeatability. **Repeatable** tests give the validity to the test. Of the 3 acceptable tests, the largest and second largest FVC and FEV_1 values must be within 150 ml. Dr. Kenyon will review the tracings for both acceptability and repeatability.

Some participants will never be able to provide 3 acceptable and repeatable maneuvers, and this is OK. The goal is to meet the acceptability and repeatability criteria, but these are not absolute requirements for data to be used. Requirements for the data to be used in the data analysis are contained within the Statistical Analytical Plan.

A5. VIEW/ DOWNLOAD DATA

VIEW DATA

FIGURE 12

The results of each test are automatically displayed at the end of each maneuver.

1) The results for all the maneuvers for that test will be displayed on the screen.

2) Predicted and best maneuver graphs are shown on the right side of the screen. Press on the plot to switch from one graphic type to the other: Flow-Volume, Volume-Time, both or game and a small Flow-Volume graph.

3) On right side of the screen, the summary frame will contain the FVC and FEV_1 values of all the maneuvers:

    i. PRED: indicates the participant's predicted value
    ii. *: indicates the current maneuver

4) Press on the results to display all parameters of maneuvers performed.

    a) Maneuvers are sorted from best (M1) to worst (M8) according to ATS/ERS criteria and are shown in different colors: green for those that are acceptable and repeatable and from yellow to red for the lower-quality maneuvers. Press the zoom symbol to enlarge or reduce the graph.

    b) One of the following will be shown on in the middle column of the test screen:

        i. Temporal bar: Progress bar in function of time, in three colors: red indicating less than 4 seconds, orange between 4 and 6 seconds and green for more than 6 seconds

ii. Volume bar: Progress bar in terms of the expired volume. Red indicates 75% below the predicted value, the orange between 75% and 100% of the predicted value, and green 100% and above the predicted value

iii. Games for children: Choice of two cartoon graphics

Press the middle column to switch between the different displays. Generally for children, the games will be the most effective screen. However, the technician may elect to change the screen if the Temporal bar or Volume bar is a more effective choice for that participant.

DOWNLOAD DATA

DOWNLOAD DATA IN BETWEEN EACH PARTICIPANT

The AstraTouch Spirometer can store at least 1000 maneuvers. However, the data in each spirometer will be uploaded to the AstraPRO Spirometry Software on the study laptop **each day** that the spirometer is used. The AstraPRO Spirometry Software can allow you to view, print, manage and/or save the tests to the computer.

To download data from the spirometer:

1) Launch the AstraPRO Spirometry Software on the computer.

2) Connect the spirometer to the computer using the USB cable.

3) Load the data to the computer, by pressing the upload icon as depicted in the red circle in Figure 13.

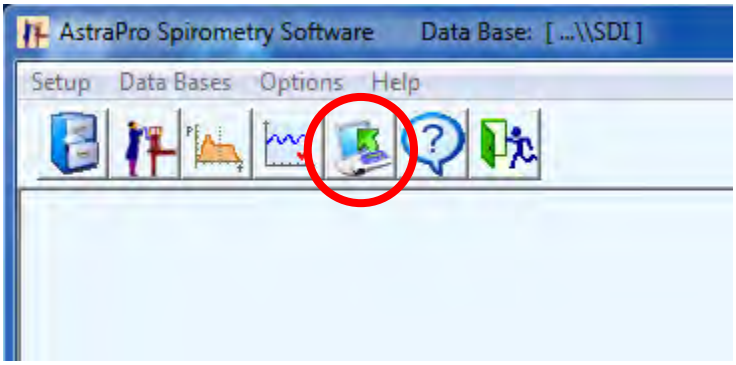


FIGURE 13

4) The screen shows a list of tests saved on the AstraTouch device as seen in Figure 14. Press the button circled in red on Figure 14 to select all tests (or you may elect to manually select individual tests). Press the green check mark to begin loading the tests to the computer. The data is already coded by participant ID and date.

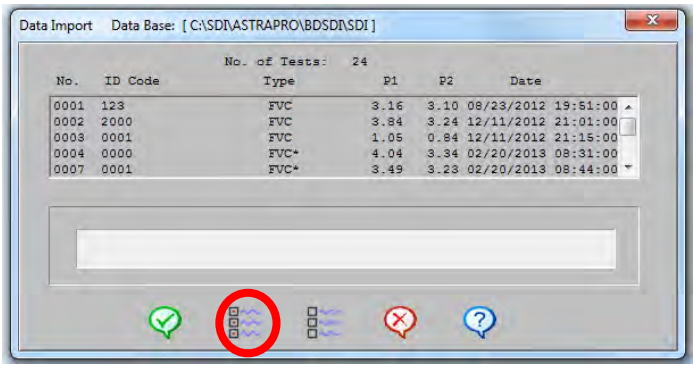


FIGURE 14

5) After the tests have been loaded onto the computer, the software will prompt you to delete the spirometer data base. Do NOT delete the data base until 500 tests have been obtained and successfully backed up onto a computer.

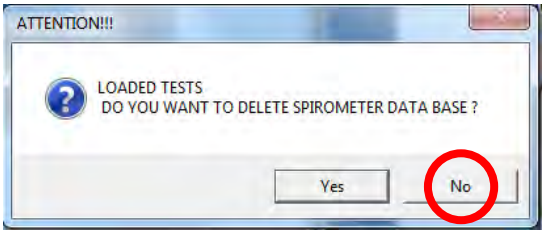


FIGURE 15

6) Once data from each spirometer has been uploaded, close the AstraPRO software window.

7) Upon returning to the field office, scan and upload all field logs, then place them in the participant file. Place all participant files in the lockbox.

CLEARING THE DATABASE

The database holds a total of 1000 test results. It will be backed up, and then cleared after 500 tests.

To clear the database:

1) Download the data, check to make sure that it is backed up.

2) Select Database.

3) Select Clear Database.

4) Press OK to confirm that you want to clear the database.

A6. EQUIPMENT CARE AND MAINTENANCE

EQUIPMENT CLEANING

SPIROMETER WILL BE CLEANED AFTER EACH PARTICIPANT

MATERIALS

Gloves
CIDEX® OPA wipes
Kimwipes
Soap
Distilled Water
Two Dishes

The AstraTouch Spirometer requires cleaning and maintenance aimed at keeping the equipment functioning correctly and ensuring safety of participants and operators. The spirometer will be cleaned after each participant use. Do NOT use alcohol to clean any part of the spirometer. Do NOT use abrasive substances or solvents.

To clean the turbine and transducer housing:

FIGURE 16

FIGURE 17

1) Put on gloves.

2) Remove the turbine from the transducer housing by pressing slightly the tab on the top so that is comes away from the transducer housing. See Figure 16 above.

3) Wipe the transducer housing and handle with a damp Kimwipe.

4) Wipe down the transducer housing with a CIDEX® OPA wipe.

5) Let the transducer housing air dry.

6) Fill one dish with soap and distilled water.

7) Fill another dish with warm distilled water.

8) Place the turbine in the dish with soap and warm distilled water.

9) Let the turbine soak for 10-15 minutes.

10) Rinse the turbine by placing it into the dish with distilled water. Do NOT rinse the turbine by holding it under running water.

11) Let the turbine air dry on a clean Kimwipe.

To clean the spirometer body:

1) Wipe the spirometer body with a damp Kimwipe.

RECHARGING THE BATTERY

The AstraTouch Spirometer has a rechargeable Ni-Mh battery (10.8V 2500mAh) with a charge life of approximately 1.5 hours. The battery is recharged by connecting the spirometer to the power supply, even though the device is turned off. The charging time is about 20 hours.

- The spirometer can be used both plugged and unplugged from a power supply.
- Make sure to check the battery charge each day the spirometer is in use.
- If the battery charge percentage is less than 20% make sure to charge the spirometer. Always keep the charger with you so that the spirometer can be plugged in if needed.

REPLACING THE INTERNAL PRINTER PAPER

To replace the printer paper of the internal printer:

- Open the printer cover.
- Lift the lever that unlocks the pull cylinder and insert the paper roll.
- Pull a small amount of paper out, put down the header lever, pass the paper through the slot of the cover and close it. A screen will appear to pull the paper in/out. Cut the paper pulling it forward against the gate.
- Check the roll at the end of each day of use and make sure to change the roll if necessary.

STANDARD OPERATING PROCEDURE FOR EXHALED NITRIC OXIDE MEASUREMENT

EXHALED NITRIC OXIDE OVERVIEW

OVERVIEW OF THE EXHALED NITRIC OXIDE EXAM COMPONENT

Exhaled nitric oxide (ENO) provides a measure of airway inflammation. Exhaled NO will be collected using the NIOX MINO, a handheld unit appropriate for field applications, collected according to the American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines. This measure will be collected at the participant's home. Collections in children will be measured at 50 ml/sec as recommended. eNO collection is flow rate dependent and the NIOX MINO has visual clues to ensure the eNO levels are measured at this flow rate in children. eNO will be collected every 6-months directly following each air-monitoring period.

The reliability of the NIOX MINO has been demonstrated for field studies. This device is FDA approved for the measurement of eNO in both the research and clinical settings and it has proven quality control measures. It has been previously used in studies with children. The ATS/ERS 2005 statement recommends collection of two eNO measurements and averaging of the two values at each study visit, and we will follow this protocol. Participants will be given 6 attempts to complete the successful measurements. The standard protocol used for adults is directly transferable for children with no modifications.

A recent 2011 consensus statement outlines "low", "intermediate", and "high" (<20 ppb, 20-35 ppb, >35 ppb respectively) eNO levels in children and these ranges assist in interpretation. A 20% change in eNO levels for baseline eNO >35 ppb is considered significant, while an absolute change of at least 10 ppb is significant for baseline levels in the "low:" or "intermediate" ranges.

ENO MEASUREMENTS

The NIOX MINO™ monitor will be used to measure Fractional Exhaled Nitric Oxide (FENO) in exhaled breath in participants. This device follows, in all essential aspects, the ATS and ERS 2005 equipment recommendations for measurement of exhaled nitric oxide. While the ATS standard calls for repeated reproducible exhalations, several articles evaluating the NIOX MINO have indicated the same degree of agreement between the mean of three approved exhaled NO measurements on the current "gold standard" device (chemiluminescence analyzer – e.g. NIOX™) and the first approved measurement in the NIOX MINO. However, we will still attempt to collect two measurements. If only one successful measurement is obtained, it will still be used in data analysis.

The ENO exhalation technique has several components, each of which is performed for a specific reason. In the first phase, the participant inhales air through the filter to fill up the lungs. The filter provides NO-free air for the subject to breathe, and therefore eliminates any background level of ENO in the room air from affecting the ENO testing. When the subject exhales, they must be coached to push out air at a standard rate. This is necessary because measured ENO levels are rate-dependent. For example, with a fixed amount of ENO in the bronchial tubes, a person breathing out forcefully will have a comparatively lower measured ENO level that a person breathing out slowly. The NIOX MINO manufacturer has therefore designed the analyzer to accept test results only if the air flow rates are held constant at 50 ml per second. This way all participants have ENO measurements taken at a constant air flow rate, and their test results are strictly comparable.

The reason for requiring a 10-second exhalation is twofold. First, it is known that the nasal passages have much higher NO levels than do the bronchial tree or the lungs. Because nasal NO is highest in the first 2 seconds of expiration, the NIOX MINO sensor will wait for 2 to 3 seconds before beginning to take readings. Following that, the NIOX MINO sensor unit will look for a steady-state plateau in the NO measurements that lasts at least 2 seconds, taking that value as the reported measurement displayed on the NIOX MINO display screen.

CALIBRATION

To verify that NIOX MINO operates properly, calibration checks will be performed at the beginning of each day that the NIOX MINO will be used. The calibration procedure consists of two parts. One positive control from a qualified staff member with a stable FENO value providing a normal biological eNO sample and a negative control consisting of a NO free gas sample, generated from ambient air.

The positive control is performed using exhaled breath samples from one or more qualified staff members. The qualified staff member should have an expected FENO value within the range 5-40ppb and measurement results within +/- 10ppb of one another. The expected measurement result is calculated as the mean value from three measurements performed on three sequential days. The reference value is then updated on a regular basis.

The negative control consists of a NO free sample of ambient air scrubbed through the exchangeable NO scrubber. The NIOX™ NO scrubber allows the NIOX MINO™ monitor to check a "Blank" sample using exhaled breath (zero ppb NO). The result is compared with sample generated from the zero-scrubber, used for baseline control. The result should be <5ppb.

MATERIALS

NIOX MINO™ Monitor
NIOX MINO™ Sensor
NO Scrubber
NIOX Filter
QC Plug
NIOX MINO Extension Cord
AC/DC Adapter

SELECTION AND QUALIFICATION OF QC TESTERS

A minimum of one non-smoker staff member with no ongoing allergies or asthma will need to perform three QC calibration procedure measurements, once per day for seven days. A mean expected value will be calculated from the three measurements that must be between 5-40ppb. The QC measurement on the fourth day must be within +/- 10 ppb from the mean value and the NO scrubber result <5ppb. After, the quality control has passed, the instrument will be ready for use.

To reset a QC tester:

1. Select settings.  .
2. Select Mode Configuration. 
3. Select QC. 
4. Select Reset QC tester. 
5. Select the QC tester number to be reset. Confirm by selecting the crossed out number again.

CALIBRATION PROCEDURE

CALIBRATION CHECK WILL BE PERFORMED AT THE BEGINNING OF EACH TESTING DAY

The instrument will prompt for a daily QC procedure by showing a twinkling asterisk on the display.

Before any measurement:

- Avoid nitrate rich food (e.g., Beet, broccoli, kale, cucumber, garlic, lettuce, radishes, and string bean) within 3 hours before the measurement
- Avoid strenuous exercise at least 1 hour before the measurement

Preferably do not perform a measurement in case of:

- Ongoing cold
- Acute seasonal allergy

The procedures for performing the QC check are outlined below:

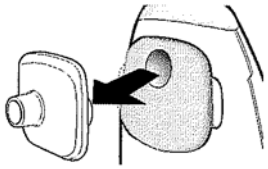
1. Gently spread the latches on the side of the NIOX MINO monitor , one a time and carefully pull out the cover. Visually inspect the NO scrubber for any damage. Do not proceed if the NO scrubber is visibly damaged. Snap the cover back into place.

2. Turn on NIOX MINO and let it warm up (up to 30 minutes)

3. Select Mode.  Select "QC".

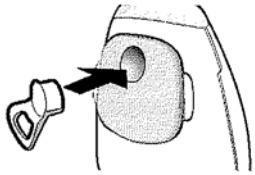
4. Select QC tester number (each QC tester must select an individual number)

5. Attach a new NIOX filter to the NIOX MINO monitor.



6. Set the monitor in Ready for Measurement mode and ensure the top blue light is lit.

7. Perform the ENO test. Use a mirror to assist you in achieving a valid measurement.



8. Remove the NIOX filter after completing the test.

9. Immediately attach the QC plug

10. Select Forward icon on display

11. Wait for analysis to be completed and the rest result to be displayed (approximately 5 minutes)

12. The QC measurement result is displayed. During the qualification days of a new QC tester, the result is displayed as presented Day 1-3.

13. Remove QC plug

14. Repeat QC test if positive and/or negative control fail (Negative control above 5ppb, positive control mean value not +/- 10ppb, not in 5ppb-40ppb range, error message displayed).

15. If the QC failure persists, notify Rebecca Moran that the unit failed to meet QC specifications

16. Disconnect the NIOX MINO™ monitor.

CONDUCTING ENO TEST IN THE HOME

MATERIALS

NIOX MINO™ Monitor
NIOX MINO™ Sensor
NIOX™ Filters
Noseclips
Scissors
Mirror
AC/DC Adapter
Extension cord
Tissue

The accuracy of the ENO examination largely depends on a coordinated effort exerted by the examinee and the conscientiousness of the technician. Consequently, it is crucial that the examination protocol be observed consistently, and that the examinee is prepared and "coached" for this examination. Two successful tests will be needed. Each participant will be given six attempts to achieve two successful tests. All participants are eligible for the ENO test.

SET UP THE NIOX MINO

1. Remove the NIOX MINO™ monitor from its storage bag;

2. If not already inserted, place the NIOX MINO™ sensor in the device

3. If not already inserted, place the NO scrubber in the device

4. Verify that the plastic modular connector plug of the AC/DC adapter is inserted into the NIOX MINO™ monitor;

5. Plug the AC/DC adapter into the extension cord and then into its own power strip or wall outlet. Do NOT plug the machine in a power strip with other equipment;

6. Let monitor warm up (up to 30 minutes);

7. Select ID on the main screen of the NIOX MINO monitor. Enter participant id using the number buttons.

PREPARE TO CONDUCT THE ENO PROCEDURE

1) Have the participant sit down in a chair. A chair without wheels should be used for the testing, and the participant should sit erect with chin slightly elevated. The purpose of the chair is to support the participant in case he/she faints during the maneuver.

2) Introduce the ENO test. Use the following suggested script:

   "We would like to measure gases in your breath using this device. First you will face the mirror. Empty your lungs by breathing away from the machine. Then put your mouth over the new filter and seal your lips tightly around it. Take a deep breath until you fill up your lungs and then breathe out at a normal rate through the filter."

EXPLAIN AND DEMONSTATE THE MANEUVER

1) Use scissors to cut open the bag with the plastic filter mouthpiece and using the plastic bag to grasp the filter, securely attach the filter to the NIOX MINO™ monitor. Ensure that the participant is sitting and facing the mirror in order to clearly see the image displayed on the monitor. If needed, have participant move closer to the mirror.

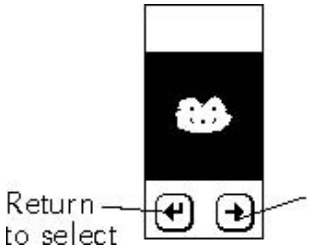
2) Briefly explain to the participant that he or she will empty his or her lungs, inhale deeply through the filter first, and then exhale slowly without removing his or her mouth from the unit. The participant will use the cloud pictures and sound cues to guide him or her through the exhalation, which will be 10 seconds.

3) Use the Demonstration mode in the NIOX MINO™ to show the participant the steps during the test with display of audiovisual feedback. While in demo mode use the suggested script:

   "When you breathe into the machine, you see the cloud getting bigger. Once the cloud is big, you can breathe out. As you breathe out, the machine will display a cloud that you will see in the mirror and you will hear a beeping sound. When the cloud is centered within the black box and you hear a constant sound, it means that you are breathing out at the right rate. When the cloud is under the black box and you hear a low-pitched sound, this means that you are breathing too

slowly. When the cloud is above the black box and you hear a high-pitched sound, it means that you are breathing too hard."

4) Select the mode icon on the main display screen. Then select the D icon to go to Demonstration mode. To move from screen to screen press the arrow key. To exit the Demonstration mode, press on the arrow key twice.



Inhalation: the cloud is growing during the inhalation sequence and the top light is turned off.

Correct Exhalation Pressure: the cloud is in a steady centered position, the top light is lit, and the audio emits a constant sound.

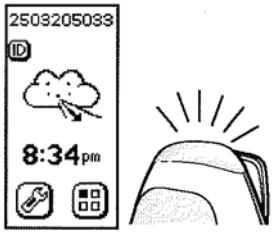
Too Weak Exhalation Pressure: the cloud is partly below the valid exhalation pressure area, the top light is flickering, and the audio emits a low intermittent sound.

Too Strong Exhalation Pressure: the cloud is partly above the valid exhalation pressure area, the top light is flickering, and the audio emits a high intermittent sound.

Measurement Processing: a scrolling image of clouds is shown during the analysis phase after a correct exhalation, and before a measurement value is shown.
\

INITIATE TEST

1) Prior to beginning the test, ensure that the participant is seated and can see themselves in the mirror. Let the participant hold the NIOX MINO™ monitor. Be sure the monitor is in the Ready for Measurement mode. Touch the smiling cloud on the NIOX MINO™ monitor. The screen will change to show the cloud with arrows pointing in and out of the cloud. The top blue light should be lit.



5) When the participant is ready and has assumed a correct posture, fit the nose clip if necessary and begin the ENO test.

1. Have the participant take a deep breath and empty his or her lungs.
2. Have him/her raise the NIOX MINO™ monitor to a position where he or she can place his or her mouth with a tight seal on the filter mouthpiece and inhale deeply through the filter to total lung capacity.
3. Have him/her exhale slowly though the filter.
4. The participant will use the cloud pictures and sound cues to guide him or her through the exhalation, which will be 10 seconds until the top light and the sound turns off.

Note: Face the participant and the mirror to assist with your coaching. Observe to see if the participant does any breath holding at any time during the procedure. If this should occur, the test should be repeated. Breath-hold results in NO accumulation in the nasal cavity and lower airway, which causes NO peaks in the exhalation profiles of NO versus time. For this reason, the use of breath hold is discouraged in the ENO standardized testing technique. Also observe to see that the participant does not remove his or her mouth from the filter during the exam.

2) Record each trial result and ENO measurement on the field log. If trial is successful, please record the measurement obtained on the ENO Field Log. If the trial is not successful, please record the appropriate error code on the form. When the trial is not successful, the NIOX MINO™ monitor quickly cuts off. Reset the monitor by touching the display screen and begin again coaching the examinee with the audio and visual cues. Continue coaching until a successful test is conducted assuming the subject is able to continue. Repeat until second successful trial is completed.

Each participant is given 6 attempts to achieve two successful trials. An attempt will be counted when a participant inhales and exhales into the machine and the visual and auditory signals appear regardless of the outcome. In situations where instead of a result, the ENO machine produces an error message, that maneuver will be counted as an attempt. When the ENO

machine is stabilizing or when spinning circles appear while trying to conduct the exam, it does not count as an attempt. However, even when a participant has a difficult time producing a successful trial, the 6 attempts rule will apply.

Note: It is not unusual for the participant to need several tries before he or she has a successful test. Be patient and calm so as to minimize participant frustration when he or she is having difficulty. If needed, provide short breaks in between maneuvers, for some participants might become lightheaded. If the subject is unable to continue, stop the test and record the reason the participant was unable to continue on the ENO field log.

ENO QUESTIONS

3) When the participant has completed the test successfully, ask the participant to set the monitor on the table and administer ENO-related questions during a successfully completed Test waiting period. These questions are included in the component solely to support data analysis and interpretation. Read the questions exactly as they appear on the form. The questions will be administered to all participants.

The complete questions for ENO are listed below:

ENO Q1: Within the **last hour** have you smoked a cigarette, cigar, pipe, or used any other tobacco product? *(ONLY ask for children over age 13)*

ENO Q2: Within the **last hour** have you exercised strenuously?

ENO Q3: Within the **last hour** have you had anything to eat or drink?

ENO Q4: Within the last **three** hours have you eaten beets, broccoli, cabbage, celery, lettuce, spinach, or radishes?

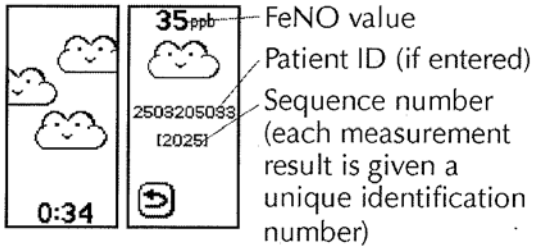
ENO Q5: Within the last **three** hours have you eaten bacon, ham, hot dogs, or smoked fish?

ENO Q6: Within the last two days have you used any oral or inhaled steroids? This list provides some examples (show hand card).

ENO Q7: In the past 7 days, have you had a cough, cold, phlegm, runny nose, or other respiratory illness? Do not count allergies or hay fever.

ENTER ENO TRIAL RESULTS

4) The wait time for results is 1 minute and 45 seconds. The Monitor screen will display clouds and countdown to zero. Once results for ENO trial are ready, the NIOX MINO™ monitor will beep and display the results. Make sure to enter the results for the trial on the ENO Field Log.



5) After the eNO test is completed, place the NIOX MINO™ monitor on the table or desk. Document any information about a participant's inability to complete a successful exam, e.g. refused test, unable to hold breath, etc… These comments should be recorded in the box located at the bottom of the ENO Field Log.

TROUBLESHOOTING ENO EXAMINATIONS

See Appendix C for a list of troubleshooting warning messages and a list of error message codes that could appear on the NIOX MINO™ monitor screen.

Report all ENO equipment malfunctions immediately to Rebecca Moran.

EXPLANATION OF RESULTS TO PARTICIPANT

Participants may ask how they did on this test. Assure them that this is currently being used for research only to compare nitric oxide levels. In addition, many factors may affect their results such as what they last ate, whether or not they smoke, and their respiratory health in general. We will not provide results to the ENO test.

EMERGENCY PROCEDURES

Ordinarily, the ENO examination should pose little risk to the safety of the participant. In rare cases, the participant may hyperventilate and become dizzy during ENO testing. Any participant who feels faint should be guided onto a chair with his or her head down toward the knees, and encouraged to breathe slowly and deeply until he or she recovers.

If the participant fails to recover normal breathing, faints, or reports feeling ill, the technician should summon the field manager immediately. The field manager will assume command of the emergency response. The field manager should always be consulted if there is any question regarding the participant's safety status during the exam.

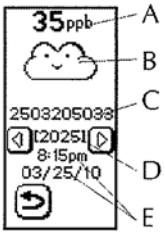
VIEW DATA

VIEW STORED RESULTS

The measurement result is automatically displayed at the end of a measurement. All previous results are stored in the instrument and can be viewed at any time. To view previous results:

1. Select Mode 
2. Select Measurement results 

3. The latest stored measurement is displayed showing



   A. FeNO value
   B. Measurement mode
   C. Patient ID
   D. Sequence number (Each measurement is given a sequence number)
   E. Time and date or measurement

4. Use previous and next buttons to step through the stored measurements
5. Select return (back error symbol) to go back to the mode screen.

EQUIPMENT CARE AND MAINTENANCE

The NIOX MINO™ monitor has an expiration date; either 3.5 years from date of manufacture or 1,500 measurements. However, when the monitor is close to its expiration date or permitted measurements, an error code of "E9000" will be displayed on the monitor. This code indicates that 50 measurements are left on the monitor.

The NIOX MINO™ sensor also has a measurement limit. The sensors are allowed a specified number of measurements and must be changed when the number of measurements displayed on the NIOX MINO™ monitor is insufficient to accommodate all tests that have been scheduled during a day. For example, if there are only 5 tests left on the sensor, but there are 3 participants scheduled for the day, you should insert a new sensor. The number of measurements left is displayed on the monitor above the cloud with the "#" sign and the number of measurements. When the expiration date approaches, a warning message will be displayed on the monitor screen.

NIOX MINO™ MONITOR

For infection control purposes, the NIOX MINO™ monitor must be cleaned weekly. On a daily basis, the technician will also inspect the external surfaces of the monitor and wipe them clean with disinfectant wipes as needed.

To clean the device:

1) Remove the NIOX MINO™ monitor from the mesh bag;
2) Unplug the AC adapter plug from the extension cord;
3) Remove the plastic modular connector plug from the device;
4) Wipe the outside perimeter of the device with alcohol prep pads; only the areas where the participants generally place their hands; and
5) Do not wipe the bottom part of the device where the sensor is located.

NIOX MINO™ SENSOR

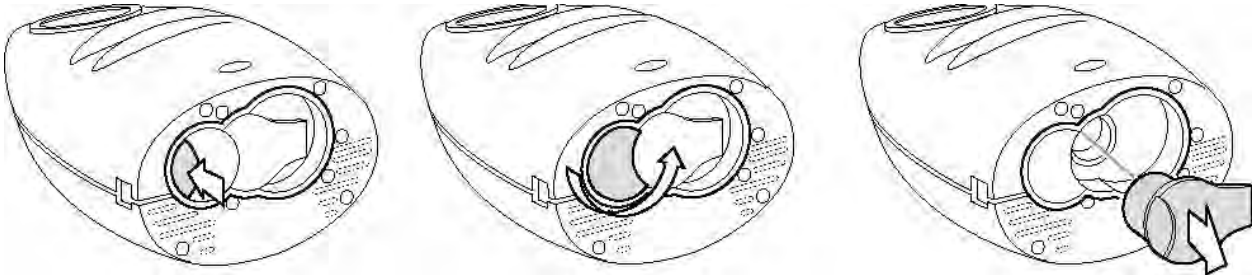
Prior to leaving UC Davis for a week of field sampling, ensure that there are adequate tests left on the sensor. If not, pack an extra sensor.

In general, sensors must be changed when the number of measurements displayed on the NIOX

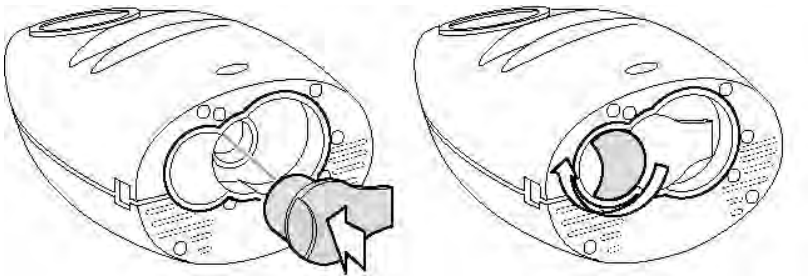
MINO™ monitor is insufficient to accommodate all tests planned for that day. For example, if there are only 5 tests left on the sensor, but there are 3 participants scheduled for the day, you should insert a new sensor.

To change sensors, make sure the AC/DC adapter is disconnected before the sensor exchange. Be careful when opening the sensor can. The inside of the opening has sharp edges. Follow these instructions:

Press and hold the blue part… ..while turning the orange part.. Remove the grey sensor.



Insert the new sensor. Turn back the orange part until locked.

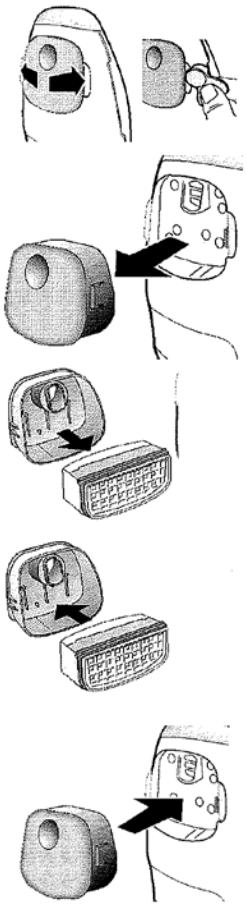


Make sure to touch only the grey part when exchanging the sensor. After the sensor is exchanged, it might take up to 30 minutes for the NIOX MINO™ monitor to warm up. If the sensor is completely depleted, please place the used sensor in the sensor box and label it “Used.” Take it back to UC Davis.

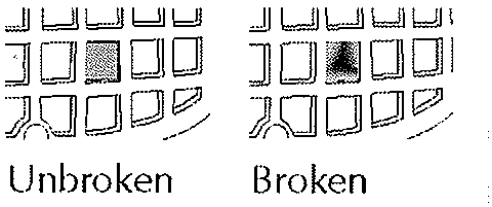
NIOX MINO™ NO SCRUBBER

The NO scrubber is used for elimination of ambient NO in a patient’s sample. The shelf life of a NO scrubber is 2 years in an unopened package. Once inserted, the NO scrubber expires after 1 year or after 1000 measurements.

To insert a new NO scrubber:



1. Gently spread the latches on the side of the NIOX MINO monitor , one a time (Optionally, use the red QC plug to spread the latches apart) and carefully pull out the cover.
2. Remove the used NO scrubber from the cover.
3. Insert the new NO scrubber into the cover. Make sure to use a new NO scrubber with unbroken holes.



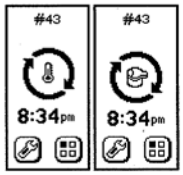
4. Replace the cover and snap it back into place.
5. Select settings on the monitor screen. Select the NO scrubber icon.
6. Input the passcode 0000 using the number buttons to confirm that a new NO scrubber as been installed.
7. Select OK to accept changes.
8. The NO scrubber contains potassium permanganate and should be disposed of as hazardous waste in accordance with the local waste disposal regulations.

APPENDIX: TROUBLESHOOTING AND ERROR CODES FROM THE AEROCRINE USER MANUAL

TROUBLESHOOTING

Troubleshooting

Warning	Action
	Asterisk shown. The instrument has not been verified by a daily QC. Perform a QC measurement.
	Daily QC measurement outside limits. Restart the daily QC measurement with another QC tester.
	The inhalation was too weak to initiate a measurement or an exhalation into the instrument was performed prior to an inhalation. Stop the procedure immediately when this warning appears. Wait until the main menu screen is displayed and repeat the inhalation with a stronger inhalation force.
	NO scrubber reminder. The symbol is shown at first start-up of the instrument as a reminder to insert and set the software for a new NO scrubber. See *Installation and set-up* section page 4.
	NO scrubber almost expired. Order a new NO scrubber. The symbol is shown when 10% of the measurements remain or 2 weeks before expiration date and continue until the NO scrubber has expired. A NO scrubber can be used for 1000 measurements or 1 year. Refer to the Change NO scrubber section on page 15.
	No Sensor connected. Insert a Sensor.

Warning	Action
	Sensor almost expired. Order a new Sensor. The symbol is shown when 10% of the measurements remain or 2 weeks before expiration date and will be shown until the Sensor has expired. Refer to the Change Sensor section page 15.
	Instrument almost expired. Order a new instrument. The symbol is shown 4 months before the instrument expires or when 10% of the measurements remain. The instrument will not work after the indicated date, or after the indicated number of measurements. It is still possible to view measurements stored in the instrument memory and download data to a PC.
	Make sure that the ambient temperature is between 60 and 85°F (+16 and +30°C). Wait for the Sensor to stabilize.
	Remove any sources of disturbance (such as cordless or mobile telephones, or gas emitting appliances). Wait for the Sensor to stabilize.
	Wait for the Sensor to stabilize. < 4 minutes (countdown started).

Alert codes

Alert messages and other information are shown as codes at the top of the instrument display. The table below provides the recommended actions to be taken for an alert code. If alert persists, contact Aerocrine Inc.

Code	Action
User alerts	
A10	Exhalation too strong. Select Return and repeat the measurement with less force.
A11	Exhalation too weak. Select Return and repeat the measurement with greater exhalation force and exhale until signal for completed exhalation is heard.
A12	No exhalation detected. Select Return and repeat the measurement and exhale into the instrument directly after inhalation.
A13	Select Return and repeat the measurement. Do not breathe through the patient filter during analysis.
A14	Wrong passcode for NO scrubber exchange.
Instruments alerts	
A20	Check that ambient temperature is within specification. If necessary, shut the instrument down, move it to another location and restart the instrument.
A21	Remove any sources of disturbance (such as cordless/mobile telephones, or gas emitting appliances). When the instrument is ready try to repeat the measurement. If the alert persists, unplug and reconnect the power supply unit to restart the instrument.
A22	Unplug and connect the power supply unit to restart the instrument.
A23	Remove any sources of disturbance (such as cordless/mobile telephones, or gas emitting appliances). When the instrument is ready try to repeat the measurement. If the alert persists, unplug the power supply unit, remove and reinsert the Sensor, reconnect the power supply unit and restart the instrument.
A24	Check that the supply voltage is within specification. If necessary replace the power supply unit.
Connection alert	
A31	Check the USB connection to the PC
QC alerts	
A50	The mean value of the three qualification results does not fall between 5-40 ppb. Restart the QC tester qualification from qualification day 1.
A51	There has been an attempt to perform several QC measurements at the same day with the same test person. Wait one day and perform the next QC measurement.
A52	Moving mean value out of range. Restart the QC tester qualification from qualification day 1.
A53	NO scrubber result over 5 ppb. Check that the QC Plug was attached when instructed. Restart the QC measurement. If continuously shown replace the NO scrubber.
A54	Daily QC result lower than 5ppb. Restart the measurement with a test person who has a FeNO value higher than 5 ppb.
A55	Daily QC result higher than 40 ppb. Restart the measurement with a test person who has a FeNO value lower than 40 ppb.
A56	Failure to press the QC plug forward button in time (within 1:30 min). Repeat the QC measurement and make sure to press the forward button after the QC plug is inserted.
Instrument and Sensor expiration alerts	
A90	Instrument expiration date has passed or all instrument measurements have been used. It is still possible to view measurements stored in the instrument memory and download data to a PC. Contact Aerocrine, Inc.
A91	Sensor expiration date has passed or all measurements on the Sensor have been used. Replace the Sensor.

STANDARD OPERATING PROCEDURE FOR PIKO PEAK FLOW METER

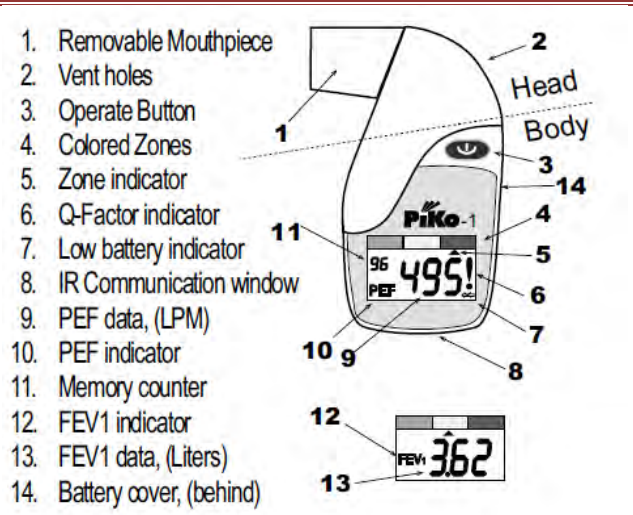
(FROM NATIONALJEWISHHEALTH.ORG)

The Piko peak flow meter is an inexpensive, practical way to measure lung function at home. The Piko peak flow meter measures how fast and how much air a person can blow out after taking a deep breath. The Piko measures PEF. This is the peak expiratory flow rate. In addition, the Piko also measures FEV1. This is the Forced Expiratory Volume in the first second you exhale. Many peak flow meters measure PEF, but not FEV1. The Piko peak flow meter measures both. These measures, which are read as numbers, may reflect the amount of obstruction in the airways. This will help us look at the effectiveness of environmental control measures.

A daily (or regular) record of peak flow numbers can also sometimes provide a valuable early warning sign of asthma. Sometimes peak flow numbers will decrease hours, or even a day or two, before other asthma symptoms become evident.

Peak flow numbers are effort dependent. This means the participant needs to put forth a good effort to have reliable, consistent results.

PEAK FLOW METER



INSERTING AND CHANGING THE BATTERIES

The Piko does not come with the batteries in the device. You must put the batteries in the device before you use it. The battery must also be changed **each time** the peak flow meter is given to a new participant.

To insert or change the batteries:

1. The battery cover is on the back of the Piko.
2. Use a coin to turn the battery cover one quarter turn to open it. Remove the plastic insert where the batteries go if this is the first time you are inserting the batteries.
3. Insert two type 357 silver oxide or lithium 3106 button cells. Place the negative side down.
4. Replace the battery cover. Turn the battery cover one quarter turn to close it.

CLEANING THE PEAK FLOW METER

Remember to clean the Piko peak flow meter between each participant to keep it recording accurately.

To clean the Piko peak flow meter:

1. Take off the clear plastic mouthpiece by moving it sideways. Discard.
2. Clean the Piko top section (not the display section) with low-flow water at room temperature. Shake off the excess water and dry thoroughly. Do not immerse the display section in water.
3. Put on a brand new clear plastic mouthpiece. Place the mouthpiece on by snapping it into place. The mouthpiece should face straight out once replaced. A new mouthpiece MUST be put on each time the device is given to a participant.

GIVING THE PEAK FLOW METER TO PARTICIPANTS

In the home, show the parent and the child the peak flow meter and explain that the peak flow meter measures how fast and how much air you can blow out after taking a deep breath and helps reflect how well the lungs are working. Explain that the child will need to use the peak flow meter **two times** each day for **one week** (7 days)- once each morning and once each evening. Emphasize that the procedure doesn't hurt and that he/she must breathe as hard and as fast as possible in order to get consistent and reliable results.

Review the "Participant Instructions" with both the parent and the child. Demonstrate the correct technique and then have the child perform the technique for you until they do it correctly and understand the procedure. Once you are confident that the child can perform the test on their own or with the help of their parent, leave the handout and the piko-1 flow meter with the parent for a week. Make sure to remind the parent to call us if they have any problems or questions. Tell the participant whether we will be picking the peak flow meter up at their home or if they are to mail it back to us. If they are to mail it back to us, be sure to show them the addressed and stamped envelope that they should use.

PICKING UP THE PEAK FLOW METER AFTER MONITORING PERIOD

After one week of monitoring, the peak flow meter will be either picked up at a home visit or mailed back to the study by the participant. Once the device is retrieved, complete the following steps:

DOWNLOAD DATA

DOWNLOAD DATA IN BETWEEN EACH PARTICIPANT

The memory bank will be downloaded to a computer using the cradle and the PikoNET lung health management software after each participant. To download the data from the Piko-1:

1. Open PikoNet Pro software.
2. Plug cradle into USB port, making sure the red light on the cradle is pointing towards you.
3. Click on the binocular icon on the PikoNet software taskbar to select an existing participant from the database or create a new participant, if this is the first download for that participant.

    a) If creating a new participant, enter participant ID #, child's last name and first initial only. Leave all other fields blank.
    b) The dates are automatically coded into the file.

4. Place the Piko unit in the cradle, with the display facing the red light on the cradle.
5. Click the Piko download icon in the PikoNet software taskbar.
6. Press the power button on the Piko unit 2 times to initiate the download. The downloading progress will be indicated by the cycling segments on the display.
7. If prompted to change the owner of the Piko, click "Yes".
8. Say "No" to reference value
9. Upon completion of the download, click "Yes" when prompted to clear the memory of the Piko unit.
10. Save the data as a PDF and then as a CSV file:
    1. Export data as a PDF file by going File → export as PDF
    2. Export data as a CSV file by going File → export as CSV

Note: It is possible to interrupt the downloading process at any time by removing the Piko-1 from the Cradle.

CHECK THE MEMORY

The memory bank should be cleared after downloading the data, but it is important to check and make sure the memory is cleared before giving the device to another participant (Display will show 0 if memory is cleared).

PEAK FLOW METER INSTRUCTIONS:

The Piko peak flow meter is a small, easy-to-use instrument that enables you or your child to measure lung function at home, at work, at school—wherever you go. The peak flow meter measures how fast a person can blow out air after a maximum inhalation. It helps reveal how well you or your child's lungs are working.

HOW DO YOU USE THE PIKO PEAK FLOW METER?

1. Take the Piko peak flow meter out of the plastic case.
2. There is one button on the side of the Piko peak flow meter. This is the button you will push to perform the different functions using the Piko.
3. If the display is blank, press the button once. The display will show the most recent test results.
4. Stand up (or sit up straight). Hold the Piko peak flow meter so you don't cover the vent holes. The vent holes are at the top of the Piko peak flow meter behind the mouthpiece.
5. Press the button once. You will hear a short beep. Wait to hear a second beep. The display will look like this: **0- -**
6. Take a deep breath in.
7. Place the mouthpiece in your mouth; close your lips around the mouthpiece. Do not put your tongue in the mouthpiece.
8. Blow out as hard and as fast as you can without bending over. Blow for at least 2 full seconds.
9. Look at the display. Your test results will appear in the display right away. The test results will change from PEF to FEV1.
10. You can repeat steps 3 through 8 up to two more times. The Piko will select and save the highest of the three good results if the tests are completed within 3 minutes.
11. The Piko automatically turns itself off if not used in 3 minutes.

WHAT DOES (!) MEAN IN THE DISPLAY?

The explanation mark (!) after the reading in the display means there was a problem with your technique. You need to repeat the test again. You may also hear a long beep after the test. Try blowing harder and longer and make sure you do not cough during the test. If you are having problems, call a study staff member for help.

HOW DO YOU KEEP A RECORD?

You do NOT need to write anything down. The Piko peak flow meter holds up to 96 test results in the memory. To view the stored tests, press the button for 5 seconds. The latest test result will appear on the display screen. Each time you press the button the display will show a test result, moving backwards from the most recent test result. To exit the memory mode either press the button again for 5 seconds or don't press the button for 20 seconds.

WHAT TO DO IF YOU HAVE PROBLEMS?

If you have any problems or any questions about your peak flow meter, call the study staff at (530)754-8272.