Final report: Contract Number 03-327

Traffic Pollution and Children's Health: Refining estimates of exposure for the East Bay Children's Respiratory Health Study.

Principal Investigator:
Bart Ostro, Ph.D.
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Prepared for:

The California Air Resources Board and the California Environmental Protection Agency

Prepared by:
Bart Ostro Ph.D., Chief
Janice J Kim, MD, MPH
Air Pollution Epidemiology Unit
Office of Environmental Health Hazard Assessment
Oakland, CA 94612
(510) 622-3157/510 622-3198
Email: Bostro@oehha.ca.gov
jkim@oehha.ca.gov

Disclaimer

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgements

This study was supported by the California Air Resources Board (ARB Contract 03-327). Additional support was received from the US Environmental Protection Agency, Region IX (CH-97942501-2), and the Centers for Disease Control and Prevention (under Cooperative Agreement Number U50/CCU922449 with California Department of Health Services).

Dr. Michael Lipsett of the California Department of Public Health was a co-investigator on the overall project and study design. Dr. Michael Jerrett of UC Berkeley and Zev Ross of ZevRoss Spatial Analysis were lead investigators in the development of the land use regression models. Svetlana Smorodinsky of CA Department of Public Health provided invaluable assistance with study design, execution, and early phases of this project. Karen Huen, Abby Hoats, Sara Adams of UC Berkeley and Brian Malig of OEHHA provided assistance with the analysis. Dr. Edmund Seto of UC Berkeley provided additional GIS support. The study team would also like to thank Brett Singer, Alfred T Hodgson, and Toshifumi Hotchi of Lawrence Berkeley National Laboratories, for work on the air monitoring study; Jackie Hayes and Donna Eisenhower, Survey Research Center, University of California, Berkeley, for coordinating the survey; and Craig Wolff, CA Department of Public Health, for providing us with the traffic data layer. Shelley Green, Rachel Broadwin, and Rupa Basu of OEHHA also provided helpful discussions.

We also want to thank the school districts, principals, teachers and all study participants and their families for their time and commitment to this project. We thank the staff of the Air Resources Board for assistance with grants administration and their support and helpful comments and suggestions during the contract period.

TABLE OF CONTENTS

List of Figures

List of Tables

Abstract

Traffic emissions are the major source of air pollution in urban centers, and concentrations of traffic pollutants are higher near busy roads. We conducted a cross-sectional study of children (n=1080) living at varying distances from high-traffic roads in the San Francisco Bay Area, a highly urbanized region in Alameda County characterized by good regional air quality due to coastal breezes. Health information and home environmental factors were obtained by parental questionnaire. This current study builds on an earlier study of this population where children's pollutant exposures were based on measurements taken at neighborhood schools. In the earlier study, we found modest associations between traffic pollutants and current asthma and bronchitis based on a two-staged analysis. In this project, exposure estimates were developed for smaller spatial scales using geographic information systems (GIS) methods and utilized in health analyses. Associations with respiratory morbidity were examined using several measures of residential proximity to traffic calculated using GIS including: (1) traffic metrics that measure traffic distance, volume and/or density; and (2) a land use regression model (LUR) that predicts nitrogen dioxide (NO_2) for Alameda County. We found that various efforts to enhance estimates of traffic exposure resulted in stronger associations with respiratory morbidity, particularly current asthma symptoms. For example, stronger associations were found when we restricted the sample to those living close to the school-based measurements. Traffic-based estimates developed through GIS were moderately correlated with actual pollutant measurements, especially nitrogen oxides (NOx) and nitric oxide (NO), and also associated with current asthma. The highest risks of asthma were among those living within 75 m of a freeway/highway and those exposed to very high levels of nearby traffic density. A land use model developed for Alameda County successfully predicted NO_2 concentrations which were then found to be associated with current asthma. There was poor agreement between self-reported residential proximity to traffic and more objective measures using GIS methods. Our findings provide evidence that even in an area with good regional air quality, proximity to traffic is associated with adverse respiratory health effects in children.

Executive Summary

Background:

Traffic emissions are a major source of urban air pollution, and epidemiological studies in the past decade have found links between residential proximity to busy roads and adverse impacts on health, including respiratory symptoms, cancer, and death. Most of these studies have been conducted in Europe, where fleet compositions, emissions factors, fuel specifications, and population distributions near busy roads differ from those in California and the U.S. as a whole. More recently, several studies have been conducted in Southern California. The majority of studies have been conducted in areas with high background levels of ambient air pollution, making it challenging to isolate an independent effect of traffic. Most investigations have used surrogates of exposure; few have measured traffic pollutants directly as part of the study. Traffic is ubiquitous, and a careful analysis of traffic exposures and possible health impacts will have important policy implications in future strategies to decrease adverse impacts of air pollution on vulnerable populations.

Methods:

The Office of Environmental Health Hazard Assessment (OEHHA) recently conducted a school-based cross-sectional epidemiological study in 2001 (The East Bay Children's Respiratory Health Study (EBCRHS)) and found associations between traffic pollution and asthma and bronchitis episodes in the past 12 months. In the previous analysis, we used group-level measurements of pollution, obtained at local schools as an estimate of a child's overall exposure to traffic. However, traffic-related pollution is likely to vary on a local scale, and one important area of uncertainty in the EBCRHS that needed further examination was the exposure estimate for traffic-related pollution. This project extended the earlier published results of the EBCRHS by refining estimates of exposure to traffic-related pollutants using geographic information systems (GIS) technology and other available methods including land-use regression (LUR) models. GIS and LUR approaches can provide epidemiologists with new tools to develop estimates of environmental exposures that vary spatially. Traffic emissions are clearly not distributed uniformly over a wide area or easily characterized by simple air dispersion models. Thus, the use of GIS and LUR methods may provide an efficient mechanism for the assessment of the health impacts from busy roads through the integration of spatially resolved traffic, air pollution, and health data.

In this project, we took three approaches to refining estimates of exposure. These exposure estimates were then tested in a health analysis of several outcomes including: current asthma (doctor-diagnosed asthma and wheezing or an episode of asthma in the last 12 months), bronchitis symptoms in the last 12 months, and history of allergic rhinitis. As the first exposure metric, we restricted our study population to those children living within 1 km of the schools where pollution measurements were undertaken, since there is likely to be less measurement error. We then compared results of the group level health analyses using the full sample versus one restricted to living with 1 km of the school. Residential exposures to traffic are important determinants of a child's overall exposure to traffic pollution. Therefore, we focused on developing estimates of individual-level exposure, based on residential proximity to traffic. We developed traffic metrics based on factors such as traffic volume, distance, and location (i.e.,

upwind or downwind from major roadways). Many traffic metrics were explored including maximum annual average daily traffic (AADT) with 150 meters or 300 meters, the closest AADT with 150 or 300 meters, several traffic density measures, and distance to the nearest freeway or highway. After comparing these residential-based traffic metrics with neighborhood measurements made of concentrations of oxides of nitrogen (NOx), nitrogen dioxide (NO_2) and nitric oxide (NO), they were used in an analysis of health data. (The gas NO should be viewed here as a surrogate for fresh traffic emissions (e.g. ultrafine particles)). Finally, we developed LUR models to provide estimate of residential levels of nitrogen dioxide, (NO_2) for our study population for use in the health analyses. We also explore the relative contribution of exposures at school and home in the same logistic regression model.

Self-reported residential proximity to busy roads has been used as an estimate of exposures to traffic pollution. In this study, we first compared self-reported proximity of home to traffic based on questionnaire data and with more objective GIS-based traffic estimates and second, examined associations between self-reported proximity to traffic and respiratory morbidity.

Indoor air quality (IAQ) at the schools could confound associations between traffic and children's respiratory outcomes. We analyzed survey data previously collected that assessed IAQ at the schools and tested school IAQ variables using multivariate logistic regression. Finally, we explored whether there was differential exposures to residential traffic exposures by socioeconomic measures and race ethnicity using statistical test in our study population.

Results:

Overall, we found associations between proximity to traffic and current asthma using a variety of analytical approaches. Associations with bronchitis were less consistent. After restricting our analyses to a subset of individuals living within a 1 km radius of the schools (where pollution measurements were taken), higher point estimates were observed for current asthma, relative to the full data set (Table 2). Statistically significant associations ($p < 0.05$) were observed between asthma and both NO and black carbon (BC) and more modest associations ($p < 0.10$) were observed for NOx and PM_{10}, with no association observed for $PM_{2.5}$ or NO_2.

As a second measure of exposure, we developed individual-level estimates of traffic exposures at the home using GIS metrics. Traffic metrics were compared with measured levels of traffic–based pollutants (NOx, NO_2 and NO). In general, GIS-based traffic metrics were moderately correlated with measured levels of traffic pollutants. Most GIS-based traffic metrics were better correlated with NOx and NO compared with NO_2. Correlations between NO_2 levels and traffic metrics (other than distance to freeway/highway) were significant only for metrics using 300 m buffers. A LUR model of traffic pollution (NO_2) was also developed and validated. Several alternative models were explored including weight least squares (WLS), WLS with interaction terms for downwind of highways (WLS-int), and WLS with universal kriging with and without the interaction. The LUR performed well in predicting NO_2 with an adjusted coefficient of variations (R^2) of between 0.66 and 0.73 depending on the model used and the geographic coverage. This corresponds to a correlation of around 0.83.

Thus, we observed higher correlations with NO_2 from the LUR than the traffic-based exposure metrics. We lacked monitoring data to develop LUR models of other pollutants such as BC or NOx.

To examine the association of the exposure metrics with respiratory morbidity, we used a multivariate logistic regression analyses that controlled for individual-level risk factors. Using GIS-based traffic metrics, we found associations between current asthma and several of the measures of residential proximity to traffic. For example, children in the highest quintile of various traffic metrics (e.g., maximum AADT or traffic density within 150 m) had approximately twice the adjusted odds of current asthma compared to children in the lowest quintile of exposure. The highest risks were among those living within 75 m of a freeway/highway. Using land use regression estimates of NO_2, we found similar impacts on children's respiratory health in our study population.

We also explored whether the associations with health were stronger after using NO_2 measurements from both the residence and school. In general, we found little evidence of a better predictive model using a time-weighted average of NO_2, incorporating exposures at both the home and school. Residential exposures alone generated the strongest associations with current asthma.

In our study, we found that more objective measures using GIS-derived traffic metrics or land use regression models are better predictors of traffic pollutants NO_2 and NOx. In multivariate logistic regression models, we found no associations between respiratory outcomes and self-reported residential proximity to traffic.

The school IAQ survey data was or poor quality, limiting our ability to interpret the data. With this qualification, in further analyses, we found little evidence that traffic pollutant concentrations at the schools were confounded by IAQ factors at the school. Finally, we found that Hispanics had the highest residential traffic exposure in our study population, and measures of socioeconomic status (SES) such as crowding and poverty were associated with increasing traffic. However, in our dataset, SES and race-ethnicity were not important predictors of health outcomes. This might be due, in part, to our study design since schools were selected to have relatively similar measures of SES status.

Conclusion:

We found that various efforts to enhance estimates of traffic exposure resulted in stronger associations with respiratory morbidity, particularly current asthma symptoms. Associations for bronchitis were less consistent across different traffic metrics. Stronger associations between current asthma and pollution were found when we restricted the sample to those living close to the school-based measurements. Traffic-based estimates developed through GIS were moderately correlated with actual pollutant measurements, and also associated with current asthma. The traffic metrics correlated better with NO and NOx than with NO_2 which suggests that, at least for our study, the primary pollutants might be more important in impacting health. The LUR model also successfully predicted NO_2 concentrations in the East Bay (with correlations higher than those observed from the traffic-based metrics). The LUR-based estimates of ambient NO_2 at residences were associated with current asthma. The importance of the LUR was evident in that residential-based estimates of NO_2 from the LUR were associated with asthma, while neighborhood levels of NO_2 (based on school measurements) were not.

Future research is needed to improve understanding of the spatial distribution of NO_2 and other traffic-based pollutant(s) as well as the relative respiratory toxicity of the constituents of traffic exhauast.

The findings in our current study signify that, even in urban areas with good regional air quality, exposures to air pollution from nearby traffic may be associated with risks to children's respiratory health. Our results contribute to a growing body of evidence linking residential proximity to traffic with the prevalence of respiratory symptoms and asthma in children. These findings are observed across diverse populations worldwide, despite differences in demographics, lifestyle, transportation patterns, and levels of regional air pollution. Although further studies are needed to explore which constituents of traffic pollution contribute to health impacts, traffic emissions clearly have an adverse impact on both local and regional air quality and respiratory health. Reducing exposures from nearby traffic will likely require a comprehensive, multi-faceted strategy including regulation of motor vehicle emissions, transportation planning, urban and building design, lifestyle changes, and a re-evaluation of potential hot-spots of exposures where children live, attend school, and play.

Traffic-related Air Pollution and Children's Respiratory Health: Improving Estimates of Exposure to Traffic Pollution.

Introduction:

Traffic emissions are a major source of urban air pollution and concentrations of traffic pollutants are greater in close proximity to major roads (Zhu et al. 2002a; Zhu et al. 2002b). Most epidemiological studies of health effects of air pollution have studied effects on large populations using central site air monitors as estimates of exposure to air pollution. However, more recently, epidemiological studies have linked proximity to busy roads and adverse impacts on health, such as respiratory symptoms, asthma, adverse birth outcomes, and mortality due to cardiopulmonary disease (Delfino 2002) (Wilhelm and Ritz 2003) (Hoek et al. 2002). Methods for estimating exposures to traffic pollutants have varied among studies and include neighborhood or school-based estimates of traffic (Wjst et al. 1993) (Brunekreef et al. 1997; Kim et al. 2004; van Vliet et al. 1997), self-reported residential proximity to traffic (Ciccone et al. 1998; Duhme et al. 1996), distance to freeways or busy roads (Gauderman et al. 2005; McConnell et al. 2006) (Garshick et al. 2003), presence of a busy road within a given buffer (Venn et al. 2001), or measures of traffic density within a given radius (English et al. 1999; Wilhelm and Ritz 2003).

Several recent studies utilized geographic information systems (GIS) to estimate traffic exposure metrics. However, few have evaluated these GIS-based traffic metrics against measured traffic-related pollutants (Hoek et al. 2002) (Gauderman et al. 2005 ; Nicolai et al. 2003) (Brauer et al. 2007). Additionally, many of these studies were conducted in areas of Europe or Southern California with moderate or high levels of regional air pollution.

Because it was uncertain to what extent these findings apply in urban areas of California where patterns of emissions and exposures differ from Europe, the Office of Environmental Health Hazard Assessment (OEHHA) recently conducted the East Bay Children's Respiratory Health Study (EBCRHS), a school-based cross-sectional epidemiological study in the San Francisco Bay Area (Kim et al. 2004).

This current project builds on this initial study. To give context to this current project, we will briefly describe the first phase of the study as follows:

Previous work: The EBCRHS was conducted in the San Francisco Bay Area, a highly urbanized region of the United States where traffic is the major source of air pollution. This region ranks among the top four metropolitan areas with the worst traffic congestion in the United States (Schrank and Lomax 2005). However, the area experiences relatively good regional air quality due to onshore breezes. Thus, in contrast to most major metropolitan areas in the U.S., there are only occasional exceedances of the federal ozone 8-hour standard or fine particulate matter (particles less than 2.5 microns in diameter or PM2.5) 24-hr standard. This allowed us to examine the impacts of local variations in traffic in the absence of significant levels of background ambient pollution.

In the initial phase of our study, we measured traffic-related pollutants at the neighborhood school sites and found increased concentrations of traffic-pollutants (total nitrogen oxides, nitrogen dioxide and black carbon) at schools nearby versus more distant (or upwind) from major roads. To determine how well the school-based measurements represent residential exposures, additional neighborhood-scale monitoring was also conducted near several schools (Singer et al. 2004). In health analyses, we found modest but statistically significant associations between measured traffic pollutants and recent episodes of asthma and bronchitis using traffic pollutants at the neighborhood schools as estimates of children's overall exposures (Kim et al. 2004).

The goal of this current study was to refine exposure estimates using GIS-derived traffic measures at the children's residences and to evaluate associations between residential proximity to traffic and respiratory health outcomes for the study population.

We hypothesized that, by reducing measurement error, we would be able to elucidate more clearly the relationships of traffic to respiratory health outcomes among a vulnerable population of children and also determine the relative importance of different approaches to refining exposure estimates.

Specific aims:

1. Develop and test empirical models that relate school- and neighborhood-scale ambient pollution monitoring to GIS-based traffic metrics.
2. Develop and test the association of traffic estimates with several health outcomes, using traffic-based exposure measures at our study subjects' schools and residence. Evaluate the impact of these traffic-based exposure metrics on the direction, magnitude, and precision of the health effect estimates.
3. Evaluate other potential school-facility specific factors that might contribute to respiratory symptoms using a School Indoor Air Quality (IAQ) Survey.
4. Use GIS-based traffic estimates to validate self-reported traffic measures
5. Utilize GIS-based traffic estimates to empirically test for differential exposures by SES, race and ethnicity.

Overview of the report: In the first section we describe general aspects of the epidemiological study design and health assessment as it is applicable to all the specific aims outlined above. To address specific aims 1 and 2, we utilized three different approaches to estimating traffic exposures: (1) school-based pollutant concentrations restricted to a subset of participants living within a given radius of the school; (2) traffic exposures based on residential traffic metrics estimated using GIS methods; and (3) traffic exposures based on a land use regression (LUR) model. For each method of traffic exposure estimation, we will describe the methods for determining exposures and subsequent health analyses and present the results, grouped by type of exposure estimation. We will follow with sections on school IAQ (Aim 3), GIS-based traffic metrics vs. self-reported proximity to traffic (Aim 4), and an evaluation of sociodemographic factors and differential exposures to traffic in our study population (Aim 5).

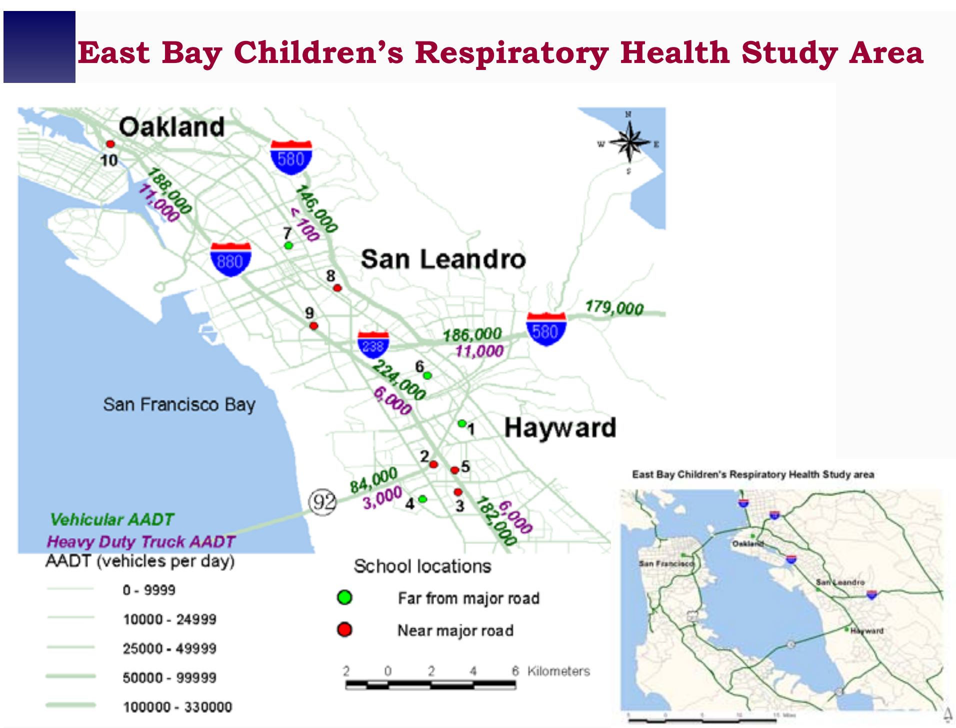
Section 1: Exposures to traffic pollutants and evaluation of health risks (Specific aims 1&2)

Materials and Methods:

Study design and Health Assessment

The EBCRHS study design has been described previously (Kim et al. 2004; Singer et al. 2004). Briefly, we recruited students in grades 3-5 from ten neighborhood schools located at various distances from major roadways. The study area is shown in Figure 1. There were no major stationary sources of pollution near any residences. Smaller local sources of airborne respiratory irritants were not evaluated and could, in theory confound the health analyses. This is unlikely unless the proximity to small local sources were consistently associated with both high traffic exposures and health outcomes.

Figure 1: East Bay Children's Respiratory Health Study Area. The study region is to the east and across the bay from the City of San Francisco (see inset). Locations of schools (1-10), major roads, and daily traffic counts (total vehicular and heavy-duty truck) on selected roads are shown (see text).



Respiratory health outcomes were obtained from responses to parental questionnaires and included ever-asthma (physician-diagnosed),current asthma symptoms (ever-asthma and wheezing or an episode of asthma within the past 12 months, bronchitis symptoms in the past 12 months, wheezing in the last 12 months (regardless of diagnosed asthma), and history of allergic rhinitis (physician-diagnosed). (Table 1). Additional questionnaire data included demographics, familial history of asthma, home and environmental factors, and activity patterns. The Committee for the Protection of Human Subjects of California Health and Human Services Agency reviewed and approved the study protocol.

Other sources of data for this study included: (i) California Department of Transportation (CalTrans) Annual Average Daily Traffic (AADT) for 2001 and road classification data for all freeways, highways, and major (non-local) roads; (ii) meteorological data for Oakland and Hayward airports (Western Region Climate Center, Reno, NV); and (iii) traffic pollutant measurements conducted for this project. For additional details on study design and methods see Appendix A and (Kim et al. 2004)

Table1. Definition of health outcomes used in analyses

Health outcome	Definition
Current asthma	A doctor has *ever* said the child has asthma – and "an episode of asthma " or "wheezing" occurred in last 12 months
Bronchitis (in the last 12 months)	1) a positive response to the question: "During the past 12 months, did your child have bronchitis?" or (2) a report of cough and chest congestion or phlegm lasting at least three consecutive months of the past 12
Ever-asthma	A doctor has *ever* said the child has asthma
Allergic rhinitis	A doctor has *ever* said the child has allergic rhinitis or hayfever.
Wheezing (in the last 12 months)	A child had "wheezing" in the last 12 months regardless of diagnosis of asthma.

Exposures to traffic pollution and health analyses

We geocoded residential addresses of study participants and determined residential proximity to traffic using GIS methods. GIS analyses were conducted using ArcGIS 8.3 software (Environmental Systems Research Institute, Redlands, CA).

To address specific aims 1 and 2, we used three different approaches to estimate traffic exposures: (a) a simple restrictive model where the study population was limited to those within 1 km of the school, and pollutant measures at the school were used as estimates of exposure (b) exposures based on GIS-derived traffic metrics and (c) exposures based on a land-use regression model.

(a) *Estimates of exposure using a simple restrictive model, a comparison of the full data set to the spatially restricted data set*

Rationale: Our earlier publication used school pollutant levels as an approximation for neighborhood exposures (i.e., residences as well as schools). Restricting the study population to those living closer to the school might decrease misclassification of exposure.

Methods: In this task, we examined the potential impact of measurement error by restricting the data set to those living close to their respective school, where the pollution measurements were recorded. Using GIS, we calculated distance from each child's geocoded residence to the school they attended and selected students living within 1 km of their school. Concentrations of traffic pollutants at the school were used as estimates of exposure, and associations between traffic pollutant and respiratory outcomes were evaluated. Because individual exposures to traffic were assigned based on traffic pollutant levels at the schools (i.e. exposures were assigned at the group level), the observations were not independent. Thus, statistical analysis of associations between respiratory outcomes and school-based pollutant concentrations required a hierarchical or two-staged modeling approach (Berhane et al. 2004). This analytical method has been used in air pollution epidemiological studies such as the Children's Health Study in Southern California where individual level data on health outcomes and covariates are collected but exposures to air pollution were based on measurements at the school (McConnell et al. 2003).

Briefly, we used a two-stage regression model as previously described (McConnell et al. 2003). In the first stage, the log odds of current asthma was modeled as a function of individual-level intercept terms, individual covariates, and school-specific intercept terms. In the second stage, the 10 school-specific intercept coefficients from the first stage were regressed as a function of the annual average pollution levels for each school. The two stages were combined into a logistic mixed-effects model to utilize the data most efficiently. To allow for intra-community variability, an additional random effect term was added to account for heterogeneity. Analyses were conducted using the GLIMMIX (generalized linear mixed models) macro in SAS. The two-stage regression model was performed on the full sample and a sample restricted to those living within l km of their school.

The demographics of the restricted population were not different from the full population (percent change ranging from 0.1% to 1.8% for selected demographic variables such as race, age, asthma symptoms in the last 12 months). However, when stratified by school, several demographic characteristics were slightly different for seven out of ten schools, mostly those representing measures of socioeconomic status (SES). For example, in three schools, the proportion of students at or below poverty level was higher in the sample of students living within 1 km of their school. In one school, the proportion of renters decreased by 9% compared to the full sample; whereas in another school the proportion of renters increased by 17% (the largest change in a demographic characteristic). The prevalence of the health outcomes was generally similar between the restricted and full samples. However, while asthma prevalence was higher in the restricted versus the full sample (12% versus 11.5%), the prevalence of bronchitis was lower in the restricted sample (11.5% versus 12.4%). Because there were some apparent differences in SES in the restricted and full samples, we adjusted for SES by including a measure of crowding (persons per household divided by the number of bedrooms).

Results: The restricted sample contained 779 students out of 1111 in the full sample. The results of the health analyses (Table 2) indicate that for the spatially restricted data set, associations with current asthma were observed for a similar set of pollutants (BC, NO and NOx) as in the original unrestricted analysis. While in the original data set, the strongest associations were observed for those who resided at their current address for more than a year, in the restricted data set, statistically significant associations were observed for the entire sample, independent of residential mobility for asthma. In addition, the point estimates of the effect of pollution on asthma in the restricted data set were higher, and confidence intervals tended to be narrower, than that observed in the full data set. Stronger associations with BC, NO, and NOx (versus NO_2) suggest that pollutants from primary traffic emissions may be more important in causing asthma symptoms. For bronchitis, the point estimates generally did not increase in the restricted sample. However, for bronchitis, the risk estimates dropped in the restricted model and were no longer statistically significant. This may reflect a loss in statistical power for bronchitis and the lower bronchitis prevalence in the restricted sample. Additionally, only 40% of children with bronchitis in the past 12 months had a current asthma. Most episodes of bronchitis in children is related to a viral infection in otherwise healthy children, and there may be insufficient cases to determine whether there is an association between bronchitis and traffic in this multi-level analysis.

Although we adjusted for a measure of SES (crowding) in our models the comparative results of the two samples (unrestricted location versus restricted sample within 1 km of the school) should be interpreted with caution given the demographic differences in SES and other potential differences in subject characteristics in the full versus restricted sample. In addition, the sample size in the restricted data set is fairly small with only about 85 cases of current asthma and 82 cases of bronchitis. Thus, subject to these caveats, there is some evidence that the reduction in measurement error leads to a higher effect estimate for current asthma in the East Bay Children cohort.

Table 2. Associations between current asthma and school-based pollutants. Comparison of full data set versus data set of those within one kilometer of their school.

Outcome	Pollutant	beta	s.e.	n	p-value	OR_{IQR}	Lower CI	Upper CI
Restricted Data (residence < 1 km from school)								
Current asthma	PM_{10}	0.297	0.175	503	0.09	1.52	0.94	2.47
	$PM_{2.5}$	0.182	0.250	504	0.47	1.14	0.8	1.61
	BC	3.491	1.756	504	0.05	1.72	1.01	2.92
	NO_2	0.067	0.072	504	0.35	1.27	0.77	2.09
	NOx	0.034	0.020	504	0.08	1.67	0.94	2.96
	NO	0.051	0.025	504	0.04	1.76	1.03	3.03
Bronchitis								
	PM_{10}	0.227	0.130	518	0.08	1.38	0.96	1.97
	$PM_{2.5}$	0.169	0.175	519	0.34	1.13	0.88	1.44
	BC	0.528	1.509	519	0.73	1.09	0.69	1.71
	NO_2	0.004	0.054	519	0.94	1.01	0.70	1.48
	NOx	0.009	0.016	519	0.58	1.14	0.72	1.82
	NO	0.015	0.021	519	0.46	1.19	0.75	1.88

Full Data set

Current asthma	PM_{10}	0.213	0.188	708	0.26	1.35	0.80	2.27
	$PM_{2.5}$	0.080	0.241	708	0.74	1.06	0.76	1.48
	BC	2.723	1.770	709	0.12	1.52	0.89	2.60
	NO_2	0.045	0.068	709	0.51	1.18	0.73	1.90
	NOx	0.026	0.020	709	0.18	1.48	0.83	2.63
	NO	0.041	0.025	709	0.10	1.61	0.91	2.83
Bronchitis	PM_{10}	0.217	0.111	730	0.05	1.36	1.00	1.85
	$PM_{2.5}$	0.262	0.113	730	0.02	1.21	1.03	1.41
	BC	2.074	1.005	731	0.04	1.38	1.02	1.87
	NO_2	0.060	0.039	730	0.12	1.24	0.94	1.62
	NOx	0.026	0.011	731	0.02	1.48	1.07	2.04
	NO	0.039	0.015	731	0.01	1.57	1.11	2.20

Logistic model adjusted for: child's respiratory illness before age 2; pests, indicator of mold presence; maternal history of asthma, crowding and indicator for school. Current asthma = ever diagnosed with asthma plus asthma or wheeze in the previous year. Odds ratios and lower and upper confidence interval are for an interquartile change in pollutant concentration (IQR). IQRs: PM_{10} = 1.4 mcg/m^3; $PM_{2.5}$ = 0.7 mcg/m^3, Black carbon (BC) = 0.15 mcg/m^3, NO_2 = 3.6 ppm; NOx = 14.9 ppb; NO = 11.6 ppb.

(b) ***Estimates of exposures using GIS-based traffic metrics and health analyses***

Methods, exposure estimates: We geocoded residential addresses of study participants and determined residential proximity to traffic utilizing metrics that have been associated with adverse health outcomes in previous studies (English et al. 1999; Gauderman et al. 2005; Gunier et al. 2003; McConnell et al. 2006). GIS analyses were conducted using ArcGIS 8.3 software (Environmental Systems Research Institute, Redlands, CA). Traffic metrics are described in Table 3 (See also Appendix 1).

To explore the influence of wind direction, we calculated a three-level ordinal variable incorporating both residential proximity to a freeway/highway and location upwind or downwind of a freeway: (1) ≤ 300m of a freeway/highway and downwind; (2) ≤ 300m of a freeway/highway and upwind (3) > 300m from a freeway/highway, regardless of wind direction (reference group). Freeways and highways in the study area generally run north/south and prevailing winds are from the west. Therefore, locations east of the freeways were designated as downwind and west of the freeway as upwind. A few residences (n < 10) located upwind of a major freeway and downwind of an intersecting smaller highway were designated as downwind.

Oxides of nitrogen (NOx) and nitrogen dioxide (NO_2) are good indicators of nearby traffic (Rodes and Holland 1981; Singer et al. 2004). To evaluate whether the GIS –based traffic metrics were correlated with traffic pollutants, we took advantage of existing data from a neighborhood monitoring study conducted on a subset of homes in the study area.

In previous work, we measured outdoor concentrations of NOx and NO_2 using Ogawa passive diffusion samplers (Ogawa & Co, USA, Inc., Pompano Beach, FL) deployed for a one-week period at 52 locations in the study area (10 schools, 41 student residences or neighborhood locations, and one regional monitor). The results of the neighborhood monitoring study have been previously described and a summarized in Appendix 1 (Singer et al. 2004). These sites were at varying distances upwind or downwind of a major freeway. Values of NOx and NO_2 are listed given in the Appendix 1- Table 2A.

Locations of the monitors were determined using a global-positioning system (GPS) device. For each location, GIS-based traffic metrics and upwind/downwind status were determined as described above. Nitrogen oxide emissions in traffic exhaust are primarily in the form of nitric oxide (NO), which can react with ambient oxidants to form NO_2. Thus, the concentration of NO was estimated by the difference NO = NOx – NO_2. NO is used here to represents fresh traffic emissions which might also include ultrafine particles or BC.

We evaluated the relationships between NOx, $NO_{2,}$ and NO and GIS-based traffic metrics at the same location using Spearman's correlation coefficient. We also used univariate linear regression to assess the relationship between NOx and distance to a freeway or the natural logarithm of distance to a freeway. To evaluate the influence of wind direction, we added to the regression model an interaction term between downwind and natural-log of distance. Tests of whether median pollutant levels differed by the categories: (i) > 300 m, (ii) ≤ 300 m downwind, and (iii) ≤300 m upwind were performed using the Wilcoxon rank sum test (α adjusted for Bonferroni inequality).

Table 3: Traffic metrics used in exposure assessment

Traffic metric[a]	Description	Reference
Maximum AADT within 150 m	Highest traffic count of any road within 150 m radius.	English et al. 1999
Closest AADT within 150 m	Traffic count of the closest non-local road within 150 m radius.	English et al. 1999
Distance-weighted traffic density (DWTD)	Sum of Gaussian-weighted AADT values for all streets within a 300 m buffer. Formula assumes 96% of traffic pollutant dispersion from a road with a given AADT at 500 ft (152.4 m).	English et al. 1999 Wilhelm and Ritz 2003
Traffic Density (TD)	Vehicle miles traveled (VMT) within a 150 m radius of the residence. VMT = sum of [(bidirectional AADT) x (length of respective road segments)].	Gunier et al. 2003
Distance to major road	Different definitions of "major road" evaluated based on federal highway designations (e.g. interstates, highways, major arterials, see text). Natural-logarithm of distance used in some analyses.	Gauderman et al. 2005

[a]AADT = Average Annual Daily Traffic; local roads assigned a value of zero. Traffic metrics using a buffer radius of 300 m were also evaluated in sensitivity analysis:

Methods, Health analyses: We examined associations between each traffic measure and health outcomes using multivariate logistic regression. For model development, we included risk factors that were shown in previous studies to be predictors of respiratory disease, including demographic variables, host factors, and home environmental factors as previously described (Kim et al. 2004). We also used stepwise logistic regression to identify additional covariates associated with health outcomes. Covariates that changed regression estimates of traffic metrics by >10% were retained in the final model. In our study population, SES indicators such as crowding, poverty, race-ethnicity, and parent education were not important predictors of health outcomes. This may be due, in part, to our study design (i.e., the schools were selected to have relatively similar measures of SES status.) In developing the most parsimonious multivariate logistic regression model, we evaluated potential confounders such as race/ethnicity and other SES variables to the full model one at a time and looked at the change in the effect estimate for traffic. None of these SES indicators changed the traffic estimates by greater than 10%, although crowding decreased the traffic effect by ~8%. However, because of concerns that SES indicators are often important determinants of respiratory health, ultimately, we elected to leave crowding in the full models as a potential confounder in health analyses.

We calculated adjusted odds ratios (OR) and 95% confidence intervals (CI) for each quintile of traffic and for the 90th percentiles based on the metric's distribution for the study population. For distance to a major road we used the categories ≤ 75 m, >75 and ≤ 150 m, > 150 and ≤ 300 m, and >300 m, based on results of previous studies demonstrating that elevated pollutant levels near freeways decreased to background levels by around 150 to 300 m downwind (Rodes and Holland 1981; Zhu et al. 2002a; Zhu et al. 2002b). Traffic metrics incorporating wind direction were also evaluated. Distance to freeway and natural-log distance were also evaluated as continuous variables. Sensitivity analyses included increasing the buffer radius of traffic measures to 300 m and restricting the sample to those who had lived at their current residence for at least one year.

We also conducted stratified analyses to explore whether associations between traffic and health outcomes were modified by gender and family history of asthma. Finally, we explored whether school proximity to traffic was independently associated with increased current asthma or bronchitis.

All statistical analyses were conducted using SAS versions 8.2 and 9.1 (Cary, NC), or STATA version 8 (College Station, TX).

Results: GIS-based traffic metrics and health analyses

Study population and demographics:

Over 70% of students who received questionnaires participated in the study (1111 of 1571). We were able to geocode 1086 (98%) participants' addresses. Of these, four were excluded because they resided in a neighboring county for which traffic data were not readily available, and two were excluded because they had cystic fibrosis. The final sample included 1080 participants. Eleven percent of the latter had current asthma symptoms, while almost 20% had a history of asthma (ever-asthma). Twelve percent of children had bronchitis symptoms in the past 12 months; 12% had a history of allergic rhinitis (diagnosed by a physician).

Table 4 summarizes data on demographics, home environmental factors and traffic exposures. Our study population was of lower economic status and more racially and ethnically diverse than the general population of California, reflecting the demographics of the study area. Over 30% of household incomes were at or below the federal poverty level. Thirty-two percent of children lived within 100 m of a road that was classified as "non-local". (Appendix A). Sixteen percent of study participants lived within 100 m of a major road (principal arterial, expressway, highway or interstate), while five percent lived within 100 m of a freeway/highway. This indicates that a considerable proportion of children in our study resided in close proximity to busy roads. There was considerable mobility in our population; only 30% had lived at the same address since before age two; 56% had lived at their current residence since age six.

Measured traffic pollutant vs. GIS-based traffic metric:

Pollutant measurements at sites took place in Spring 2001 during one of two non-sequential weeks. Not all sites were monitored simultaneously due to resource constraints, but 11 sites were monitored during both weeks. Of the eleven sites with measurements taken during both weeks, there was no statistical difference between the pollutant concentrations. This allowed us to combine data from both weeks into a single dataset.

Correlations between measured NOx, NO_2 and NO and traffic metrics based on 52 samples are shown in Table5. Most traffic metrics were better correlated with NOx and NO compared with NO_2. Several metrics (e.g., traffic density, maximum AADT) explained over 50% of the variability in NOx and NO in univariate analyses.

Correlations between NO_2 levels and traffic metrics were significant only for metrics using larger buffers. Compared with other traffic metrics, AADT Closest (traffic count of the nearest non-local road within a 150 m radius) was a relatively poor predictor of NOx and NO_2. To capture correlations with traffic pollutants and linear distance vs. log distance to freeway we used a Pearson correlation, which is appropriate for normally distributed data and larger sample sizes. Pearson's correlation coefficients between distance to freeway/highway and NOx, NO2, NO of -0.500, -0.393, and -0.53, respectively; Pearson's correlations using the log of distance were -0.67, -0.54, and -0.69, respectively.

NO is used here as a crude surrogate for fresh traffic emissions (e.g. ultrafine particles or BC). We are not attributing any health effects specifically to NO. Because concentrations of NO are derived from subtraction of two measured pollutants, it will have added measurement error. In Table 5, we have reported the correlations with NO to illustrate that a measure of fresh traffic emissions correlate differently with GIS-based traffic metrics compared with NO_2.

Plots of NOx versus distance to the closest freeway/highway suggest that: (i) NOx levels differ for a given distance, depending on whether the location is upwind or downwind of the freeway, and (ii) the pollutant concentration decays exponentially downwind (Figure 2). Consistent with the observed exponential decay, the log of distance from the freeway/highway was a better predictor of NOx than the linear distance in univariate linear regressions (R^2 : 0.45 vs. 0.29, respectively). An interaction term between log distance and an indicator of wind direction (log distance X downwind) was significant ($p< 0.001$) in regression models of predictors of NOx. Results were similar for NO_2 and NO. In another test of whether wind direction influenced pollutant levels, median pollutant levels for locations <300 m and downwind were significantly different from locations <300 m and upwind and locations >300m; whereas median pollutant levels at locations <300 m and upwind versus locations > 300 m were similar.

Health outcomes and their associations with residential proximity to traffic:

Table 6 summarizes the odds ratios for current asthma and bronchitis within the last 12 months with increasing residential traffic, adjusted for the following covariates: pests, mold, chest illness before the age of 2, and crowding. Current asthma models also adjusted for maternal history of asthma. Overall, comparing the highest with the lowest quintiles, most traffic metrics using a 150 m buffer (Traffic density, Maximum AADT, DWTD) were associated with increased odds ratios for current asthma symptoms. For bronchitis, there were associations with the 90^{th} percentile of exposure, with DWTD and traffic density (both estimated with a 150 m buffer) being statistically significant. Dropping the school closest to a freeway did not change the effect estimates appreciably, although confidence intervals were wider (data not shown, see also (Kim et al. 2004). This school also had the highest measured pollutant concentrations, a high percentage of Hispanic students, and the lowest survey response rate. Metrics using a buffer size of 300 m showed similar but less consistent associations.

Although results in Table 6 demonstrate that traffic exposures at the highest quintiles are associated with current asthma, associations for other levels of traffic are less clear. We tested whether there was a trend with increasing traffic as an ordinal variable and found only traffic density and DWTD were significant at $p \leq 0.1$ (Jewell, 2004). The frequency of asthma cases in the lower quintiles of traffic appeared adequate, so power was unlikely to be an issue. Additionally, we combined categories of traffic to look for evidence of trends across three categories: low (1st quintile); medium (20th-80th percentile); and high (80th percentile and above) and found significant associations only the highest quintile of traffic.

We also tested to see whether there was evidence that these traffic metrics could be represented as continuous variables A chi-square for departure from linearity was calculated for metrics that were reported by quintile in Table 6. For maximum and closest AADT there was evidence that the data fit better as a categorical variable, whereas model fit was comparable using either quintiles or continuous measures of traffic density 150 and DWTD 150 (See Jewell, 2004).

Using traffic metrics based on linear distance to a freeway/highway, we found increased odds ratios for current asthma and bronchitis, but the results were not significant. However, using log-distance as an exposure metric, the odds ratios became significant. This is consistent with our observation that levels of traffic pollutants decay exponentially rather than linearly with increasing distance from a freeway. Using residential distance cut-points: ≤75 m, > 75 and ≤150 m, > 150 m and ≤ 300 m, > 300 m, the odds ratios for current asthma were greatest within 75 m of a freeway/highway (Table 6). While odds for bronchitis increased within 300 m of a freeway/highway, this result did not attain statistical significance.

To explore the effect of wind, we calculated odds ratios for current asthma and bronchitis for those living within 300 m of a freeway/highway, by wind direction (Table 6). The results suggest that those living within 300 m downwind were at increased risk; however, the results were not statistically significant, possibly due in part to small numbers in the higher exposure categories.

In addition to freeways/highways, other major roads may be significant sources of traffic emissions. We evaluated whether residential proximity to "other principal arterial roads" as classified by federal standards might also lead to increased odds of current asthma or bronchitis. Overall, we found no independent effect of living within 100 m of major arterials after adjusting for residence within 300 m of a freeway/highway (Table 6). Similarly, we found no association after restricting our analysis only to those participants who did not live within 300 m of a freeway/highway (data not shown). The results were similar for bronchitis.

We were unable to determine whether school proximity to traffic was independently associated with increased current asthma or bronchitis. The log of distance of residence or distance of school to freeway/highway were each significant in logistic regression models when introduced individually into the model. However, these two metrics were highly correlated (Pearson correlation $r = 0.93$) making it impossible to estimate an independent effect when both were included in the model. However, this study was not designed to look separately at the contribution of traffic at school vs home nor was the sample size sufficient.

We found that the association between the log of distance to freeway and current asthma was higher among children without a maternal history of asthma (Table 6). Paternal history of asthma was not a risk factor or effect modifier for asthma in our study. We found no clear difference in associations between current asthma or bronchitis and proximity to traffic when stratified by gender (data not shown).

We found no evidence of associations between residential proximity to traffic and allergic rhinitis or ever-asthma (data not shown). Wheezing in the past 12 months (regardless of doctor's diagnosis of asthma) was associated with proximity to traffic primarily at the 90th percentile of exposure. In sensitivity analyses, restriction of the sample to those who lived at their current residence for at least one year did not change the overall point estimates; however, precision was affected due to smaller sample size (data not shown). Finally, our findings were robust to a different questionnaire-based definition of current asthma (Doctor telling parents that the child had asthma in the last 12 months).

Over 40% of children with bronchitis in the last year (episode of doctor-diagnosed bronchitis or persistent productive cough) also had asthma. The sample size was too small to determine whether the associations between bronchitis and traffic were primarily among those with asthma.

Table 4: Demographics, home characteristics, and residential traffic exposures of study participants (n=1080)

Gender	
% Female	52.3
Race/Ethnicity	
% White	12.9
% Black	11.0
% Hispanic	43.3
% Asian	13.7
% Other/Multiracial	19.2
Indicators of Socioeconomic Status	
% Household at/below Federal poverty level	31.4
% Parent's education: high school or less	29.6
Crowding (# people/bedroom, median)	2.0
Family history	
% Mother with asthma	12.2
% Maternal smoking during pregnancy	10.4
Home indoor environment	
% Smoker in the household, current	7.4
% With furry pet in the house	37.2
% Pests, past 12 months	63.1
% Gas stove	63.2
% Indicator or mold/mildew, past 12 months	44.8
Residential Proximity to Traffic (median, range)	
Maximum AADT within 150 m[a] (vehicles/day)	9500 (0, 245000)
Closest AADT within 150 m [a] (vehicles/day)	8190 (0, 245000)
DWTD[b] within 150 m (vehicles/day)	6295 (0, 265,244)
Traffic density within 150 m (vehicle-km traveled)	2884(0, 74042)
Distance to freeway/highway (m)	791 (22 , 3671)
Distance to arterial or higher (m)	246 (7 , 996)
% living within 100 m of major road (principal arterial, expressway, highway or freeway)	16.0
Health Characteristics	
Ever- asthma	19.7
Current asthma	11.5
Bronchitis in the past 12 months	12.4
Hay fever or allergic rhinitis	11.9
Chest illness before 2 years of age	23.5

[a]AADT = Average Annual Daily Traffic; local roads assigned a value of zero.
[b]DWTD = Distance-weighted traffic density (see text).

Table 5: Spearman correlation (ρ) between traffic pollutants and GIS-based traffic metrics

Traffic metric	Nitrogen dioxide (NO_2)		Nitrogen oxides (NOx)		Nitric oxide (NO)	
	ρ	p-value	ρ	p-value	ρ	p-value
Maximum AADT within 150 m	0.14	0.325	0.37	0.006	0.43	0.001
Maximum AADT within 300 m	0.38	0.006	0.56	< 0.001	0.60	<.001
Closest AADT within 150 m	0.01	0.957	0.22	0.118	0.26	0.058
Closest AADT within 300 m	0.14	0.324	0.29	0.034	0.22	0.117
DWTD within 150 m	0.15	0.302	0.37	0.007	0.44	0.001
DWTD within 300 m	0.25	0.077	0.48	< 0.001	0.56	<.001
Traffic Density within 150 m	0.14	0.333	0.36	0.008	0.41	0.003
Traffic Density within 300 m	0.40	0.003	0.58	<0.001	0.62	<.001
Distance to nearest freeway/highway[a]	-0.30	0.028	-0.48	<0.001	-0.69	<.001

[a]Spearman correlations are same for linear and log distance to freeway

Table 6: Associations between residential proximity to traffic and current asthma and bronchitis in the last 12 months[a]

A. Odds for increasing quintiles of residential traffic

	Current Asthma n = 88/724		Bronchitis n = 87/745	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Maximum AADT within 150m *(vehicles/day)*				
1st Quintile *(local traffic only)*	1.00		1.00	
2nd Quintile *(up to 7120)*	1.50	(0.67,3.36)	0.93	(0.46,1.87)
3rd Quintile *(7121 to <18,900)*	2.33	(1.03,5.28)	1.02	(0.49,2.12)
4th Quintile (18,901 to 28,700)	0.60	(0.21,1.69)	0.46	(0.19,1.12)
5th Quintile *(28,701 to 245,000)*	2.50	(1.13,5.53)	1.42	(0.71,2.81)
≥ 90th Percentile *(67,000 to 245,000)*	2.40	(1.13,5.07)	1.96	(0.97,3.95)
p-value[b]	0.14			
Closest AADT within 150m *(vehicles/day)*				
1st Quintile *(local traffic only)*	1.00		1.00	
2nd Quintile *(up to 5700)*	1.39	(0.62,3.11)	0.77	(0.38,1.57)
3rd Quintile *(5701 to 10,900)*	2.83	(1.23,6.54)	1.40	(0.67,2.91)
4th Quintile *(10,901 to 23,800)*	1.40	(0.6,3.29)	0.90	(0.43,1.86)
5th Quintile *(23,801 to 245,000)*	1.58	(0.69,3.65)	0.90	(0.42,1.90)
≥ 90th Percentile *(35,100 to 245,000)*	1.16	(0.53,2.54)	1.11	(0.52,2.33)
p-value[b]	0.33			
DWTD within 150m				
1st Quintile	1.00		1.00	
2nd Quintile	1.79	(0.80, 4.0)	0.73	(0.35, 1.53)
3rd Quintile	1.11	(0.47, 2.65)	1.34	(0.67, 2.66)
4th Quintile	1.65	(0.7, 3.84)	0.68	(0.31, 1.50)
5th Quintile	2.37	(1.04, 5.45)	1.12	(0.54, 2.33)
≥ 90th Percentile	2.18	(1.04, 4.55)	2.29	(1.20, 4.37)
p-value[b]	0.10			
Traffic Density within150m				
1st Quintile	1.00		1.00	
2nd Quintile	1.23	(0.53, 2.83)	0.58	(0.27, 1.25)
3rd Quintile	1.96	(0.85, 4.52)	1.47	(0.73, 2.95)
4th Quintile	1.40	(0.60, 3.30)	0.78	(0.36, 1.67)
5th Quintile	2.37	(1.05, 5.36)	1.16	(0.57, 2.36)
≥ 90th Percentile	2.14	(1.02, 4.52)	2.12	(1.09, 4.10)
p-value[b]	0.04			

Table 6 (continued)

B: Odds for low, medium, and high levels of residential traffic exposure [c]

	Current Asthma n = 88/724		Bronchitis n = 87/745	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Maximum AADT within 150m *(vehicles/day)*				
low *(local traffic only)*	1.00		1.00	
medium (up to 28,700)	1.43	(0.71, 2.88)	0.81	(0.45,1.47)
high *(28,701 to 245,000)*	2.50	(1.13,5.53)	1.42	(0.71,2.81)
Closest AADT within 150m *(vehicles/day)*				
low *(local traffic only)*	1.00		1.00	
medium *(up to 23,800)*	1.71	(0.86, 3.42)	0.96	(0.54,1.72)
high *(23,801 to 245,000)*	1.58	(0.69,3.65)	0.90	(0.42,1.90)
DWTD within 150m				
low	1.00		1.00	
medium	1.51	(0.75, 3.03)	0.90	(0.50,1.61)
high	2.37	(1.04, 5.45)	1.12	(0.54, 2.33)
Traffic Density within150m				
low	1.00		1.00	
medium	1.49	(0.74, 3.00)	0.89	(0.49,1.60)
high	2.37	(1.05, 5.36)	1.16	(0.57, 2.36)

---

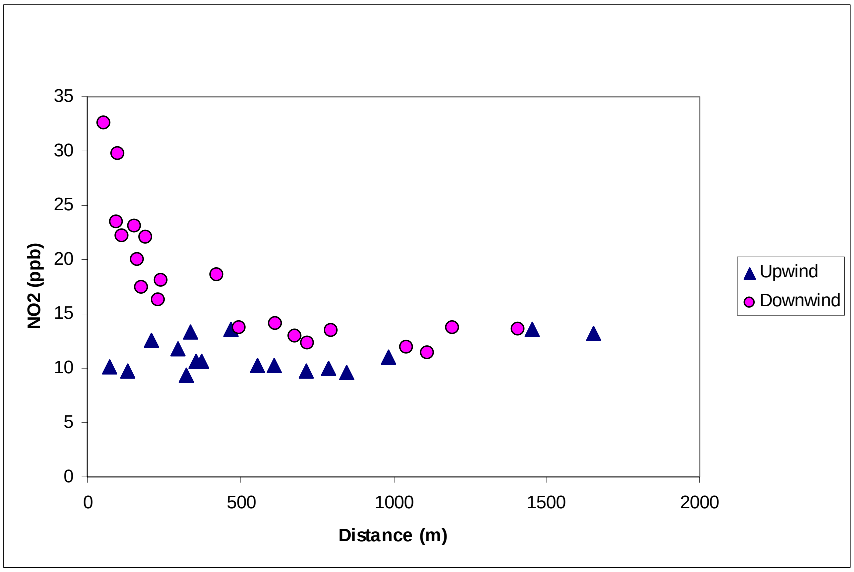
[a]Odds ratios adjusted for chest illness before age of 2; pests, indicator of mold presence, crowding. For asthma, models were also adjusted for maternal history of asthma.
[b]p-value using a categorical measure of exposure for each traffic metric (Jewell, 2004)
[c]low traffic: ≤ first 20^{th} percentile; medium traffic : > 20^{th} percentile up to 80^{th} percentile; high traffic: ≥ 80^{th} percentile

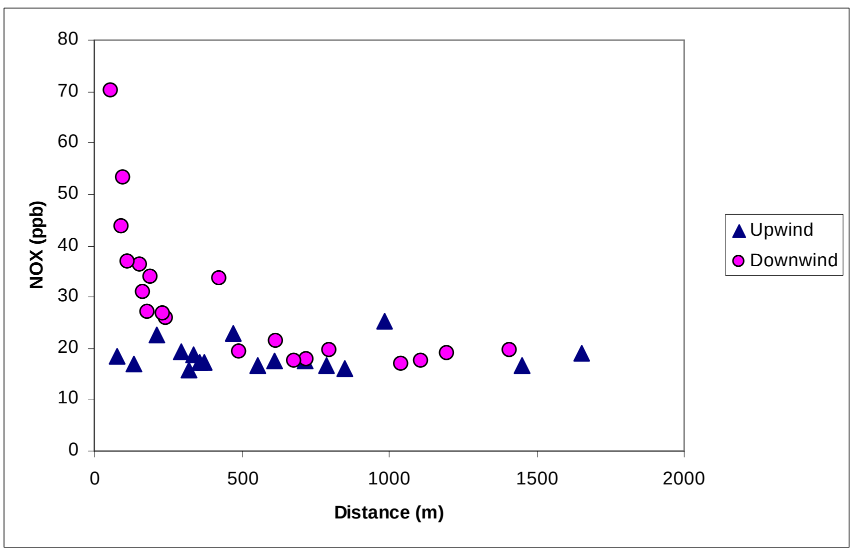
Table 7: Associations between respiratory symptoms and residential proximity to major roads

		Current Asthma		Bronchitis	
		Odds Ratio	(95% CI)	Odds Ratio	(95% CI)
Distance to Freeway/Highway[a]		1.25	(0.83, 1.9)	1.43	(0.97, 2.13)
Log Distance to Freeway/Highway[a]		1.43	(1.04, 1.54)	1.47	(1.11, 1.96)
[b]Stratified by maternal asthma					
No	(n=872)	1.54	(1.14,2.04)	--	
Yes	(n=113)	0.94	(0.54,1.67)	--	
Distance to Freeway/Highway [c]					
≤ 75 m	(n=36)	3.80	(1.2,11.71)	2.81	(0.94, 8.39)
>75 m to ≤150 m	(n=64)	1.87	(0.71,4.90)	1.82	(0.75, 4.40)
> 150 m to ≤300 m	(n=113)	1.25	(0.50, 3.11)	2.00	(0.93, 4.29)
Over 300 m	(n=869)	1.00		1.00	
Distance to Freeway/ Highway and wind orientation					
≤300 m, downwind	(n= 121)	1.41	(0.81, 2.46)	1.42	(0.87 ,2.33)
≤ 300 m, upwind	(n= 92)	1.05	(0.58, 1.91)	1.13	(0.66, 1.95)
Over 300 m	(n=867)	1.00		1.00	
Distance to Principal Arterial (adjusted for living near freeway/highway)					
≤ 100 m	(n=122)	1.33	(0.61, 2.91)	1.39	(0.66, 2.91)
Over 100 m	(n=960)	1.00		1.00	
Distance to Principal Arterial (exclude those near Freeway/Highway)					
< 100 m	(n=102)	1.48	(0.63, 3.47)	0.93	(0.52, 1.65)
> 100 m	(n=765)	1.00		1.00	

[a]Model adjusted for crowding, pests, mold, chest illness before the age of 2. Current asthma For distance to freeway (and log distance), odds ratios are for the interquartile ranges (IQR), i.e. the difference between the 25th 75th percentiles of residential distance from the freeway; specifically, 75th percentile (1352 m) – 25th percentile (413 m).
[b] Stratified analysis adjusted for crowding, pests, mold, chest illness before the age of 2
[c]Distance categories: ≤ 75 m; > 75 m but ≤ 150 m; > 150 m but ≤ 300 m; and > 300 m.

Figure 2: Concentrations of nitrogen oxides and nitrogen dioxide as a function of distance to freeway/highway. Data presented here are for week 1.





(c) *Estimates of exposures using a land use regression model and health analyses*

Methods: We developed land use regression models (LUR) to predict nitrogen dioxide concentrations in Alameda County, California based on traffic, land use and demographic characteristics around monitoring locations. The data, methods and results are detailed in Appendix 2 of this report and described briefly below.

Two sources of data were used for development of the land use regression model of NO_2 (1) Office of Environmental Health Assessment (OEHHA) data This dataset consists of NO_2 samples obtained as part of the EBCRHS neighborhood study (Singer et al. 2004). (2) California Department of Public Health's Environmental Health Investigations Branch (EHIB) data. These NO_2 samples were obtained by EHIB as part of an Environmental Health Tracking project, developing a land use regression model for Alameda County.

We utilized OEHHA data from the neighborhood monitoring study described in section (b) of this report.. The EHIB data set consists of samples of NO_2 in Fall 2004 and Spring of 2005 The EHIB data covered a more extensive area but had less neighborhood scale data (i.e., monitoring sites were not chosen to look for within neighborhood variability in traffic pollutant concentrations). Criteria and methods for EHIB sampling are described in Appendix 2.To take advantage of additional data cover the entire study area, we combined OEHHA data with EHIB data in the development of the land use regression model. Ultimately, a total of 106 samples (95 locations) were in the bounding region of study participants (61 from OEHHA, 24 from EHIB in 2004 and 21 from EHIB in 2005).

The models were developed as follows: At each sample location, we constructed circular buffers in a geographic information system (GIS) and captured information on roads, traffic flow, land use, population, and housing. In order to combine the OEHHA and EHIB data in model development, an indicator (or phase) variable was also used for the different "phases" of data (OEHHA, EHIB1, EHIB2). Using multiple linear regression methods, we developed a predictive model of NO_2. Additionally, for each phase of data collection, EHIB had replicate monitors at each location. This was taken into account in the analyses by performing multivariate linear regression with weighted-least squares (WLS). Before model development, we withheld 20% of samples for use in model validation studies (Appendix 2).

For health analyses to test the association of these land-use model based estimates of NO_2, we used a multivariate logistic regression model with covariates and methods as described earlier in this report.

Results: We generated models based on the full set of samples (i.e., data from both OEHHA and EHIB) and generated models based only on samples within the geographic region bounding study participants using methods previously described (Ross et al. 2006). Final models include an indicator for sampling time period, as well as traffic and land use variables. The final models for Alameda County included the following variables: total vehicular density within a 300 m buffer; urban permeability within a 500 m buffer; an indicator of East or West of a high traffic road (i.e. road with two-way traffic counts of >100,000 vehicles/day); heavy duty truck traffic (3-axel) within 1000m; and road density within 50 m. Models also included a phase variable or indicator variable (OEHHA, EHIB1, EHIB2). This variable accounts for different sampling times and slightly different sampling and analytical methods . The final model based on all the samples explains approximately 71% of the variation (73% when validation samples are included in the modeling) and predicts validation locations to within 2.1 ppb (15%). A leave-one-out cross validation predicts excluded samples to within 2.4 (16%) and suggests that the variables are relatively robust to sample inclusion. See Appendix2 for details of model development.

The geographically limited model included: traffic density within 50 m; traffic density within 50-300m; total traffic within 300-1000 m; an indicator of whether the location was East or West of a high traffic road (i.e. road with two-way traffic counts of >100,000 vehicles/day); and a phase indicator. The geographically limited model explains 63% of the variation (66% when validation samples are included) and predicts validation locations to within 2.2 ppb (16%). A leave-one-out cross validation based on this model predicts excluded samples to within 2.6 (16%). When the cross validation results of the two models are directly compared for samples in the bounding area, we find that the geographically limited model predicts slightly more accurately.

We also explicitly included an interaction term to account for the relationship between our wind surrogate variable (whether a monitoring location was east (downwind) or west of the nearest high-traffic road) and traffic within the 50-300m buffer. The final model with an interaction term predicts validation locations to within 2.25ppb (16%) and leave-one-out cross validation predicts excluded samples to within 2.50ppb (16%).

Although these models predict validation samples well, we found residual autocorrelation in all the traditional models above. In order to address this violation of standard regression assumptions, we employed a kriging model with external drift. This model allowed us to model both the large-scale trend (represented by the linear regression model discussed above) as well as the small-scale variation in the residuals. In this model we used all observations rather than generating a within-site average so direct comparisons of predictions cannot be made. Nevertheless, these models also appeared to perform well in predicting validation samples to within 2.5ppb (15%) for the models with and without an interaction term. In leave-one-out cross validation, the kriging model with an interaction term predicts slightly better – to within 2.0 ppb (12%) compared to 2.1ppb (13%). Parameters common to all four models show strong similarity.

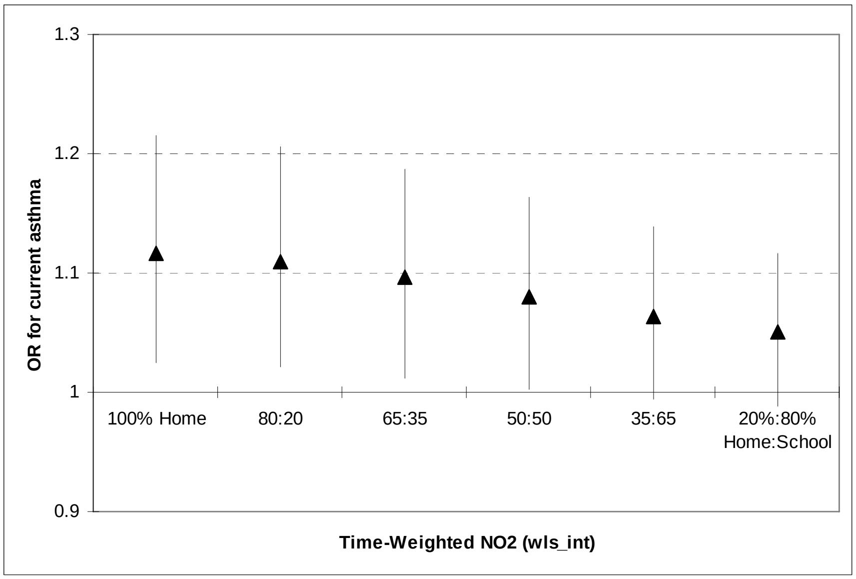
We generated estimates of nitrogen dioxide at residences for study participants using each of the four models (1) land use regression model (weighted least squares regression – designated WLS), (2) a land use regression model with wind-traffic interaction term (WLS w int), (3) WLS with a universal kriging term (WLS-UK), and (4) WLS with interaction and a universal kriging term (WLS w int – UK). Since the NO_2 model includes an indicator or phase variable, the estimates at each residence are not annual averages; the predicted NO_2 values would depend on the value of the constant for the specific phase. In this study, we set the phase to that for the OEHHA period of study. Although absolute value of the NO_2 values differ by phase, the relative values of NO_2 at the residences do not differ.

To test the association of these land-use model based estimates of NO_2, we used a multivariate logistic regression model with covariates and methods as described earlier in this report.

We found consistent positive associations between modeled NO_2 and current asthma and bronchitis symptoms in the last year (Table 8). The alternative methods for estimating NO_2 in the LUR models generated fairly similar point estimates and confidence intervals, and in several models the associations were statistically significant. Results were also similar using another definition of current asthma (i.e., being told by the doctor that they had an episode of asthma in the previous year; data not shown). We also found a statistically significant association between bronchitis using the WLS-int model. In general, the use of LUR models with a wind interaction term to predict residential NO_2 yielded somewhat higher effect estimates compared with those using predicted NO_2 based on models without a wind interaction term.

We also explored whether the associations with health were stronger after using NO_2 measurements from both the residence and school, in an attempt to examine the relative importance of these exposures. NO_2 measures for the home were based on the LUR model while actually measured NO_2 was used at the school. We applied successively lower weights for the home exposure, starting at 100% and moving to 20%. In general, for our data set, residential exposures alone generated the strongest associations with respiratory morbidity and we found little evidence of a better predictive model using a time-weighted average of NO2, incorporating exposures at both the home and school (Figure 3). However, in certain situations, school-based measurements may provide reasonably good estimates of residential exposure. For example, in this study, the correlation between residential exposure, based on the LUR models, and school exposure, based on actual measurements, was between 0.48 and 0.55 depending on the actual LUR model used.

Figure 3: Odds of current asthma and bronchitis for time-weighted NO_2 exposures (home and school). Home exposures are modeled NO_2 (wls-int), school exposures are measured NO_2.



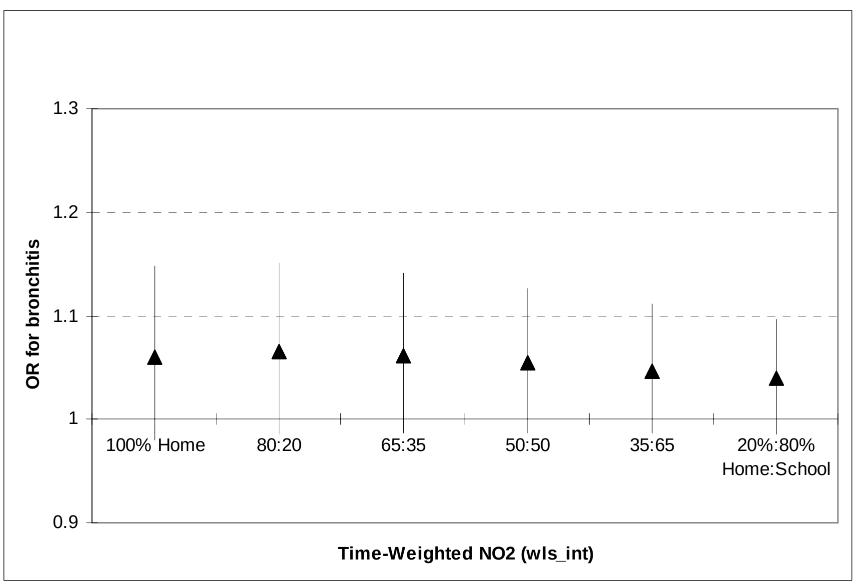


Table 8. Associations between respiratory outcomes and predicted residential nitrogen dioxide based on land use regression models

Outcome	Modeled NO_2	beta	s.e.	OR_{IQR}	Lower	Upper	OR_{90-10}	Lower	Upper
Bronchitis in the last 12 months	WLS	0.045	0.041	1.14	0.90	1.44	1.37	0.77	2.45
	WLS w int	0.059	0.041	1.15	0.95	1.40	1.42	0.97	2.30
	WLS-kriging	0.047	0.039	1.16	0.91	1.48	1.43	0.80	2.56
	WLS w int –kriging	0.063	0.042	1.15	0.96	1.38	1.42	0.90	2.26
Current Asthma	WLS	0.082	0.045	1.27	0.98	1.65	1.80	0.96	3.37
	WLS w int	0.110	0.043	1.31	1.06	1.61	1.93	1.05	3.22
	WLS-kriging	0.061	0.043	1.21	0.93	1.57	1.58	0.84	2.98
	WLS w int –kriging	0.120	0.045	1.31	1.08	1.59	1.96	1.20	3.20

OR per IQR or 90%ile vs 10%tile. WLS- weighted-least squares. WLS-int – weighted-least squares includes wind interaction term. WLS-kriging: weighted least squares with kriging. WLS-int – kriging - weighted-least squares includes wind interaction term with kriging IQRs/90-10%tile: WLS = 2.93/7.13 ppb; WLR w int = 2.43/6.00 ppb; WLS - krig: 3.15/7.58 WLS w int-krig. : 2.24/5.61 ppb Logistic model bronchitis adjusted for: chest illness before age of 2; pests, indicator of mold presence, crowding. For asthma, models were also adjusted for maternal asthma.

Specific Aim #3: Evaluate other potential school-facility specific factors that might contribute to respiratory symptoms using a School Indoor Air Quality (IAQ) Survey.

Factors at the schools that correlate with traffic pollutant concentrations (e.g. mold/dampness) could confound the children's respiratory outcomes in the East Bay Children's Respiratory Health Study (EBCRHS). At a minimum, during primary data collection for our EBCRHS, we wanted to determine whether there were any obvious indoor air quality problems at the schools which might be contributing to the children's respiratory symptoms. To accomplish this, we surveyed teachers on indoor air quality problems in the classroom and had a technician conduct a walk-through survey. These data had not been previously analyzed.

In this project, we examined the data previously collected in the two surveys assessing indoor air quality (IAQ) at the schools—the teacher questionnaire and the technician walk-through survey—for associations between children's respiratory outcomes and potential classroom exposures. Prevalence of selected classroom exposures from both surveys is roughly comparable to our results with those from other studies that used the same or very similar surveys, including CARB's Portable Classroom Survey (PCS). We also explored potential associations with classroom exposures and found that use of air fresheners was associated with asthma in multivariate models. Details of the study are in Appendix C.

The data appeared to be of poor quality. Most of the exposures to the potential respiratory irritants had no association with asthma and for remaining irritants, both positive and negative associations with asthma were observed. When entered into the logistic regression for asthma, with a few minor exceptions, most of the IAQ school factors did not alter the point estimates and confidence intervals. Thus, we found little evidence that traffic pollutant concentrations at the schools were confounded by IAQ factors at the school.

Specific Aim #4: Use GIS-based traffic estimates to validate self-reported traffic measures

Rationale: Self-reported residential proximity to busy roads has been used to estimate residential exposure to traffic pollution; (Ciccone et al. 1998; Duhme et al. 1996; Weiland et al. 1994) however, this metric has not been extensively validated (Kuhlisch et al. 2002).

The EBCRHS questionnaire asks several questions on residential proximity to traffic. In addition, we collected information on the home address of study participants and calculated GIS-related traffic metrics at the child's residence as described above. We also have limited outdoor measurements of NOx and NO_2 at residences (n=42) in neighborhoods surrounding three of the schools.

We conducted a validation study comparing GIS-derived traffic metrics at the residence with self-reported residential proximity to traffic obtained from the questionnaire. Comparisons were also made among those residences where residential monitoring data is available.

Materials and Methods:

The EBCRHS questionnaire contained information on self-reported proximity to traffic, health outcome and covariates as described above. There were 1082 with valid address inside Alameda County. Final participants used for regressions of health outcomes involving distance n=1080.

We determined distance to non-local roads classified as minor arterial or higher (functional class categories11,12, 14, 16) for all students with valid addresses as follows: (see Appendix A for details)

Caltrans HPMS Functional System Codes

Rural Functional System Codes		Urban Functional System Codes	
1	Principal Arterial Interstate	11	Principal Arterial Interstate
2	Other Principal Arterial	12	Principal Arterial Other Freeways & Expressways
6	Minor Arterial	14	Other Principal Arterial
7	Major Collector	16	Minor Arterial
8	Minor Collector	17	Collector
9	Local	19	Local

In the 2001 HPMS traffic count dataset , several roads in the Caltrans database were missing functional class assignments. We used more recent Caltrans data, to recode missing functional data to the appropriate function class (i.e. FC 14, 16, or 17) and made these changes to the Caltrans shapefile in ArcMap. Using GIS methods, we determined three variables for distance to the three functional class categories for each residential address. Four of the 1086 students live outside Alameda County.. Since our road data only includes Alameda County, the distance data is erroneous for these home addresses. Therefore, distance data sample size=1082.

Self-reported traffic measures in the EBCRHS questionnaire: There are two questions in the EBCRHS questionnaire in which parents were asked to characterize traffic near the child's home. In those questions, parents self-reported distance to traffic (Q39a) and amount of traffic from trucks or buses near the home (Q39b). These questions on self-reported proximity traffic were modeled after those used by Ciccone et al. 1998 and Duhme et al. 1996.

In the questionnaire, distances were gauged in blocks, and blocks were converted to an equivalent distance in meters for the analysis.

Question 39a: How close is your child's home to a street with heavy traffic? (For this question, "a street with heavy traffic" could be a freeway, highway, major intersection, or a city street with heavy traffic.)

q39a
1. Immediately in front, behind, or beside your child's home
2. Less than one block away
3. 1-3 blocks away
4. 4 or more blocks away

Question 39b: On <u>weekdays</u>, how often do large trucks or buses pass through on the road(s) in front, behind, or beside your child's home?

q39b
5. Immediately in front, behind, or beside your child's home
6. Less than one block away
7. 1-3 blocks away
8. 4 or more blocks away

Cross-tabulations of self-reported proximity to traffic and objective measures of distance to busy roads were done. Because parent's perception of busy road might differ from that of a functional classification of that road, we performed cross-tabulations using several definitions of busy road (FC 11, 12; FC 11,12, or 14; FC 11,12, 14, or 16).

We also used multivariate logistic regression to test for associations between self-reported residential proximity to traffic and respiratory outcomes using methods described earlier in this report.

Results:

Question 39a: How close is your child's home to a street with heavy traffic? (For this question, "a street with heavy traffic" could be a freeway, highway, major intersection, or a city street with heavy traffic.)

Raw survey results:

q39a	Frequency	Percent
9. Immediately in front, behind, or beside your child's home	223	21.0
10. Less than one block away	203	19.1
11. 1-3 blocks away	371	34.9
12. 4 or more blocks away	267	25.1
Missing	47	
Total	1111	100.0

For estimates of block length, we contacted the Hayward, San Leandro, and Oakland departments of zoning or planning for estimates on the length of a block. From below, it is clear that 150 meters is a good estimate for the length of a block.

City	Contact	Office	Estimate given	Converted to meters
Hayward	Tim Koonze	Development Review/Current Planning	10 to 11 blocks per mile	1/10 mile = 161 meters 1/11 mile = 146 meters
San Leandro	Keith Cooke	Engineering & Transportation	500ft center to center blocks	500 feet = 152 meters
Oakland	Neil Gray	Community & Economic Development	*No response	

In order to test agreement, the responses to q39a were converted to estimates of distance assuming a distance (150m) for the length of a block. (NB: In geocoding address, the side offset of the house from the road is 25 feet, or 7.6 meters)

Q39a Responses	Translation into blocks	Block = 150m	Percent
1. Immediately in front, behind, or beside your child's home	< 0.5 block	<75m	21.0
2. Less than one block away	0.5 - 1 block	75m -150m	19.1
3. 1-3 blocks away	1 - 3.5 blocks	150m - 525m	34.9
4. 4 or more blocks away	> 3.5 blocks	>525m	25.1
			100.0

Question 39b: On weekdays, how often do large trucks or buses pass through on the road(s) in front, behind, or beside your child's home?

Raw survey results:

Q39b		Frequency	Percent
I.	Never or rarely	374	34.5
II.	Sometimes	274	25.3
III.	Frequently throughout the day	255	23.6
IV.	Almost the whole day	180	16.6
Missing		28	
Total		1111	100.0

Questionnaire responses to q39a were cross-tabulated with the GIS-derived distance to functional class categories for the following three groupings: 11 or 12; 11, 12 or 14; 11, 12, 14, or 16. Because the wording of q39a asks parents to estimate distance to a "freeway, highway, major intersection, or a city street with heavy traffic", distance to functional class 11, 12 or 14 is probably the most accurate comparison group by the definition. Distance to functional class 11 or 12 only includes interstates, freeways or expressway while the questions explicitly include city streets with heavy traffic. Distance to functional class 11, 12, 14, or 16 is questionable since minor arterials are not likely to have "heavy traffic" and also because there are only 11 subjects who live more than 525m from a road in this category.

The following table lists the frequencies of the distance categories.

N=1082 (1086 homes with valid address, 4 home addresses outside Alameda County removed)

Table 9. Number (percent) of EBCRHS participants by distance of residence to major road

Road type	<75 m	75 – 150 m	150-525 m	>525 m	Total
Freeway/highway	36 (3.3%)	64 (5.9 %)	250 (23%)	732 (68%)	1082
Major arterial or busier road*	117 (10.8%)	193 (17.8%)	595 (55%)	177 (16%)	1082
Minor arterial or busier road**	272 (25,1%)	261 (24.2%)	538 (50%)	11 (0.8%)	1082

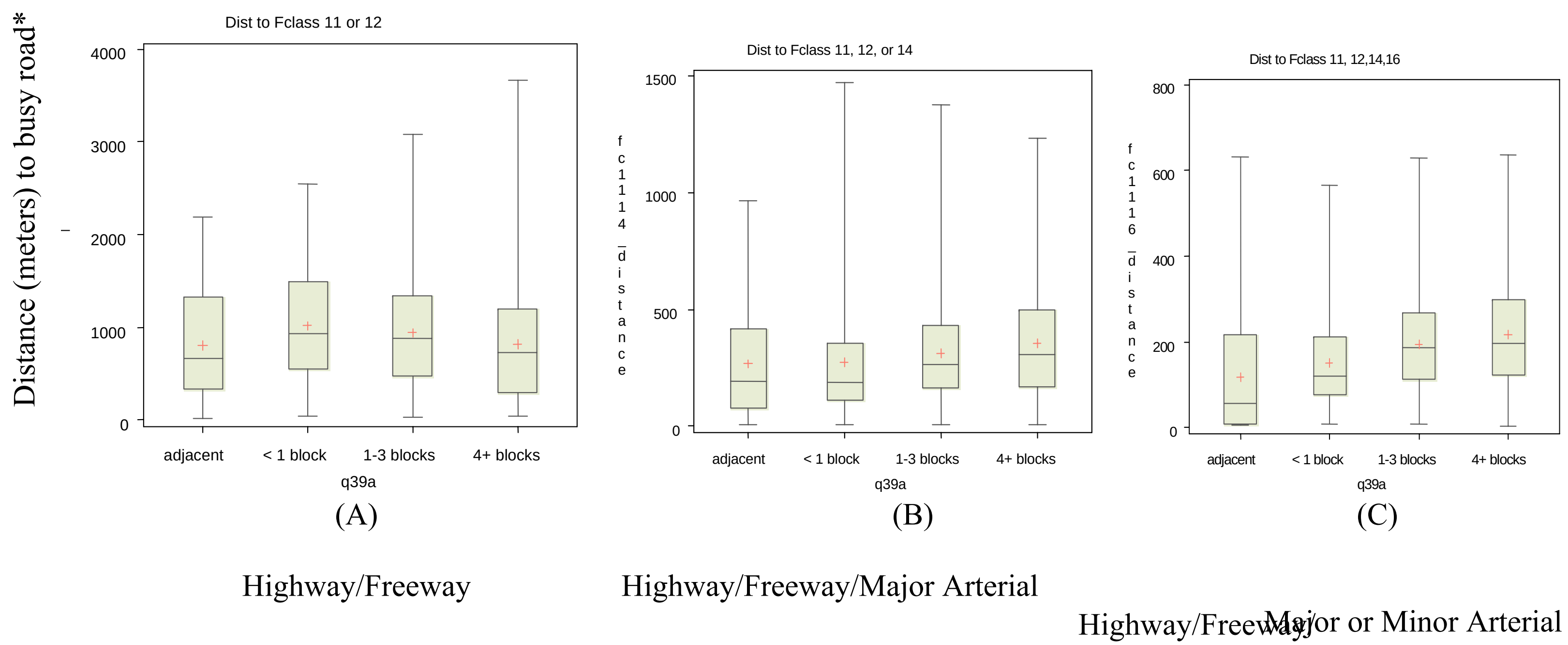
*Major arterial or freeway/highway
**Minor arterial, major arterial or freeway/highway

To evaluate whether there was agreement between q39a and GIS-derived distance to functional class, we needed to determine what parents considered a busy road.

We constructed box-plots of objective measures of distance to major road and self-reports of "adjacent, <1 block, 1-2 block, or 4+ blocks) to a road with heavy traffic (4). Panel (A) shows distance to highway/freeway. Panel (B) shows distance to the nearest busy road defined as a major arterial, freeway, or highway. Panel (C) shows distance to nearest busy road defined as a minor arterial, or busier road. Of the three panels, self-reported proximity to a busy road correlated best with distance of residence to a road classified as minor arterial or higher.

Thus, we see that, on average, parents considered any road classified as minor arterial or higher (FC 11-16) as a road "with heavy traffic"

Figure 4. Box-plots of self-reported residential proximity to major road (x axis) vs. GIS-derived distance of residence to major road (y axis) for three classes of major roads. Panel (A) shows distance to highway/freeway. Panel (B) shows distance to the nearest busy road defined as a major arterial, freeway, or highway. Panel (C) shows distance to nearest busy road defined as a minor arterial, or busier road.



Questionnaire responses to q39a were cross-tabulated with the GIS-derived distance to functional class categories for the following three groupings: Highway or Freeway (FC11 or 12); Highway/Freeway/Major Arterial (FC 11, 12 or 14); Highway/Freeway/Major or Minor Arterial (FC11, 12, 14, or 16). An example is shown below:

Table 10. GIS-derived distance of residence to highway/freeway versus self-reported residential proximity to traffic.

	Distance of residence to highway/freeway based on geocoded address				
Self reported residential proximity to busy road	<75 m	75 to <150 m	150 to 525 m	>525 m	Total
"adjacent"	18	16	45	141	220
<1 block	4	11	30	154	199
1-3 blocks	5	20	78	257	360
4+ blocks	5	15	79	159	260
Total	34	62	232	711	1039

If we assume that the geocoded addresses are correct, from the above table we see that among the 34 that lived <75 m from a freeway/highway, 22 (65 %) reported living with a block of a road with heavy traffic, 7 (20%) reported living over 4 blocks from a road with heavy traffic. Thus there is some exposure misclassification using self-reported proximity to traffic. Alternatively, participants could be reluctant to give their true address in this survey although we assured participants that data was confidential.

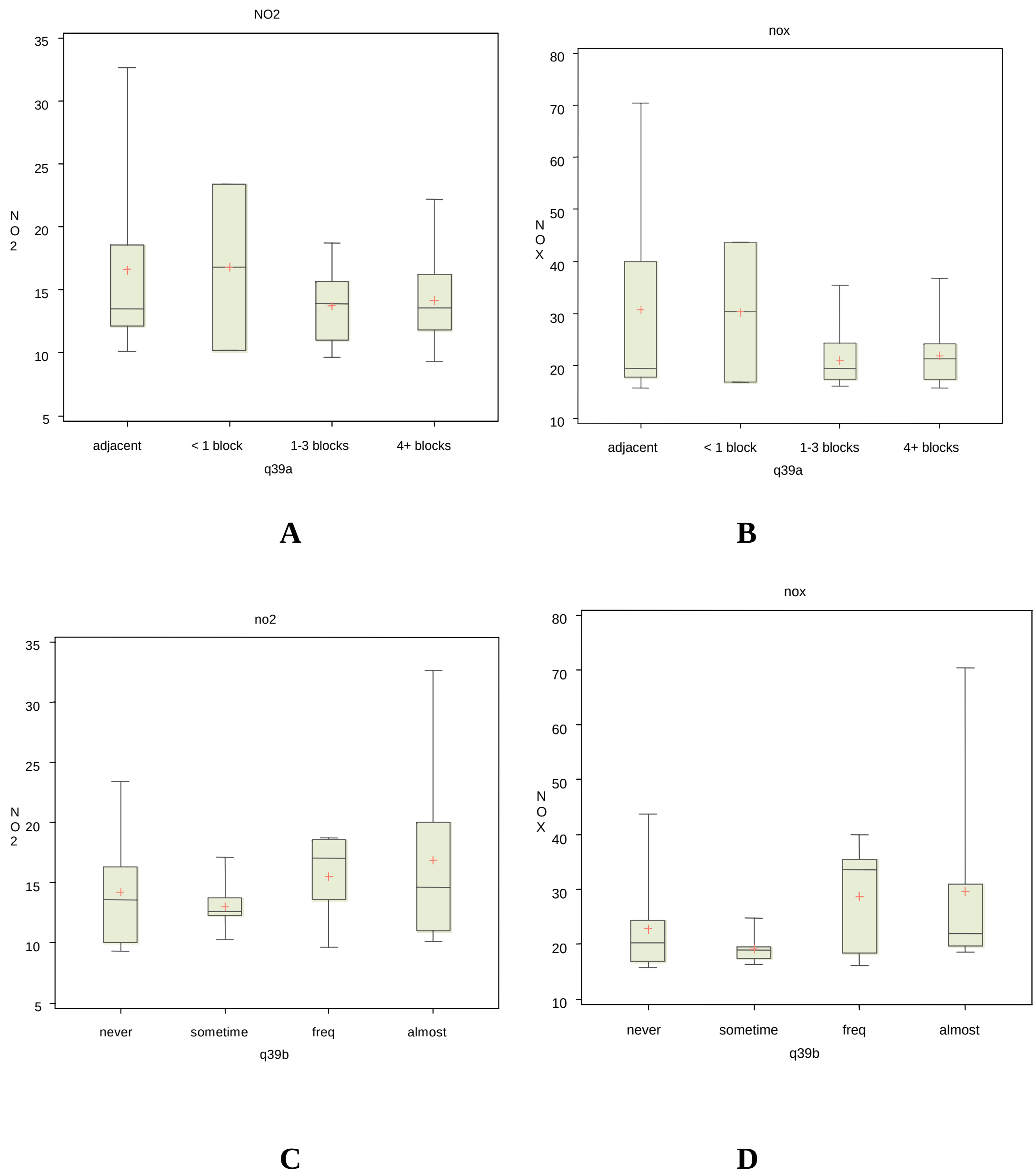
Among 113 that lived within 75 m of a major arterial or higher, 67% reported living adjacent to a road with heavy traffic whereas 12% reported living over 4 blocks from a road with heavy traffic. Similarly, of 257 that lived <75 m of a minor arterial or greater, 47% reported they lived within a block of a road with heavy traffic, 12% reported that the lived over 4 blocks of a road with heavy traffic.

For 42 homes with home monitoring, we examined the agreement between NO2 or NOx and q39a and q39b using box-plots (Figure 5). There was a range of NO2 and NOx levels with no clear relationship between self-reported proximity to heavy traffic or frequent bus or truck traffic.

Thus, more objective measures using GIS-derived traffic metrics or land use regression models are better predictors of traffic pollutants NO_2 and NOx.

In multivariate logistic regression models, we found no associations between current asthma or bronchitis symptoms in the last 12 months and self-reported residential proximity to heavy traffic roads or high frequency of buses/trucks. These null findings are expected since we found that the majority of our study participants perceived that minor arterials were considered a "busy road" and in health analyses, only proximity to freeways/highways were associated with respiratory symptoms.

Figure 5. Box-plots of self-reported residential proximity to heavy traffic vs. outdoor levels of Nitrogen Dioxide (A) or Nitrogen Oxides (B) and self-reported frequency of large trucks or buses adjacent to the residence vs. levels of Nitrogen Dioxide (C) or Nitrogen Oxides (D) for 42 homes.



Specific Aim #5 Utilize GIS-based traffic estimates to test empirically for differential residential exposures by SES, race and ethnicity in our study population.

Rationale: Since our study population has a wide range of family incomes and substantial racial diversity (85% nonwhite), we attempted to augment the scant literature on residential traffic exposures and environmental justice. Specifically, we examined whether within our sample of school children, factors measuring SES, race and ethnicity were related to higher levels of traffic pollutants at the home and school. There is evidence that nonwhites and those of lower socioeconomic status have higher exposure to traffic (Green et al. 2004; Gunier et al. 2003) . Thus, environmental justice issues may be intertwined with studies of traffic-associated health effects.

Methods: We have individual-level data on race/ethnicity and socioeconomic status (household income, parent level of education, health insurance, etc.) and developed GIS-based traffic estimates of residential exposures (Specific Aim 1). We can test for associations between groups with differing traffic exposures (dichotomous or multiple categories) and race/ethnicity or socioeconomic (SES) factors using t-tests (for binary exposures) or analysis of variance (ANOVA) for multi-level exposures.

Methods:

Analyses were run on the relationship between various demographic characteristics and measures of traffic density. The demographic categories investigated were: poverty (income above or below twice the poverty level), health insurance coverage (insured vs. not and government or no insurance vs. other insurance), crowding in residence (less than 2 per bedroom vs. 2 or more), as well as household income, parental education, and race/ethnicity. Measures of traffic were defined in five ways: distance to a freeway/highway, traffic density within 150m, traffic density within 300m, distance-weighted traffic density within 150m, and distance-weighted traffic density within 300m.

Tests of associations between measures of residential traffic and race or SES indicators were done by t-tests (for binary levels) or ANOVA analyses (for SES variables with more than two levels) for each combination of demographic characteristic and exposure metric mentioned above using SAS 9.1.

Results:

Differences between demographic groups were most evident when using either distance-weighted density category ($DWTD_{150}$, $DWTD_{300}$) or traffic density within 150m (TD_{150}). For these measures, statistically significant differences ($p < 0.03$) were found between those of different poverty and crowding groups. No statistically significant differences were found between those with health insurance compared to those without.

Analyses using these traffic metrics also detected a significant trend ($p_{trend} < 0.01$)in which those of lower educational categories lived in areas of higher traffic. When traffic density within 150m was used, a significant trend in which higher income was associated with lower traffic was detected ($p = 0.02$). The pattern was also evident but not significant using the distance-weighted densities.

In our study population, Hispanics had the highest residential traffic exposure, with Whites and African-Americans posting similar averages. When the sum of traffic density within

150m was used, Hispanics had a significantly higher exposure than Whites. However, no differences were found between either group and Whites, or among any of the groups when distance-weighted traffic density was used. The percent of African Americans in our study area was small and we did not test for differential traffic exposures and % African American.

Note that although crowding and poverty were associated with measures of traffic, in our study population, SES indicators such as crowding, poverty, race-ethnicity, and parent education were not important predictors of health outcomes. This may be due, in part, to our study design (i.e., the schools were selected to have relatively similar measures of SES status). As noted in discussions above, because of concerns of SES indicators as a potential confounder, ultimately, we left crowding in the full models as a potential confounder in health analyses.

Discussion

In general, exposures at home and school are important determinants of a child's overall exposure to traffic pollution. In our first publication (Kim et al. 2004), exposure estimates were assigned at a group level based on school exposures using a hierarchical analysis. Thus, the nature of the exposure assignment was an important area of uncertainty.

In this study, we demonstrated associations between residential proximity to traffic-related air pollution and current asthma symptoms using several approaches for estimating exposure. Overall, findings of associations between traffic and bronchitis symptoms in the last 12 months were less robust than those for current asthma.

We used several methods to improve exposure estimates. First, we reasoned that restricting the study population to those living closer (within 1 km) of the school would decrease uncertainties in exposures of using school-based estimates. Limiting the study population to those living within a kilometer of the school gave higher effect estimates for current asthma compared with the full sample. The positive findings using this two-stage analysis approach lends support for the use of neighborhood levels of pollutants as estimates of a child's overall exposure and indicates that reducing exposure misclassification may be important in studies of traffic-based pollutants. For bronchitis, the risk estimates dropped in the restricted model and were no longer statistically significant. This may reflect a loss in statistical power for bronchitis and the lower bronchitis prevalence in the restricted sample. In general, across all of the exposure models, the findings for bronchitis were less robust than those for asthma.

Next, we developed individual level estimates of exposure based on residential proximity to traffic. Most residential GIS metrics used (maximum AADT within 150 m, traffic density 150 m, log distance to freeway) were moderately correlated with primary traffic pollutants (BC, NOx, and NO) and showed statistically significant associations between traffic and current asthma with the highest levels of traffic. Risk of current asthma were decreased with the log distance of residence to freeway.

We also evaluated the use of a simpler metric based on residential distance to busy roads (e.g., arterial or freeway) with categories reflecting rapid decay of pollutant concentrations with increasing distance from roads. We found that children living within 75 m of a freeway were at increased risk of current asthma. This is consistent with studies in Southern California and southeastern Massachusetts, which have found elevated risks primarily among those living within the first 50 to 100 meters of a busy road (Garshick et al. 2003; McConnell et al. 2006). In contrast, the same investigators in Southern California found that, in a different cohort of children, risks of asthma declined with increasing linear distance from a freeway, with increased risks extending beyond several hundred meters (Gauderman et al. 2005). It is unclear whether the more linear decline in risks in the latter study are due to direct impacts of freeway traffic emissions or may include the influence of other covariates, e.g., other major roads, area sources, and land use differences near freeways in urban areas. Additionally, those investigators found an increased risk of asthma among those living near other major roads whereas we did not (McConnell et al. 2006). The traffic volumes on some freeways and other major roads in Southern California can be as much as twice as high as those experienced in the San Francisco Bay Area, which may explain the null findings in our studies.

We developed a land use regression model to predict nitrogen dioxide concentrations in the study area based on traffic, land use and demographic characteristics around monitoring locations. The LUR model was validated and had a higher predictive value compared with the simpler GIS-traffic metrics. The LUR model was then used to determine residential NO_2 for study participants. Modeled residential NO_2 showed consistent associations with current asthma.

In additional analyses, we found little evidence that traffic pollutant concentrations at the schools were confounded by IAQ factors at the school. Finally, we found that self-reported proximity to traffic had poor agreement compared with objective measures of exposures to traffic in our study population.

Further analyses of associations between GIS-based traffic metrics and other health outcomes e.g. wheezing (regardless of diagnosed asthma) and allergic rhinitis were not clearly associated with residential proximity to traffic. We did not find an association between life-time history of asthma and residential proximity to traffic, a result different from those of other recent studies (Gordian et al. 2006; McConnell et al. 2006). Our null results are likely due to the high residential mobility in our study population (only a third of participating children had lived at their current address since age two). This could lead to exposure misclassification to the extent that early childhood exposures are important predictors of ever-asthma.

Our study and several others have found that risks of ever-asthma and current asthma associated with proximity to traffic were elevated primarily among children with no reported family history of asthma (Gordian et al. 2006; McConnell et al. 2006) or maternal history of asthma (this study) . Although paternal history of asthma was not a risk factor or effect modifier for asthma in our study, paternal asthma may have been under-reported (6.6% reported a paternal history of asthma versus 12.3% maternal history).

A strength of this study is the evaluation of agreement between several GIS-based indicators of traffic exposure and measured levels of traffic pollutants. Although previous studies have utilized GIS methods to develop residential exposures to traffic-related pollutants, few have evaluated these metrics with either measured traffic-pollutants or previously validated models (Brauer et al. 2007; Gauderman et al. 2005; Hoek et al. 2002; Nicolai et al. 2003). The results of our traffic metric evaluation against measured nitrogen oxides were consistent with a recent study in San Diego County, in which traffic density within 300 m explained almost 60% of the variation in NO_2 (Ross et al. 2006).

Model comparison: One of the objectives of this study was to compare the different methods for assessing exposure to traffic. Each method of estimating exposure has both advantages and disadvantages (Jerrett et al. 2005). The GIS-based traffic metrics are relatively straightforward to calculate from existing traffic data and yielded positive results that were robust to the use of different traffic metrics. This methodology is less labor intensive than the data collection and analysis needed to develop a land use regression model. Nevertheless, the land use regression model is valuable in that it allows a better quantification of risks of adverse respiratory outcomes with increasing levels of NO_2. Additionally, the use of LUR models with a wind interaction term to predict residential NO_2 yielded somewhat higher effect estimates compared with those using predicted NO_2 based on models without a wind interaction term. These findings supports that both proximity to traffic and meteorological factors are important in our study area. In general, it may be easier to incorporate spatial and temporal differences in traffic pollutants through LUR models compared to other approaches.

The school-based exposures were group level estimates of exposure. We found associations between current asthma and school based BC and NO but not NO2 in group level analyses. If we improve estimates of exposures by using individual level estimates of exposures to traffic based on residential exposures, positive associations are found between current asthma and residential NO2 (and other GIS-based estimates of residential proximity to traffic). Overall, if group level assignments of exposure are used in analyses, our findings suggest that measured BC or NOx/NO may be important pollutants to consider.

The most direct comparison of models is provided through examination of effects of NO2 since that was the only pollutant that was estimated in the LUR models. For the traffic-based metrics, most measures demonstrated low correlations with NO2, with correlation coefficients below 0.40. This compares to an explained variation of approximately 0.7 in the LUR mode or a correlation of around 0.84. However, it should be noted that the NO_2 measurements used to test the traffic-based metrics were based on a convenience sample of residences that agreed to host the monitors. It is possible that more careful (or even random) placement of the NO_2 monitors would have generated a higher correlation with traffic. Ultimately, the LUR-based estimates of NO_2 were associated with current asthma. In contrast, since NO_2 was not correlated with the simpler GIS-based traffic metrics, it is reasonable to infer that NO_2 may not be the most important traffic pollution that were associated with current asthma in our study. It is also important to note that we were not able to estimate NOX or NO (or BC) in a LUR model due to lack of data so we could not compare these directly with the traffic-based metrics which were highly correlated with these pollutants. The LUR model allow residential-based estimates of NO_2. These improved exposure estimates of individuals based on LUR estimates of residential NO_2 were associated with asthma, while group level analysis using school based measurements of NO_2 were not.

We calculated the Akaike's information criterion (AIC), a measure of the goodness of fit of an estimated statistical model for traffic metrics used in this study. (http://www.ats.ucla.edu/stat/sas/output/SAS_logit_output.htm). Table 11 lists the AIC for logistic models of current asthma with covariates (base) and AIC after addition of continuous measures of residential traffic (e.g. log distance to freeway or traffic density) or NO_2 based on land use regression models. (Closest AADT and maximum AADT do not fit well as continuous variables (section b) and were not included. The level of significance of the traffic metric is also included. From Table 11, linear distance to freeway performs poorly compared with log distance to freeway. Overall, we see that the AIC values are similar across different models for most traffic metrics including predicted NO_2. These findings suggest that, in general, there is no “best metric” that fits our dataset.

Table 11. Model fit for current asthma after addition of traffic metrics to logistic regression models

Model for current asthma	AIC[a]	P value for traffic metric[b]
Base model[b]	431.64	
Base + DWTD 150 (continuous)	428.78	0.02
Base + TD 150 (continuous)	429.20	0.03
Base + distance to freeway	432.46	0.28
Base + log distance to freeway	428.77	0.03
Base + land use regression NO2	430.40	0.07
Base + land use regression NO2 with wind interaction	427.70	0.01
Base + LUR NO2 with wind interaction + kriging	426.99	0.01

[a]AIC = Akaike's information criterion, a measure of the goodness of fit of an estimated statistical model. http://www.ats.ucla.edu/stat/sas/output/SAS_logit_output.htm
[b]the p-value reflects the level of significance of the traffic metric when the term is added to the base model
[c]Base model covariates: maternal history of asthma, chest illness before age of 2; pests, indicator of mold presence, crowding.

To summarize, the risks of current asthma are increased for the highest quintiles of traffic within 150 m of a residence (measured as maximum AADT, DWTD, or traffic density) compared with the lowest quintile). Continuous variables such as log distance to freeway, traffic density, or DWTD are also reasonable traffic metrics and fit data as well as modeled NO_2 in our dataset. Given the relative simplicity of calculation, GIS-derived traffic metrics based on nearby traffic volumes and distance, seem to be reasonable measures of residential traffic exposures.

Nonetheless, validated land use regression models of traffic pollutants can provide a more objective estimate of residential exposures to traffic for comparison across studies. A relatively small number of NO_2 samples were used to develop the land use regression model, and OEHHA samples were a convenient sample placed at volunteer homes. With a larger sample size and additional criteria for placing samplers, there is the potential for other model specifications. Additionally, epidemiological studies using LUR models of other traffic pollutants (e.g., diesel particulates) that are known or strongly suspected of contributing to respiratory morbidity are needed.

This study adds to a growing body of evidence linking proximity to traffic and adverse respiratory effects. When this study was initiated, a number of studies, primarily in Europe, had identified associations between proximity to traffic and adverse respiratory outcomes (reviewed by Delfino 2002 (Delfino 2002)). However, extrapolations of the results of European studies to the United States is subject to a variety of sources of uncertainty, including differences in fleet composition (diesel vs. gasoline), emission controls, land use patterns, and population characteristics. Additionally, California has the most stringent emissions standards for motor vehicles in the United States. These differences could results in lower exposures to traffic pollutants among California residents relative to those in European cities.

Our study location and design allowed us to evaluate the effects of traffic pollution in a small area with relatively low levels of regional air pollution. This restricted study area allowed us to focus on variations in air quality strictly related to localized traffic-related air pollution. Our air monitoring pilot study confirmed that this small area variation in air quality was due to local impacts of traffic. As such, our study implicates local traffic as an important risk factor for respiratory disease in an urban area that meets federal air quality standards for ozone and annual average PM_2.5 and has rare exceedances of the 24 hr $PM_{2.5}$ standard. In other American studies of traffic and respiratory health involving populations from Southern California, the Northeastern United States, and Anchorage, Alaska, there were moderate to high regional levels of ozone and/or $PM_{2.5}$ (English et al. 1999; Garshick et al. 2003; Gauderman et al. 2005; Lin et al. 2002; McConnell et al. 2006) or volatile organics from gasoline exhaust (Gordian et al. 2006). Thus, our study provides additional evidence that local traffic may have respiratory impacts even in an area with good regional air quality.

It should be noted, however, that these traffic metrics are surrogates for a complex mixture of traffic pollutants comprised of reactive gases and particulate matter and not just nitrogen oxides. For instance, human exposure studies have found that both fine particulates in diesel exhaust and nitrogen dioxide can enhance allergic responses (Barck et al. 2002; Riedl and Diaz-Sanchez 2005). Spatial models of other important constituents may differ from that of nitrogen dioxide.

It is interesting to note that in our study, NO_2, a secondary product of traffic emissions, had stronger correlations with 300 m metrics compared with 150 m metrics. However, traffic metrics at 300 m (traffic density 300 and maximum AADT 300) had weaker associations with current asthma compared with the corresponding metric at 150 m. This may be purely a dose-related phenomenon reflecting the exponential decay of pollutant concentrations with distance from freeways or may suggest that "fresh" primary traffic emissions, such as ultrafine particles, may be important determinants of the observed associations with current asthma.

This study has several limitations, including its cross-sectional study design, the relatively small sample size, the use of surrogates of exposure, and potential unmeasured confounders. The cross-sectional nature of our study design is an important limitation. We observed comparable effect estimates when we restricted our analysis to those who had lived at their present address for at least one year, providing support for our findings that traffic pollution is associated with increased respiratory symptoms; however, confidence intervals were wider due to small sample size. Our small sample size would make it less likely to find statistically significant associations between respiratory outcomes and exposures to traffic. Despite these limitations, our study found consistently positive associations between current asthma and proximity to traffic. In most instances, positive associations were statistically significant despite the small sample size, Because of the small sample, we could only examine current asthma;

there were insufficient asthma cases to test for associations between asthma severity and residential traffic. Our results are in line with several recent longitudinal studies in Europe and Southern California that have found associations between residential traffic and asthma incidence as well as deficits in lung development (Brauer et al. 2007; Gauderman et al. 2005; Gauderman et al. 2007; McConnell et al. 2006).

Ideally, personal measures of long-term exposures to traffic pollutants would be preferable, but this was not feasible given the limited resources and the scope of our study. Residential location was used here as a proxy for exposures to traffic-related pollution, and recent studies have found good correlations between personal exposures to traffic pollutants and residential proximity to traffic (Nethery et al. 2007; van Roosbroeck et al. 2006). Also, outdoor traffic pollution (e.g., ultrafine particles and nitrogen oxides) in this study area is likely to readily penetrate indoors, since this region experiences mild climate conditions, and the generally older housing stock tends not to have either air conditioning or the same degree of thermal insulation found in colder climates. In general, any misclassifications of exposure are likely to decrease the likelihood of finding an association between exposure and current asthma.

Although our exposure metrics are correlated with NOx, NO and, to a lesser extent, with NO_2, these traffic metrics are more likely to be surrogates for a complex mixture of traffic-related pollutants. For instance, human exposure studies have found that both diesel exhaust and nitrogen dioxide can enhance the allergic response (Barck et al. 2002; Riedl and Diaz-Sanchez 2005). Also, since nitrogen oxides are emitted from diesel and gasoline-powered vehicles, our study was not designed to tease apart the relative contributions of diesel versus gasoline combustion.

CONCLUSIONS:

We evaluated links between living near areas of high traffic and risks of adverse respiratory outcomes, including current asthma and bronchitis symptoms in the last 12 months using data previously collected for the East Bay Children's Respiratory Health Study. To estimate exposures to traffic pollutants, we used geographic-information systems (GIS) methods to estimate measures of traffic density near the home and correlated them with measured traffic pollutant concentrations. We also developed a validated land use regression model to estimate pollutant concentrations at the residence. In health analyses, we found consistent positive associations between residential proximity to traffic or modeled NO_2 exposures and risks of current asthma. Associations for bronchitis were occasionally significant but more sensitive to the exposure metric that was applied. These analyses took into account individual level risk factors such as family history, home environmental factors, and socio-demographic factors, and school indoor air quality factors. Those living within 75 m of freeways and those exposed to very high traffic volume, were at highest risk. The findings in our current study signify that, even in urban areas with good regional air quality, exposures to air pollution from nearby traffic may be associated with risks to children's respiratory health.

In summary, in an urban area with good regional air quality but relatively high levels of freeway traffic, we found associations between residential proximity to traffic and current asthma in school-aged children. Our results contribute to a growing body of evidence linking residential proximity to traffic with the prevalence (and possibly incidence) of respiratory symptoms and asthma in children. These findings are observed across diverse populations worldwide, despite differences in demographics, lifestyle, transportation patterns, and levels of regional air pollution.

RECOMMENDATIONS:

Further studies are needed to explore which constituents of traffic pollution contribute to health impacts through toxicological, clinical, and epidemiological approaches including biomarker studies of traffic exposures and response in humans. Further epidemiological studies should explore the relationship between family history of atopy as an effect modifier of traffic pollution. Epidemiological studies could be conducted to look at biomarkers of exposure to traffic and early adverse health endpoints such as evidence of lung inflammation and other measures of systemic and local oxidative stress. Finally, it is important to explore land-use models for pollutants besides NO_2, including NO and BC.

The body of evidence supports that repeated exposures to traffic pollutants is unhealthful and traffic pollution varies spatially on a local scale with implications for land use planning. Reducing exposures from nearby traffic will likely require a comprehensive, multi-faceted strategy including regulation of motor vehicle emissions, transportation planning, urban and building design, lifestyle changes, and a re-evaluation of potential hot-spots of exposures where children live, attend school, and play. Additional, research studies are needed to determine whether possible mitigation strategies such as soundwalls, vegetation, air cleaners, and ventilation systems are effective at reducing exposures.

References

1. Barck C, Sandstrom T, Lundahl J, Hallden G, Svartengren M, Strand V, et al. 2002. Ambient level of NO2 augments the inflammatory response to inhaled allergen in asthmatics. Respiratory medicine 96(11): 907-917.
2. Berhane K, Gauderman W, Stram DO, Thomas DC. 2004. Statistical issues in studies of the long-term effects of air pollution: The Southern California Children's Health Study. Statistical Science 19(3): 414-449.
3. Brauer M, Hoek G, Smit HA, de Jongste JC, Gerritsen J, Postma DS, et al. 2007. Air pollution and development of asthma, allergy and infections in a birth cohort. Eur Respir J 29(5): 879-888.
4. Brunekreef B, Janssen NA, de Hartog J, Harssema H, Knape M, van Vliet P. 1997. Air pollution from truck traffic and lung function in children living near motorways. Epidemiology 8(3): 298-303.
5. Ciccone G, Forastiere F, Agabiti N, Biggeri A, Bisanti L, Chellini E, et al. 1998. Road traffic and adverse respiratory effects in children. SIDRIA Collaborative Group. Occup Environ Med 55(11): 771-778.
6. Delfino RJ. 2002. Epidemiologic evidence for asthma and exposure to air toxics: linkages between occupational, indoor, and community air pollution research. Environ Health Perspect 110 Suppl 4: 573-589.
7. Duhme H, Weiland SK, Keil U, Kraemer B, Schmid M, Stender M, et al. 1996. The association between self-reported symptoms of asthma and allergic rhinitis and self-reported traffic density on street of residence in adolescents. Epidemiology 7(6): 578-582.
8. English P, Neutra R, Scalf R, Sullivan M, Waller L, Zhu L. 1999. Examining associations between childhood asthma and traffic flow using a geographic information system. Environ Health Perspect 107(9): 761-767.
9. Garshick E, Laden F, Hart JE, Caron A. 2003. Residence near a major road and respiratory symptoms in U.S. Veterans. Epidemiology 14(6): 728-736.
10. Gauderman WJ, Avol E, Lurmann F, Kuenzli N, Gilliland F, Peters J, et al. 2005. Childhood asthma and exposure to traffic and nitrogen dioxide. Epidemiology 16(6): 737-743.
11. Gauderman WJ, Vora H, McConnell R, Berhane K, Gilliland F, Thomas D, et al. 2007. Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. Lancet 369(9561): 571-577.
12. Gordian ME, Haneuse S, Wakefield J. 2006. An investigation of the association between traffic exposure and the diagnosis of asthma in children. Journal of exposure science & environmental epidemiology 16(1): 49-55.
13. Green RS, Smorodinsky S, Kim JJ, McLaughlin R, Ostro B. 2004. Proximity of California public schools to busy roads. Environ Health Perspect 112(1): 61-66.

14. Gunier RB, Hertz A, Von Behren J, Reynolds P. 2003. Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. J Expo Anal Environ Epidemiol 13(3): 240-246.

15. Hoek G, Brunekreef B, Goldbohm S, Fischer P, van den Brandt PA. 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study. Lancet 360(9341): 1203-1209.

16. Janssen NA, Brunekreef B, van Vliet P, Aarts F, Meliefste K, Harssema H, et al. 2003. The relationship between air pollution from heavy traffic and allergic sensitization, bronchial hyperresponsiveness, and respiratory symptoms in Dutch schoolchildren. Environ Health Perspect 111(12): 1512-1518.

17. Jerrett M, Arain A, Kanaroglou P, Beckerman B, Potoglou D, Sahsuvaroglu T, et al. 2005. A review and evaluation of intraurban air pollution exposure models. J Expo Anal Environ Epidemiol 15(2): 185-204. Jewell, Nicholas P. Statistics for Epidemiology. Boca Raton, Florida: Chapman & Hall, 2004, p 216.

18. Kim JJ, Smorodinsky S, Lipsett M, Singer BC, Hodgson AT, Ostro B. 2004. Traffic-related air pollution near busy roads: the East Bay Children's Respiratory Health Study. Am J Respir Crit Care Med 170(5): 520-526.

19. Kuhlisch W, Hirsch T, Olunczek U, Vollheim B, Gross B, During I, et al. 2002. [Validation and subjective reports of exposure to traffic by traffic count, NO2 dispersion modeling and measuring NO2 emissions]. Soz Praventivmed 47(2): 116-123.

20. Lin S, Munsie JP, Hwang SA, Fitzgerald E, Cayo MR. 2002. Childhood asthma hospitalization and residential exposure to state route traffic. Environ Res 88(2): 73-81.

21. McConnell R, Berhane K, Gilliland F, Molitor J, Thomas D, Lurmann F, et al. 2003. Prospective study of air pollution and bronchitic symptoms in children with asthma. Am J Respir Crit Care Med 168(7): 790-797.

22. McConnell R, Berhane K, Yao L, Jerrett M, Lurmann F, Gilliland F, et al. 2006. Traffic, susceptibility, and childhood asthma. Environ Health Perspect 114(5): 766-772.

23. Nethery E, Leckie SE, Teschke K, Brauer M. 2007. From measures to models: An evaluation of air pollution exposure assessment for epidemiologic studies of pregnant women. Occup Environ Med.

24. Nicolai T, Carr D, Weiland SK, Duhme H, von Ehrenstein O, Wagner C, et al. 2003. Urban traffic and pollutant exposure related to respiratory outcomes and atopy in a large sample of children. Eur Respir J 21(6): 956-963.

25. Riedl M, Diaz-Sanchez D. 2005. Biology of diesel exhaust effects on respiratory function. J Allergy Clin Immunol 115(2): 221-228; quiz 229.

26. Rodes CE, Holland DM. 1981. Variations of NO, NO2 and O3 concentrations downwind of a Los Angeles freeway. Atmospheric Environment 15: 243-250.

27. Ross Z, English PB, Scalf R, Gunier R, Smorodinsky S, Wall S, et al. 2006. Nitrogen dioxide prediction in Southern California using land use regression modeling: potential for environmental health analyses. Journal of exposure science & environmental epidemiology 16(2): 106-114.

28. Schrank DL, Lomax TJ. 2005. The 2005 Urban Mobility Report: Texas Transportation Institute. Available at http://mobility.tamu.edu/ums/.

29. Singer BC, Hodgson AT, Hotchi T, Kim JJ. 2004. Passive measurement of nitrogen oxides to assess traffic-related pollutant exposure for the East Bay Children's Respiratory Health Study. Atmos Environ 38(3): 393-403.

30. van Roosbroeck S, Wichmann J, Janssen NA, Hoek G, van Wijnen JH, Lebret E, et al. 2006. Long-term personal exposure to traffic-related air pollution among school children, a validation study. Sci Total Environ 368(2-3): 565-573.

31. van Vliet P, Knape M, de Hartog J, Janssen N, Harssema H, Brunekreef B. 1997. Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. Environ Res 74(2): 122-132.

32. Venn AJ, Lewis SA, Cooper M, Hubbard R, Britton J. 2001. Living near a main road and the risk of wheezing illness in children. Am J Respir Crit Care Med 164(12): 2177-2180.

33. Weiland SK, Mundt KA, Ruckmann A, Keil U. 1994. Self-reported wheezing and allergic rhinitis in children and traffic density on street of residence. Ann Epidemiol 4(3): 243-247.

34. Wilhelm M, Ritz B. 2003. Residential proximity to traffic and adverse birth outcomes in los angeles county, california, 1994-1996. Environ Health Perspect 111(2): 207-216.

35. Wjst M, Reitmeir P, Dold S, Wulff A, Nicolai T, von Loeffelholz-Colberg EF, et al. 1993. Road traffic and adverse effects on respiratory health in children [see comments]. BMJ 307(6904): 596-600.

36. Wyler C, Braun-Fahrlander C, Kunzli N, Schindler C, Ackermann-Liebrich U, Perruchoud AP, et al. 2000. Exposure to motor vehicle traffic and allergic sensitization. The Swiss Study on Air Pollution and Lung Diseases in Adults (SAPALDIA) Team. Epidemiology 11(4): 450-456. Comment in: Epidemiology 2001; 2012(2001) 2137-2008.

37. Zhu Y, Hinds WC, Kim S, Shen S, Sioutas C. 2002a. Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmospheric Environment 36: 4323-4335.

38. Zhu Y, Hinds WC, Kim S, Sioutas C. 2002b. Concentration and size distribution of ultrafine particles near a major highway. J Air Waste Manag Assoc 52(9): 1032-1042.

List of inventions reported and copyrighted materials produced

None

Glossary of Terms, Abbreviations, and Symbols

Abbreviations :

AADT : Average Annual Daily Traffic

CALINE : California Line Source Model

Caltrans: California Department of Transporation

CI : Confidence Interval

EBCRHS : East Bay Children's Respiratory Health Study

EHIB : Environmental Health Investigation Branch

GIS : Geographic Information Systems

IAQ : Indoor Air Quality

INT : Interaction

Land use regression : LUR

Log : logarithim (base e)

NO_2 : Nitrogen dioxide

NOx : Nitrogen oxides

NO : Nitric oxide

OEHHA : Office of Environmental Health Hazard Assessment

OR : Odds Ratios

$PM_{2.5}$: Particulate matter of aerodynamic diameter 2.5 microns or less

PM_{10} : Particulate matter of aerodynamic diameter 10 microns or less

UK: Universal kriging

WLS: weighted-least squares

Appendices for final report: Contract Number 03-327

Traffic Pollution and Children's Health: Refining estimates of exposure for the East Bay Children's Respiratory Health Study.

Principal Investigator:
Bart Ostro, Ph.D.
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Prepared for:

The California Air Resources Board and the California Environmental Protection Agency

Prepared by:
Bart Ostro Ph.D., Chief
Janice J Kim, MD, MPH
Air Pollution Epidemiology Unit
Office of Environmental Health Hazard Assessment
Oakland, CA 94612
(510) 622-3157/510 622-3198
Email: Bostro@oehha.ca.gov
jkim@oehha.ca.gov

TABLE OF CONTENTS

Appendix 1: Development of GIS-based Traffic Metrics:

Methods:

GIS-based Traffic Metrics:

Geocoding:

We geocoded residential addresses of participants and school addresses using ARCGIS 8.3 geographic information system software (Environmental Systems Research Institute (ESRI), Redlands, CA) and a Geographic Data Technology (GDT) road network (GDT version 13, Tele Atlas, Inc., Meno Park, CA, http://www.telatlas.com/). We used a side offset of 25 feet (~7.6 m) from street centerline to determine the location.

Traffic data and road network:

We obtained a base road layer with average annual daily traffic (AADT) counts from the California Department of Health Services (Craig Wolff, Environmental Health Investigation Branch (EHIB), California Environmental Health Tracking Program). This road layer had traffic count data from the California Department of Transportation (CalTrans, 2001 Highway Performance Monitoring System (HPMS) database) joined onto the base road layer (GDT street geography. The GDT road network had excellent alignment when overlaid on to a layer containing digital ortho-photographs of the study area.

The HPMS traffic database has been previously described in several recent epidemiological studies of traffic and adverse health outcomes (English et al. 1999,Wilhelm and Ritz, 2003). Only freeways, highways (HPMS functional class 11 or 12), other principal arterials (HPMS functional class 14), and minor collector roads (functional class 16 or 17) are contained in this base road layer. There are no traffic flow data for local residential streets. Of note, in the traffic database, for some of the larger roads, each direction of travel was represented as a separate roadway. The "distance to the nearest freeway" was the shortest distance from the residence to the middle of the nearest set of lanes of the freeway. For these dualized roads, the "AADT" reported here represents the daily traffic counts in both directions. Data on range of traffic in the study area are summarized in Appendix -Table 1A.

Development of Traffic Metrics

Traffic metrics were calculated using methods described previously. For metrics within a given radius buffer, a buffer size of 300m was also evaluated in a sensitivity analysis.

Briefly, for each location, a circular buffer of specific radius (usually 150 or 300 m) was created in ArcGIS. Road segments, length of road segment within the buffer, and annual average traffic count (AADT) on the road were identified (see Appendix - Figure 1A). Distance to a given road segment was calculated using ARC/Info. Traffic attributes for each location (e.g., distance to a road segment, AADT of that road segment, segment length) were exported into

SAS (version 8.2 Windows; SAS Institute Inc., Cary, NC). Using SAS software, we constructed the traffic metrics listed in Table 1 of the manuscript.

Our study area has strong prevailing winds from west to east due to bay breezes, and freeways/highways near participants' homes generally run from north to south. During the neighborhood-monitoring period, prevailing winds were from the westerly direction (hourly measurements ranged from 220°-310°) over 80% of the time. Annually, hourly measurements ranged from 220°-310° over 60% of the time.

Health Outcomes:

We defined all health outcomes and their important covariates based on the questionnaire completed by the parents. *Ever-asthma* was defined as a "yes" response to the question "Has a doctor or other health professional ever told you or your family that your child has or had asthma?". *Current asthma* (variable = asthma3) was defined as having ever-asthma AND an episode of asthma or "wheezing within the last 12 months". An alternate definition for current asthma (variable = q29b) (In the past 12 months told by a doctor that child had asthma) was also used in some analyses. *Current Bronchitis* was defined as a "yes" response to the question: "During the past 12 months, did your child have bronchitis?" OR a report of cough and chest congestion or phlegm lasting at least three consecutive months of the past 12. *Allergic rhinitis* was defined as a "yes" response to the question "Has a doctor or other health professional ever said your child has or had hayfever or allergic rhinitis?.

We also asked about factors potentially associated with asthma or bronchitis, such as race/ethnicity, measures of socioeconomic status, maternal and paternal history of asthma, current smoker in the home, mold, and commute patterns to and from school (see Kim et al. 2004).

Neighborhood monitoring of NOx/NO2 for the EBCRHS

To determine how well the school-based measurements represent residential exposures, limited additional neighborhood-scale monitoring was also conducted near several schools. Additionally, we compared NOx/NO2 concentrations at the schools to those obtained at the nearest central air monitoring station (Fremont). The study is detailed in Singer et al. 2004.

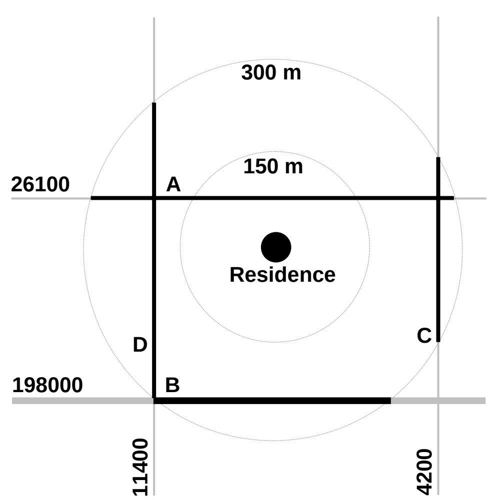
The neighborhood study included school 6, which is far from any major roadway, and schools 3 and 5 that are close, but upwind and downwind of I-880, respectively. Volunteer households that were participating in the EBCRHS were recruited by mail (n= 42). During the first week, NO_2 and NOx samplers were deployed outside at 16 residences around school 6, the 10 study schools, and the Fremont station. During the second week, samplers were deployed at 26 sites around school 3 and 5 (25 residences and a nearby school), the 10 study schools, and the Fremont station. Samplers were left in the field for one full week. Additional validation studies of Ogawa samplers were conducted by co-location studies at the Fremont air monitoring site.

Appendix 1: Table 1A: Range and mean annual average daily traffic counts (AADT) for roads within 1000m of children's residences, by functional class

Functional class	*Road description*[a]	Mean AADT	Min AADT	Max AADT
11	Principal arterial interstate	184,321	52,000	245,000
12	Principal arterial other fwys & exp	92,070	92,000	93,000
14	Other principal arterial	32,716	1,880	67,000
16	Minor arterial	17,071	347	41,889
17	Collector	7,104	500	25,500
19	Local	0	0	0

[a]"Non-local roads" are roads classified as functional class 11-17. In general, CalTrans records traffic counts on only non-local roads. (Exception, one local road had an AADDT of 4500).

Appendix 2: Figure 1A. Schematic diagram of a study residence, surrounding roads with corresponding AADT, 150 m and 300 m buffers. Road segment A with AADT of 26,100 is included in analysis using 150 m buffer. Highway segment B with AADT of 198,000, road segments C (AADT = 4,200) and D (AADT = 11,400), and segment A are all included in analysis using 300 m buffer.



Appendix 1: Table 2A

OEHHA Neighborhood Monitoring Study: Levels of Nitrogen Oxides (NOx) and Nitrogen Dioxide (NO_2).(Singer et al. 2004)

Results from neighborhood study at school 6.

Location	NO_2 (ppb)	NO_X (ppb)	NO_2/Fremont	NO_X/Fremont
School 1	14.3	20.6	1.05	1.18
School 2	17.7	25.1	1.30	1.44
School 3	13.7	18.3	1.01	1.05
School 4	12.4	17.2	0.90	0.99
School 5	23.6	33.8	1.73	1.94
School 6 (n=3)	13.6	17.8	1.00	1.02
School 7	12.5	16.1	0.91	0.92
School 8	14.1	17.3	1.03	0.99
School 9	22.3	31.2	1.63	1.79
School 10	26.7	43.0	1.95	2.47
Fremont station (n=3)	13.7	17.4	1.00	1.00
S6 Neighborhood Sites				
2513	12.1	15.8	0.89	0.91
2312	12.6	16.4	0.92	0.94
1007	12.6	17.0	0.92	0.98
1615	13.6	17.7	1.00	1.02
1113	13.6	18.3	1.00	1.05
1206	14.1	18.9	1.03	1.09
1204	15.7	19.7	1.15	1.13
2442	15.3	20.7	1.12	1.19
1220	14.6	21.9	1.06	1.26
1518	15.1	22.8	1.11	1.31
1219	16.2	24.2	1.18	1.39
2415	16.3	24.4	1.19	1.40
2404	17.1	24.7	1.25	1.42
2501	18.7	35.4	1.37	2.03
1208	17.0	39.9	1.24	2.29
School 6 mean	15.0	22.5	1.10	1.29
School 6 geomean	14.9	21.7	1.09	1.25
School 6 median	15.1	20.7	1.11	1.19

Results from neighborhood study at schools 3 and 5

.Location	NO_2 (ppb)	NO_X (ppb)	NO_2/Fremont	NO_X/Fremont
School 1	13.6	19.7	1.02	1.04
School 2	16.3	26.9	1.23	1.42
School 3 (n=2)	10.6	17.3	0.80	0.91
School 4	11.4	17.4	0.86	0.92
School 5 (n=2)	23.1	36.2	1.74	1.91
School 6	13.7	19.1	1.04	1.01
School 7	13.6	16.8	1.02	0.88
School 8	13.3	18.8	1.00	0.99
School 9	22.1	33.9	1.67	1.79
School 10	29.7	53.1	2.24	2.81
Fremont station (n=2)	13.2	18.9	1.00	1.00
S3 Neighborhood Sites				
3321	9.6	16.2	0.72	0.85
0218	10.0	16.6	0.75	0.88
0226	10.2	16.8	0.77	0.89
1608	9.7	17.1	0.73	0.90
1601	10.6	17.2	0.80	0.91
0204	9.8	17.4	0.74	0.92
0718	10.3	17.4	0.77	0.92
0704	13.0	17.6	0.98	0.93
3322	10.1	18.5	0.77	0.98
0202	11.8	19.4	0.89	1.02
0709	12.6	22.5	0.95	1.19
0108	13.6	23.0	1.02	1.21
2112	11.0	25.3	0.83	1.34
S3 neighborhood mean	10.9	18.8	0.83	1.00
S3 neighborhood geomean	10.9	18.7	0.82	0.99
S3 neighborhood median	10.3	17.4	0.77	0.92
S5 Neighborhood Sites				
3304	9.3	15.8	0.70	0.83
SES	11.9	16.9	0.90	0.89
4603	12.3	17.8	0.93	0.94
3614	13.7	19.4	1.03	1.03
3323	13.5	19.5	1.02	1.03
3314	14.1	21.3	1.06	1.12
3607	18.1	26.0	1.37	1.37
3307	17.5	27.0	1.32	1.42
3604	20.0	31.0	1.51	1.64
3401	18.6	33.6	1.40	1.77
3609	22.2	36.8	1.67	1.94
3327	23.4	43.8	1.77	2.31
3610	32.6	70.3	2.46	3.71
S5 neighborhood mean	17.5	29.1	1.32	1.54
S5 neighborhood geomean	16.6	26.5	1.25	1.40
S5 neighborhood median	17.5	26.0	1.32	1.37

Appendix 1: References:

1. Kim JJ, Smorodinsky S, Lipsett M, Singer BC, Hodgson AT, Ostro B. 2004. Traffic-related air pollution near busy roads: the East Bay Children's Respiratory Health Study. Am J Respir Crit Care Med 170(5): 520-526.

2. Singer BC, Hodgson AT, Hotchi T, Kim JJ. 2004. Passive measurement of nitrogen oxides to assess traffic-related pollutant exposure for the East Bay Children's Respiratory Health Study. Atmos Environ 38(3): 393-403.

Appendix 2: OEHHA Land Use Regression to Predict Nitrogen Dioxide Concentrations in Alameda County

Introduction:

Recent studies have demonstrated the potential of land use regression models to supply accurate, small-area estimates of air pollution concentrations without the expense of dispersion modeling (Brauer et al. 2003; Briggs et al. 2000). The objective of land use regression models is to explain as much of the variation in existing air quality data for a given pollutant using data on variables such as nearby traffic, land use and other variables.

In this study, we developed models to predict nitrogen dioxide concentrations in Alameda County, California based on traffic, land use and demographic characteristics around monitoring locations.

Methods

Sampling Methods and Sample Locations

A total of 160 samples were taken at 112 different locations in Alameda County. Sampling was conducted by two California agencies at three different time periods. The Office of Environmental Health Hazard Assessment (OEHHA) collected 63 samples in consecutive weeks in late April-early May of 2002 as part of the EBCRHS described in the main report. OEHHA samples did not span the entire EBCRHS study area but had samples more localized around several neighborhood schools. The California Department of Health Services' Environmental Health Investigations Branch (EHIB) had collected 50 NO_2 samples in November 2004 and 47 additional samples in May of 2005 throughout Alameda County. We combined samples from OEHHA and EHIB for the development of a land use regression model of NO_2 for use in this study. A total of 106 samples (95 locations) were in the bounding region of study participants (61 from OEHHA, 24 from EHIB in 2004 and 21 from EHIB in 2005).

OEHHA samples: To determine how well the school-based measurements represent residential exposures, limited additional neighborhood-scale monitoring was also conducted near several schools in the EBCRHS (Singer et al. 2004). Briefly, the neighborhood study included school 6, which is far from any major roadway, and schools 3 and 5 that are close, but upwind and downwind of I-880, respectively. During the first week, NO_2 and NOx samplers were deployed outside at 16 residences around school 6, the 10 study schools, and the Fremont station. During the second week, samplers were deployed at 26 sites around school 3 and 5 (25 residences and a nearby school), the 10 study schools, and the Fremont central site air station. Samplers were left in the field for one full week. Additional validation studies of Ogawa samplers were conducted by co-location studies at the Fremont air monitoring site. Values of NOx and NO2 are listed in Appendix 1-Eleven locations were sampled in both weeks. Based on these eleven samples, we determined that there was no evident (or statistically significant) difference between the two weeks and all samples were therefore treated as a single sampling period. (Appendix 2: Figure 1) The two values for the eleven locations were averaged and this average represented the dependent variable in the linear regression models while the raw, unaveraged sample values were used in the kriging model. OEHHA used Ogawa samplers and a colorimetric assay (OgawaUSA, Inc., Pompano Beach, FL) to analyze the samples (Singer et al. 2004).

EHIB samples: Monitoring sites were selected based on terciles of estimated particulate matter concentrations using methods similar to those described in Ross et al. 2006. At all EHIB locations two samples were deployed and measured nitrogen dioxide concurrently. The two samples were averaged. In one instance a monitoring tube broke and for this location a single value was used. EHIB used Palmes tubes in 2004 analyzed by Gradko using UV spectroscopy. In the spring of 2005, EHIB tubes were analyzed by the Environmental Health Laboratory Branch at California Department of Public Health (CDPH) using ion chromatography.

Demographic and Geographic Data

We used a vector-based landuse layer provided by EHIB. The road layer geography comes from Geographic Data Technology. Traffic and other attributes were added based on data from the California Department of Transportation and the national Highway Performance Monitoring System. CalTrans GIS-based traffic data was conflated to the GDT layer and other traffic data, provided in Excel spreadsheet form, was added manually by EHIB.

We used the US Census Bureau's Census 2000 Summary File 1 at the block group level for demographic characteristics.

Geographic Analysis

The GIS methods employed in this analysis are very similar to those discussed in detail in Ross et al 2006 and Ross et al 2007}.

In short, we used a geographic information system (GIS) to calculate land use, traffic and demographic characteristics in buffers of varying radii (50, 100, 300, 500 and 1000 meters) around sampling locations. Traffic variables include road density (km) as well as car and truck traffic density (vehicle-kilometers per hour). Land use variables include industrial, vegetation, residential and port-related land use (in acres).

For land use we calculated the total area for each land use in each buffer. Given the land use layer's high level of detail, we combined land use categories to create aggregate variables representing residential and industrial. The industrial variable includes the categories industrial general, heavy industrial, light industrial and metal salvage & recycling (grid codes 0013, 0131, 0132 and 0133). Residential includes medium density and high density residential (grid codes 0113 and 0115). Note that residential does not include general residential 0011 because none of this category exists in our buffers and it does not include low density or very low density residential, mobile homes or group quarters.

We also used a layer of urban imperviousness from the United States Geological Survey to calculate the percent impervious surface in each buffer (Homer et al. 2004). Urban imperviousness is a USGS-derived layer of urban impermeability (anthropogenic surfaces that prevent the infiltration of water). The percent impervious surface in each buffer was calculated by taking an average of all 30 m x 30 m grid cells from the urban imperviousness layer in each buffer around sampling locations.

Demographic characteristics were calculated at the block group level. For block groups that were not entirely located within a given buffer we multiplied the demographic characteristics by the proportion of the block group's area included in the buffer. Variables calculated include total population, total and percent urban population, total and percent of population living in urban clusters, total occupied housing units and total number of vehicles.

We also calculated several other candidate predictors including shortest distance and bearing to a road with very high traffic (>50,000 ADT), a categorical variable representing the direction (east vs. west) to the nearest road with very high traffic (a surrogate for wind direction), shortest distance to any road, distance straight west to the San Francisco Bay coastline and distance to the nearest large city (>100,000 people).

We generated a convex hull to delineate the geographic region bounding the study participants. We compared the best model produced using all of the samples to a model based on samples limited to this convex hull.

Statistical Analysis

Before analysis, we removed 20 percent of samples for validation. For each of the two models that we developed validation samples were removed separately using the same methodology. To ensure proportional representation from each sampling time period and geographic area we first stratified on sampling time period. We then split the datasets into North and South using the mean Y-value as the cutoff. We then randomly selected 20 percent from each of these six subsets.

With the exception of the OEHHA samples taken in consecutive weeks, samples taken at the same location in different time periods were treated as independent observations. As we determined that there was no difference between the NO_2 concentrations in consecutive weeks in the OEHHA sampling, we averaged the values for the eleven locations with two samples. In addition, all but one EHIB values is actually an average of two concurrent samples. In one instance a sampling tube broke. We accounted for the resulting difference in variance in the models by using weighted least squares and weighting by the reciprocal of the number of contributing samples. In subsequent analyses (described below), data points will be limited to the geographical area of the EBCRHS participants. This basic model for the limited geographic area will be designated the weighted least squares model (WLS).

All models included, *a priori*, a categorical variable representing sampling phase (OEHHA, EHIB November, EHIB May). The phase variable represents an indicator variable that accounts for the different sampling times and slightly different data sampling /analytical methods.

Our statistical analysis consisted of a combination of exploratory data analysis in the form of maps, plots, tables and other graphics as well as standard selection techniques and multiple linear regression. Candidate predictor variables were evaluated using a combination of forward selection, stepwise selection and all-subsets selection. Given that stepwise and all-subsets can identify models that explain significant amounts of variation but make little logical sense, forward selection was the tool we relied on most heavily.

All candidate predictors (e.g., traffic density in the 50 meter buffer, traffic density in the 100 meter buffer) were considered for inclusion in the model on the basis of explained sums of squares, variance inflation factors when considered with other predictors as well as other traditional evaluation methods (Cook's distance, residual patterns etc).

We evaluated the spatial autocorrelation levels in both the raw NO_2 levels and the autocorrelation in the residuals using the `spdep` library in R statistical software based on the four nearest neighbors. The variance of the Moran's I was calculated using a permutation test (randomization).

Results

Section 1. Developing the land use regression model

Descriptive Statistics

Nitrogen dioxide samples are approximately normally distributed with a mean of 17.4 ppb (sd=5.5 ppb). (Appendix 2: Figure 2) Samples in the limited geographic region are also approximately normally distributed with a slightly lower mean (16.6 ppb) and standard deviation (5.1 ppb). The majority of samples are located in the Hayward area – the geographically closest city with at least 100,000 residents is Hayward for 79 samples, Oakland for 45 samples, Berkeley (10) and Fremont (15).

Model Building Using Full Geographic Region

Phase alone explains 27% of the variation. (Appendix 2: Figure 3). A map of NO_2 sampling broken down by phase (EHIB 1 is fall 2004 and EHIB 2 is spring 2005) is shown in Appendix 2: Figure 4.

Traffic, truck traffic and urban imperviousness in the medium and larger buffers were the strongest predictors after phase is added to the model. Traffic in the 300 meter buffer was just slightly behind urban imperviousness (400m) and truck traffic (300m) in predictability but as it has been shown to be a strong predictor elsewhere (Ross et al. 2006), this was the first variable included and explains an additional 21% of variation. (Appendix 2: Figure 5). The next most important variable (after including traffic in the 300 meter buffer and phase) is urban imperviousness as this variable in the 200 through 1000 meters are the top five candidates. Urban imperviousness in the 500 meter buffer explains an additional 12%. The next variable is a surrogate wind variable identifying the direction to the nearest high traffic road (categorized into East and West) and explains an additional 3%. (Appendix 2, Figure 6), Next is truck traffic in the 1000m buffer (4% more). And finally we include road density in the 50m buffer (4% more). Note that the percents mentioned above are sequential percents.

With both total traffic in the 300 meter buffer and truck traffic in the 1000 meter buffer in the model, truck traffic in the 300 meter buffer is “double counted.” As a result, we subtracted the truck traffic in the 300 meter buffer from total traffic to get a new variable “car traffic” in the 300 meter buffer.

The final model predicts the 30 validation locations, locations that were not originally included in the modeling, to within 2.1 ppb (mean absolute percentage error of 15%). In percentage terms, three of the errors were very large – above 50%. All three were predictions of observed values less than 11 ppb.

When validation samples are returned to the pool the results are very similar with an average percentage change of 4% in the parameters. The maximum change is in car traffic (300m) with a 9% change. The full model with all samples explains 73% of the variation. In a leave-one-out cross validation, we predict the excluded value to within 2.4 ppb (16%).

Model Building Geographically Limited to Bounding Polygon – the Weighted least squares model (WLS)

Phase alone explains 20% of variation in NO_2 values in the bounding polygon. Traffic in the 300 meter buffer is the single best predictor explaining an additional 25% of the variation. The categorical variable representing East or West of a high traffic road is next and explains an additional 3% of the variation. Then residential land use within 500m explains an additional 7% of the variation (note that residential land use is statistically significant without the inclusion of the EW variable, but is far more statistically significant with this variable, see discussion). These four variables (phase, traffic in 300m, E or W of major traffic road, residential land use) are all strong variables that are not affected very much by inclusion or exclusion of samples. Residential land use, however, appears to be somewhat reliant on the inclusion of the EW indicator – it is statistically significant in a model without the indicator, but is much stronger with that variable. The next two variables are strongly influenced by specific samples, but we found that the model with these two improves predictions of validation samples and cross validation predictions. For example, traffic is a strong predictor when added to the model, but we find that removing a single sample (E.STOP6.1) and the prediction power plummets. Similarly, we find that traffic in the 50 meter is strongly influenced by specific samples (E.SO6.1 and E.SO6.2), but again the prediction power (based both on validation samples and cross validation) of the model with these samples suggests that they improve the model despite the added volatility.

Given that traffic at three different levels is included in the model, we avoided "double counting" by subtracting the smaller buffer regions from the larger so that we have a 0-50m buffer, a 50-300m buffer and a 300-1000m buffer.

When validation samples are returned the results are similar with an average percentage change of 7% in the parameters. The greatest percentage change is in the residential land use variable with a 12% change. The geographically limited model with validation samples included explains 66% of the variation. In a leave-one-out cross validation, we predict the excluded values to within 2.6 ppb (16%) (Appendix 2, Figure 7 and 8).

Comparison of Cross-Validation Predictions

In a direct comparison of leave-one-out cross validation predictions for locations in the geographically limited area we find that the second model (the model limited to samples in the bounding box) performs slightly better with a slightly lower mean residual (2.55 ppb vs 2.68). Among all the samples, the geographically limited model predicts more precisely for 61 of the 96 samples. In addition, this model also predicts better when we look at sampling locations with larger errors. For example, among the 71 locations that one or both of the models fails to predict within 10% the geographically limited model fares better for 45 (63%). Similarly, among the 36 locations with errors in one or both model greater than 20%, the geographically limited model predicts more precisely for 28 (78%).

Comparison to Phase-Specific Predictions

We developed individual models for each of the sampling phases to identify differences and common elements. Given the differences in phase means and variances, the model for one phase cannot be directly applied to another phase. We find that the model limited to OEHHA samples is only slightly better than models based on all the samples. For example, the model based only on OEHHA samples predicts OEHHA samples (51 locations, one was outside the hull) to within 2.34 (16.2%) whereas the full model predicts to within 2.35 (16.4%).

WLS Model with Wind Interaction Term:

Monitoring studies suggest that concentrations of traffic pollutants are elevated near and downwind of high traffic roadways (Zhu et al. 2002). Prevailing winds are from the West in the study area, and our data suggest that orientation of the road upwind or downwind may be a determinant of levels of NO_2 (Appendix 2, Figure 9).
After building the models we evaluated the effect of including an interaction term between our surrogate wind variable (whether a sample is east (downwind) or west (upwind) of the nearest high traffic road bed and the traffic variables. Here a high traffic road is defined as a road with 2-way traffic counts of AADT ≥100,000 vehicles/day. We found that the interaction with traffic within 50m was non-significant while the interaction with the other two traffic variables were statistically significant at the same level. As previous research has shown significant decay in NO2 within 300 meters of a road, we opted to include only the interaction between the East-West variable and traffic within 50-300m. This interaction term was only included in the geographically limited model.

The final model with an interaction term predicts validation locations to within 2.25ppb (16%) and leave-one-out cross validation predicts excluded samples to within 2.50ppb (16%).

Autocorrelation

Raw nitrogen dioxide concentrations, as expected, are highly correlated as are residuals from all models tested. A map (Appendix 2, Figure 10) shows the strong correlation in the residuals from the geographically limited model. Using a Moran test based on the four nearest neighbors (variance of I determined by randomization) we find that the nitrogen dioxide levels are highly correlated with a Moran's I of 0.45 (p-value < 2.2e-16). For the residuals of the full model and the geographically limited model, the Moran's I is cut in half, but is still highly significant with a Moran's I of 0.26 in both cases (p-value = 9.803e-08 for the full model and p-value = 7.639e-06 for the limited model). We experimented with several different additional variables including proximity to city and others but no additional variables lead to a significant reduction in Moran's I values. Although this model predicts validation locations well, we addressed the issue of residual spatial autocorrelation by employing a kriging model with external drift. The kriging models will be developed in section 2 of this Appendix.

Discussion: Section 1: Developing the land use regression model

We developed models that explain between 66% and 73% of the variation in measured nitrogen dioxide concentrations in Alameda County, California. Models included a combination of traffic and land use variables in the 50, 300, 500 and 1000 meter buffers around sampling locations.

Ultimately the goal of the modeling was to develop a model that best predicts nitrogen dioxide levels in a geographic region bounding study participants. We constructed a model based on samples from the entire geographic region and compared it to a model using only samples in the bounding polygon. We found that the models performed similarly but that the model based on the geographically limited samples predicted validation locations and excluded samples in a cross validation more precisely. This model includes traffic at three levels, 0-50m, 50-300m and 300-1000m along with residential land use and an indicator representing whether the sample was east or west of the nearest road with very high traffic.

In both models, the final two variables added were statistically significant but not clear choices. They improve the prediction of validation locations, locations that were not part of the modeling, but are relatively more volatile and susceptible to outlying values. Traffic in the 50 meter buffer, for example, is questionable for OEHHA data and the bootstrap histogram reveals a somewhat bimodal shape where unusually high values occur in the absence of one of three points (E.SO6, E.CSL23, O.CH1208). Nevertheless, we found that including this variable improved predictions of validation locations and improved cross-validation predictions and was included.

We were also hesitant to include the truck traffic (1000m) variable in the full model. We were surprised to find, for example, that truck traffic in the 1000 meter buffer was a good predictor while total traffic (1000m) was not. These two variables are collinear and we would expect both to be good predictors. The diagnostics on a model with truck traffic (1000m) did not reveal any problems, however, and again, the model performs better with this variable based on validation sample predictions and cross validation.

A final concern we had was with the relationship between residential land use and the indicator for E or W of a high traffic road. Without the indicator residential land use is only statistically significant at the 0.05 level while after including the indicator the importance of this variable jumps dramatically.

In our previous experience producing land use regression models we have found that the raw response variable is very highly spatial autocorrelated while the residuals were only mildly significant or non-significant. In this case, we found that all the combinations of variables we experimented with resulted in significant residual autocorrelation. In several cases, more than one measurement occurs at a single location, but even when we excluded, for diagnostic purposes, all but one measurement at a location the residual autocorrelation remains. The effect of this residual autocorrelation is unknown – although technically it reveals a violation of traditional statistical assumptions, we found that prediction at unmonitored locations performed well in the presence of this autocorrelation.

As a final modeling step, we included an interaction term between our wind surrogate variable and traffic within 50-300m. This interaction term is statistically significant and improves both variation explained and cross-validation predictions modestly.

The land use regression models developed in Section 1 and test statistics are summarized at the end of this Appendix.

Section 2: Weighted Multiple Regression with Kriging:

Although the models based on standard weighted multiple linear regression (WLS) and WLS with a wind interaction term (WLS-int) predict well at validation locations, the strong residual spatial autocorrelation technically violates the standard assumption about the independence of residuals. This can bias parameter estimates and inflate the value of test statistics thus increasing the chance of incorrectly rejecting the Null Hypothesis. In order to address these issues, we developed a model that can incorporate and make use of the residual spatial autocorrelation. In particular we developed hybrid models that simultaneously model the large-scale variation (trend) defined by our landscape variables such as traffic and land use as well as small-scale variation (variation in the residuals). This process is known as kriging with external drift (KED) and in this case the external drift is represented by the regression model previously developed (Cressie 1993). Because these models are designed to model micro-scale variation, rather than averaging multiple measurements at a single location, we included all measurements as separate observations. In order to accommodate these additional measurements in the kriging model where coincident locations are not permitted, we randomly adjusted (jittered) all locations by a centimeter in each coordinate. The jittering does not affect parameter estimates. For geographic locations with two samples, the between site variance is much higher than the within site variance (29.9 vs 1.9).

As part of the KED process we use the residuals from a traditional multiple linear regression model to estimate the small-scale variation. Our empirical variograms shows significant small-scale variation and a theoretical model based on an exponential function fits the data well (Appendix 2, Figure 11).

The fitted parameters show that the practical range of the autocorrelation is 339 meters meaning that, after accounting for our landscape variables, only locations separated by approximately 339 meters remain spatially autocorrelated. (In an exponential model the practical range represents the range at which 95% of the sill component is reached). This theoretical variogram model is then used to fit the drift parameters using generalized least squares.

As an exact interpolator, kriging is constrained to predict correctly at measurement location and without a residual a measure of residual autocorrelation cannot be directly computed. (Kriging is an exact interpolator in cases where the nugget is treated as micro-scale variation (as we've done here), it is not an exact interpolator if some level of measurement error is specified).

In order to get around this constraint we "estimated" residuals by predicting at monitoring locations jittered (again) by a centimeter in each coordinate. The completely non-significant Moran's I value shows that our new model has completely absorbed the spatial autocorrelation.

The cross validation results and predictions at validation locations cannot be directly compared to the models based on site-specific averages. Nevertheless, the results show a similarity in terms of mean absolute percentage error. The KED model both with and without an interaction term predict validation locations within 2.5ppb (15%). In terms of leave-one-out cross validation, the KED model with an interaction term predicts slightly better – to within 2.0ppb (12%) compared to 2.1ppb (13%). Parameters common to all four models show strong similarity.

Predictions at participant's homes are similar for all four models (Appendix 2: Figure 12), though we see greater differences between models with and without an interaction term than we do between WLS and KED models . We find that the differences can, in a large part, be attributed to differences in the residential land use parameter. For example, there are 23 locations where the prediction of the KED interaction model is >15% of the KED non-interaction model. In all 23 instances, the interaction term models predict higher NO_2 values. The models with an interaction term have a residential land use parameter approximately 30% higher than those without – meaning that residential land use exerts less of a negative influence on the interaction models. And among the 23 locations discussed above they have, on average, twice the amount of residential land use meaning that in the non-interaction models this high residential land use exerts a stronger pull downward than in a UK model.

In summary in this section, we developed a model that can incorporate and make use of the residual spatial autocorrelation. In particular we developed hybrid models that include landscape variables such as traffic and land use as well as small-scale variation (variation in the residuals) termed universal kriging. Models with universal kriging gave similar predictions of NO_2 at participants homes.

The two kriging models with external drift (one with an interaction term and one without; designated *wls-int-uk,* and *wls-uk*, respecitvely) and the two final regression models (one with an interaction term and one without; designated *wls* and *wls-int*, respectively) will be used to predict to predict NO_2 in the health analyses. In all cases, the models were based on the geographically limited set of samples.

Appendix 2 References:

Cressie, N. 1993. Statistics for Spatial Data: Revised Edition. John Wiley & Sons, Inc; New York.

Homer, C., C. Huang, et al. 2004. "Development of a 2001 National Land-Cover Database for the United States." Photogrammetric Engineering & Remote Sensing **70**(7): 829-840.

Fox, J. 2002. An R and S-PLUS Companion to Applied Regression. Sage Publications: Thousand Oaks.

Kim JJ, Smorodinsky S, Lipsett M, Singer BC, Hodgson AT, Ostro B. 2004. Traffic-related air pollution near busy roads: the East Bay Children's Respiratory Health Study. Am J Respir Crit Care Med 170(5): 520-526.

Ross, Z., P. B. English, et al. 2006. "Nitrogen dioxide prediction in Southern California using land use regression modeling: potential for environmental health analyses." Journal of Exposure Science and Environmental Epidemiology **16**(2): 106-114.

Ross, Z., M. Jerrett, et al. 2007. "A land use regression for predicting fine particulate matter concentrations in the New York City region." Atmospheric Environment **41**(11): 2255-2269.

Singer BC, Hodgson AT, Hotchi T, Kim JJ. 2004. Passive measurement of nitrogen oxides to assess traffic-related pollutant exposure for the East Bay Children's Respiratory Health Study. Atmos Environ 38(3): 393-403.

Zhu Y, Hinds WC, Kim S, Sioutas C. 2002. Concentration and size distribution of ultrafine particles near a major highway. J Air Waste Manag Assoc 52(9): 1032-1042.

Section 1: Land use Regression Models. Summary of Model Results

Note on all models the indicator for E or W of high traffic road uses treatment contrasts with West as the baseline (parameter represents increase in NO_2 related to being East of road)

Full Model Results

Without validation points included

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	8.3974	1.5935	5.2697	0.0000
Phase: EHIB May	-5.6465	0.6605	-8.5482	0.0000
Phase: OEHHA	-4.6690	0.7991	-5.8428	0.0000
Car Traffic (300m)	0.0005	0.0002	3.2489	0.0015
Urban Imperviousness (500m)	0.1191	0.0262	4.5493	0.0000
Indicator E or W of High Traf Rd	1.8998	0.5706	3.3296	0.0012
Truck Traffic (1000m)	0.0019	0.0005	4.1014	0.0001
Road Density (50m)	12.5507	3.4926	3.5935	0.0005

Residual standard error: 1.705 on 111 degrees of freedom
Multiple R-Squared: 0.7051,   Adjusted R-squared: 0.6865
F-statistic: 37.91 on 7 and 111 DF, p-value: < 2.2e-16

```
                GVIF Df GVIF^(1/2Df)
phase         1.293136  2     1.066378
traf.300noTR 1.434375  1     1.197654
urbimper.500 1.362497  1     1.167260
rd50k.EW      1.035490  1     1.017590
traf.tr.1000 1.428860  1     1.195349
rdln.50       1.262305  1     1.123523
```

With validation points included

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	8.5585	1.4364	5.9585	0.0000
Phase: EHIB May	-5.7886	0.5643	-10.2585	0.0000
Phase: OEHHA	-4.7691	0.6820	-6.9930	0.0000
Car Traffic (300m)	0.0005	0.0001	3.4655	0.0007
Urban Imperviousness (500m)	0.1182	0.0232	5.0907	0.0000
Indicator E or W of High Traf Rd	1.8054	0.4895	3.6885	0.0003
Truck Traffic (1000m)	0.0020	0.0004	5.1316	0.0000
Road Density (50m)	12.1334	2.9504	4.1125	0.0001

Residual standard error: 1.638 on 141 degrees of freedom
Multiple R-Squared: 0.733,   Adjusted R-squared: 0.7198
F-statistic: 55.31 on 7 and 141 DF, p-value: < 2.2e-16

```
                GVIF Df GVIF^(1/2Df)
```

```
phase         1.252531  2      1.057906
traf.300noTR 1.404512  1      1.185121
urbimper.500 1.429414  1      1.195581
rd50k.EW      1.016154  1      1.008044
traf.tr.1000 1.458173  1      1.207548
rdln.50       1.237397  1      1.112384
```

Geographically Limited Model (Weighted least –squares regression)

Without Validation

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	16.6107	1.2664	13.1163	0.0000
Phase: EHIB May	-6.0022	0.9925	-6.0478	0.0000
Phase: OEHHA	-4.3752	1.0168	-4.3031	0.0001
Total Traffic (50m)	0.0109	0.0037	2.9584	0.0042
Total Traffic (50-300m)	0.0007	0.0002	3.3742	0.0012
Total Traffic (300-1000m)	0.0002	0.0001	2.6726	0.0094
Indicator E or W of High Traf Rd	3.2091	0.8429	3.8073	0.0003
Residential Land Use (500m)	-0.0288	0.0088	-3.2746	0.0017

Residual standard error: 1.793 on 69 degrees of freedom
Multiple R-Squared: 0.6341, Adjusted R-squared: 0.5969
F-statistic: 17.08 on 7 and 69 DF, p-value: 6.876e-13

```
                GVIF Df GVIF^(1/2Df)
phase       1.387408  2     1.085303
traf.50     1.352254  1     1.162865
traf50.300  1.327932  1     1.152359
traf300.1000 1.331747  1     1.154013
rd50k.EW    1.227679  1     1.108007
res.500     1.319951  1     1.148891
```

With Validation Points

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	16.4372	1.1068	14.8505	0.0000
Phase: EHIB May	-5.7814	0.8412	-6.8730	0.0000
Phase: OEHHA	-4.3209	0.8429	-5.1263	0.0000
Total Traffic (50m)	0.0119	0.0035	3.4518	0.0009
Total Traffic (50-300m)	0.0008	0.0002	4.1682	0.0001
Total Traffic (300-1000m)	0.0002	0.0001	3.0793	0.0028
Indicator E or W of High Traf Rd	2.9284	0.7112	4.1174	0.0001
Residential Land Use (500m)	-0.0251	0.0075	-3.3625	0.0011

Residual standard error: 1.731 on 88 degrees of freedom
Multiple R-Squared: 0.6573, Adjusted R-squared: 0.63
F-statistic: 24.11 on 7 and 88 DF, p-value: < 2.2e-16

```
                GVIF Df GVIF^(1/2Df)
phase       1.304209  2     1.068653
traf.50     1.363563  1     1.167717
traf50.300  1.245349  1     1.115952
traf300.1000 1.180078  1     1.086314
rd50k.EW    1.206812  1     1.098550
res.500     1.329766  1     1.153155
```

Section 2: Summary of Model Results. Land use Regression Models with and without Universal Kriging.

Side by Side Comparison of Parameter Estimates

	WLS	WLS-INT	UK	UK-INT
(Intercept)	16.4372	16.9603	16.4524	17.2361
Phase: EHIB2	-5.7814	-5.7984	-5.5767	-5.5806
Phase: OEHHA	-4.3209	-4.4466	-4.4966	-4.6314
Traffic (50m)	0.0119	0.0132	0.0134	0.0144
Traffic (50-300m)	0.0008	0.0003	0.0008	0.0002
Traffic (300-1000m)	0.0002	0.0002	0.0002	0.0001
East or West of HWY* : West	2.9284	0.7502	2.7620	0.2114
Residential Land Use (500m)	-0.0251	-0.0184	-0.0238	-0.0166
Traf(50-300m) x East of HWY	NA	0.0010	NA	0.0011

Final Weighted Linear Regression Model (No Interaction): WLS

	Estimate	StdErr	t-value	P-value
(Intercept)	16.4372	1.1068	14.8505	0.0000
Phase: EHIB2	-5.7814	0.8412	-6.8730	0.0000
Phase: OEHHA	-4.3209	0.8429	-5.1263	0.0000
Traffic (50m)	0.0119	0.0035	3.4518	0.0009
Traffic (50-300m)	0.0008	0.0002	4.1682	0.0001
Traffic (300-1000m)	0.0002	0.0001	3.0793	0.0028
East or West of HWY*: East	2.9284	0.7112	4.1174	0.0001
Residential Land Use (500m)	-0.0251	0.0075	-3.3625	0.0011

Residual standard error: 1.731 on 88 degrees of freedom
Multiple R-Squared: 0.6573, Adjusted R-squared: 0.63
F-statistic: 24.11 on 7 and 88 DF, p-value: < 2.2e-16

Generalized variance inflation factors

	GVIF	Df	GVIF^(1/2Df)
phase	1.304209	2	1.068653
traf.50	1.363563	1	1.167717
traf50.300	1.245349	1	1.115952
traf300.1000	1.180078	1	1.086314
rd50k.EW	1.206812	1	1.09855
res.500	1.329766	1	1.153155

Mean absolute percentage error on residuals from fit:
2.33 (15%)

Mean absolute percentage error on cross validation predictions:
2.55 (16%)

Final Weighted Linear Regression Model (With Interaction): WLS w interaction

	Estimate	StdErr	t-value	P-value
(Intercept)	16.9603	1.0816	15.6801	0.0000
Phase: EHIB2	-5.7984	0.8099	-7.1597	0.0000
Phase: OEHHA	-4.4466	0.8127	-5.4713	0.0000
Traffic (50m)	0.0132	0.0034	3.9438	0.0002
Traffic (50-300m)	0.0003	0.0002	1.3342	0.1856
Traffic (300-1000m)	0.0002	0.0001	2.9398	0.0042
East or West of HWY* : West	0.7502	1.0326	0.7265	0.4695
Residential Land Use (500m)	-0.0184	0.0076	-2.4209	0.0176
Traf(50-300m) x East of HWY	0.0010	0.0003	2.8184	0.0060

Residual standard error: 1.667 on 87 degrees of freedom
Multiple R-Squared: 0.6859, Adjusted R-squared: 0.6571
F-statistic: 23.75 on 8 and 87 DF, p-value: < 2.2e-16

Generalized variance inflation factors*

	GVIF	Df	GVIF^(1/2Df)
phase	1.308701	2	1.069572
traf.50	1.390683	1	1.179272
rd50k.EW	2.744262	1	1.656581
traf50.300	2.252864	1	1.500954
traf300.1000	1.189165	1	1.090489
res.500	1.477854	1	1.21567
rd50k.EW:traf50.300	3.502593	1	1.871522

Mean absolute percentage error on residuals from fit:
2.25 (14%)

Mean absolute percentage error on cross validation predictions:
2.50 (16%)

*$GVIF^{1/2Df}$ is a one-dimensional expression of the decrease in precision of estimation due to collinearity

Kriging With External Drift Model (No Interaction): UK

(Intercept)	16.4524
Phase: EHIB2	-5.5767
Phase: OEHHA	-4.4966
Traffic (50m)	0.0134
Traffic (50-300m)	0.0008
Traffic (300-1000m)	0.0002
East or West of HWY* : East	2.7620
Residential Land Use (500m)	-0.0238

Mean absolute percentage error on residuals from fit:
Not applicable

Mean absolute percentage error on cross validation predictions:
2.10 (13%)

Kriging With External Drift Model (With Interaction): (UK- int)

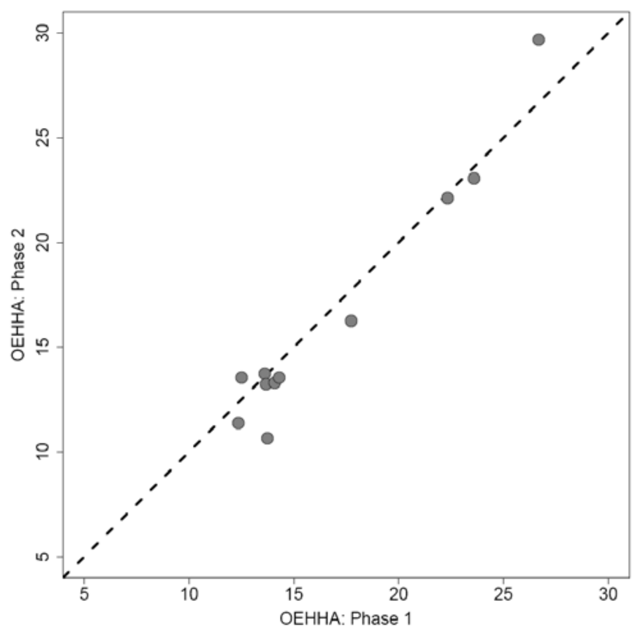
(Intercept)	17.23613
Phase: EHIB2	-5.58058
Phase: OEHHA	-4.63143
Traffic (50m)	0.01438
Traffic (50-300m)	0.000183
Traffic (300-1000m)	0.000141
East or West of HWY* : West	0.211394
Residential Land Use (500m)	-0.01658
Traf(50-300m) x East of HWY	0.00114

Mean absolute percentage error on residuals from fit:
Not applicable

Mean absolute percentage error on cross validation predictions:
2.03 (12%)

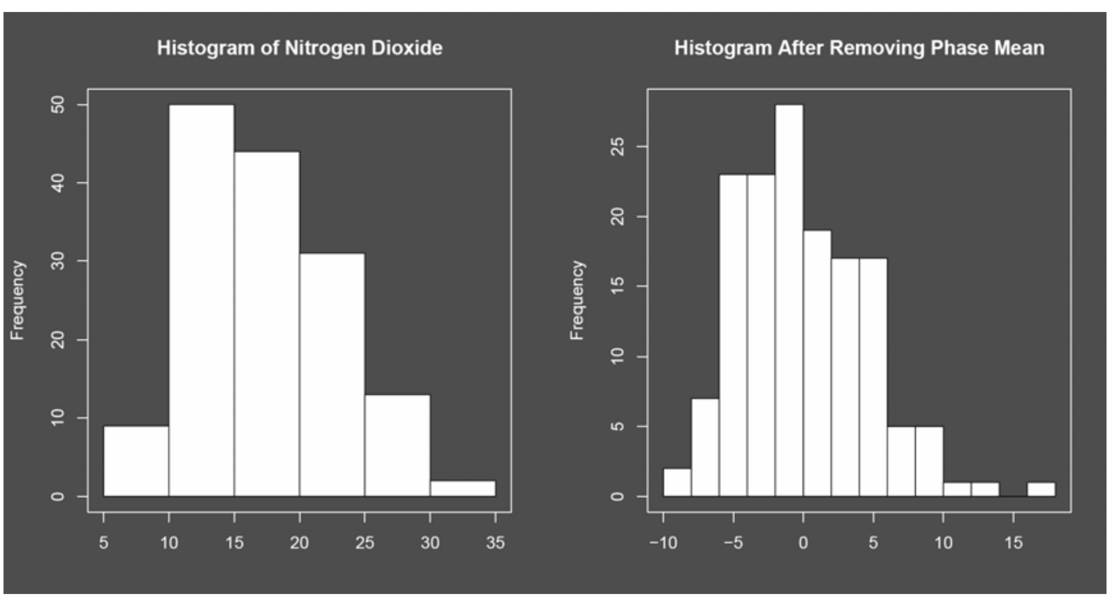
Appendix 2: Figure 1:

Eleven OEHHA locations sampled in both week one and week two. There is no statistically significant difference between the concentrations



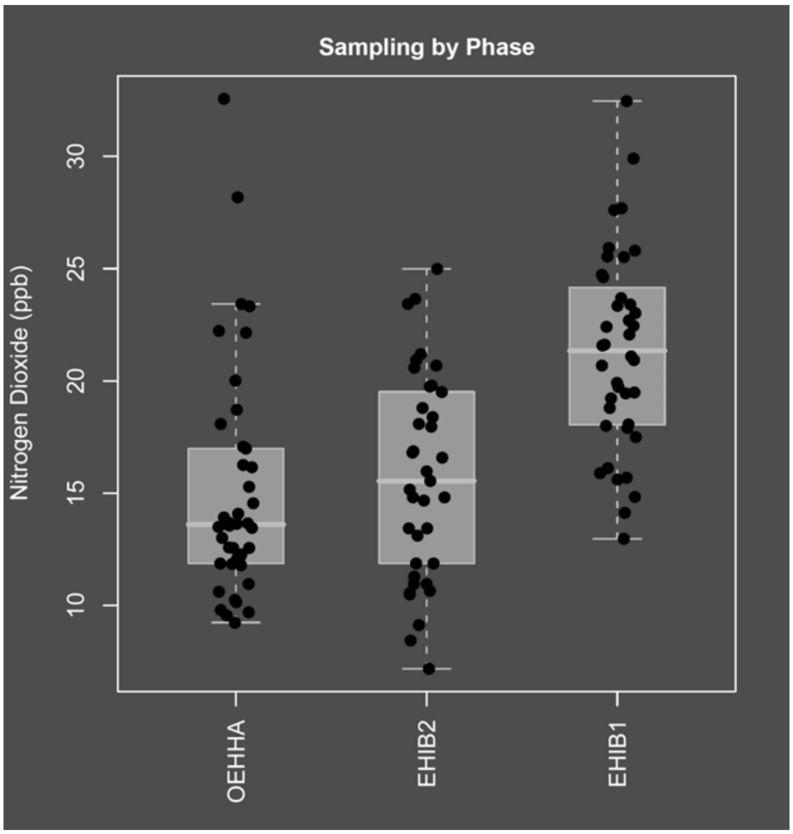
Appendix 2: Figure 2

Histograms of NO_2 concentrations for all samples.



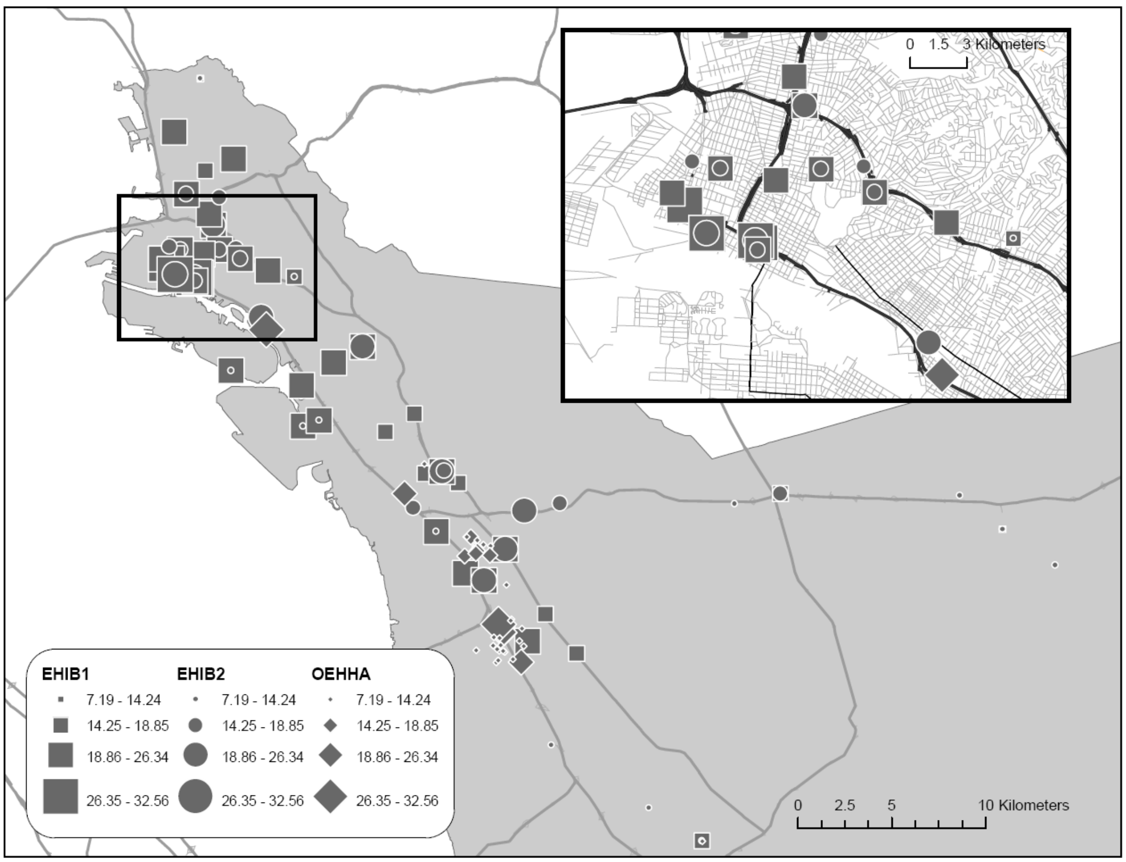
Appendix 2: Figure 3

NO_2 Sampling by Phase.



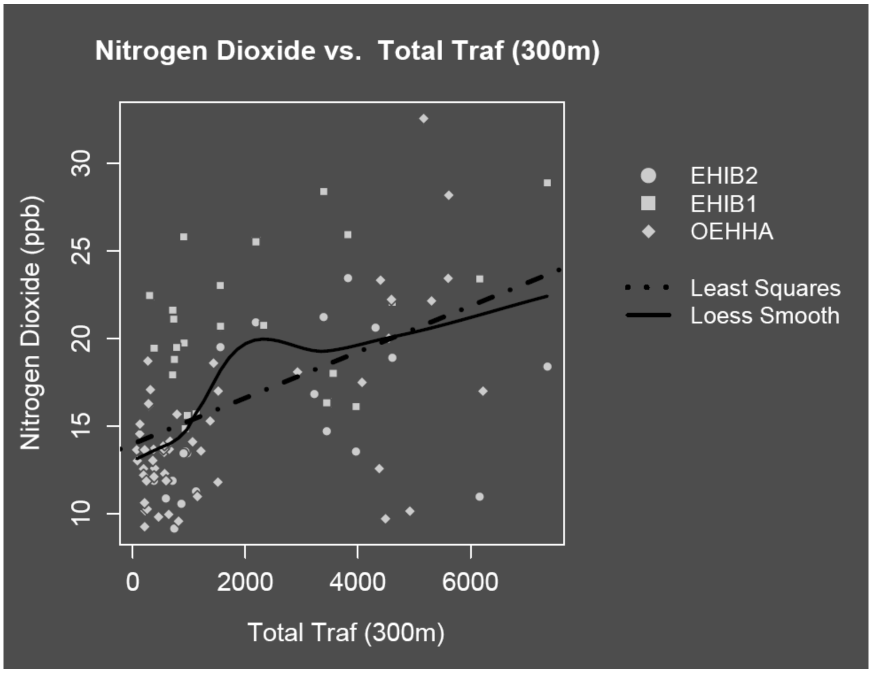
Appendix 2: Figure 4:

Map of NO_2 sampling broken down by phase (EHIB 1 is fall 2004 and EHIB 2 is spring 2005).



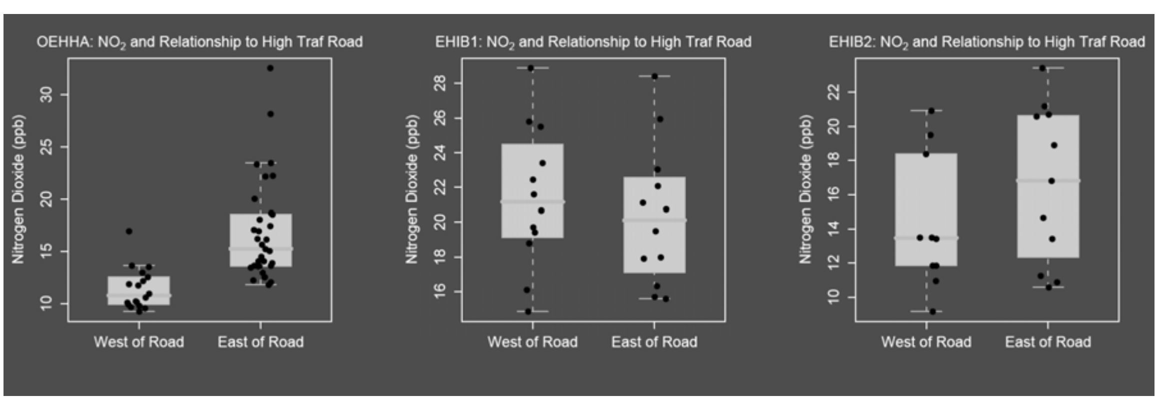
Appendix 2: Figure 5

Traffic in the 300 meter buffer is a strong predictor for all models.



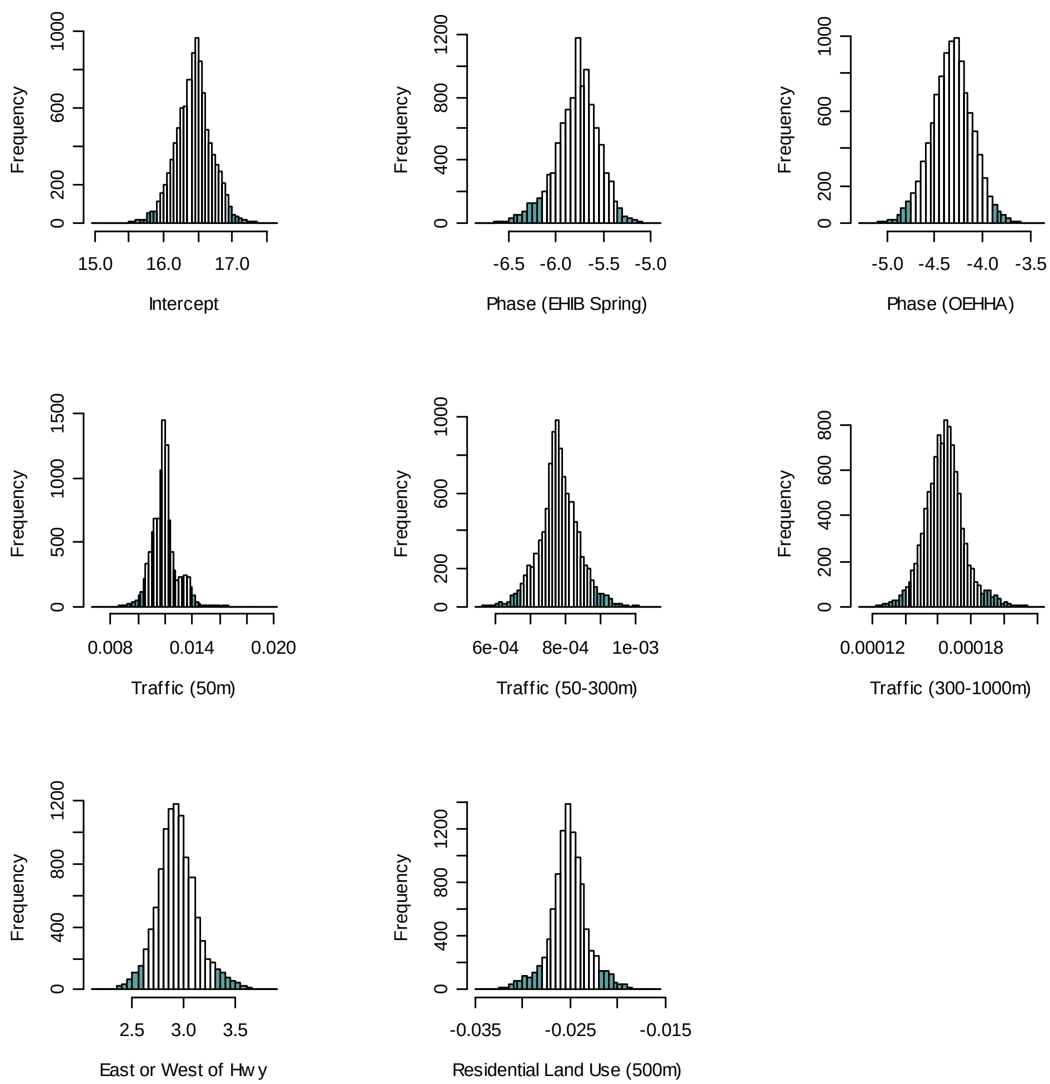
Appendix 2: Figure 6

Location East or West of the nearest high traffic road is a very good predictor of OEHHA data and less so for EHIB data (EHIB 1 is fall 2004 and EHIB 2 is spring 2005).



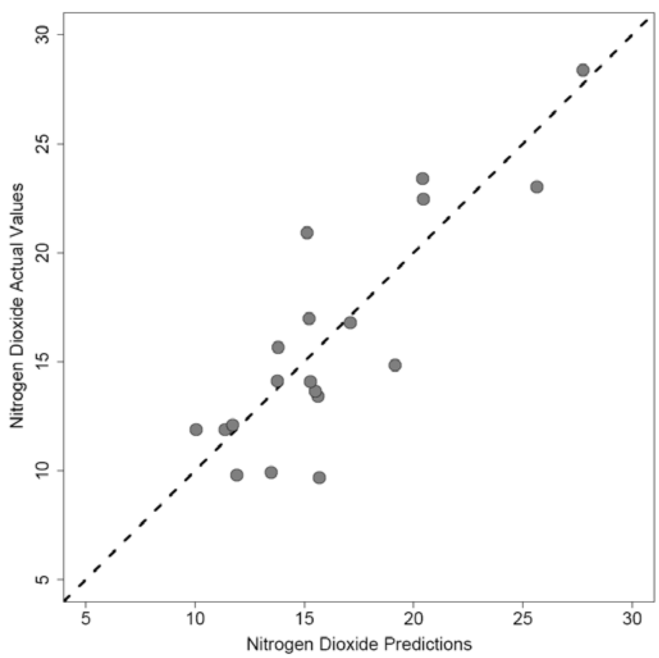
Appendix 2: Figure 7

Bootstrap of parameters from the geographically limited weighted least squares model. In each iteration, five samples were removed, the model was run and the parameters were recorded. Total of 10,000 iterations.



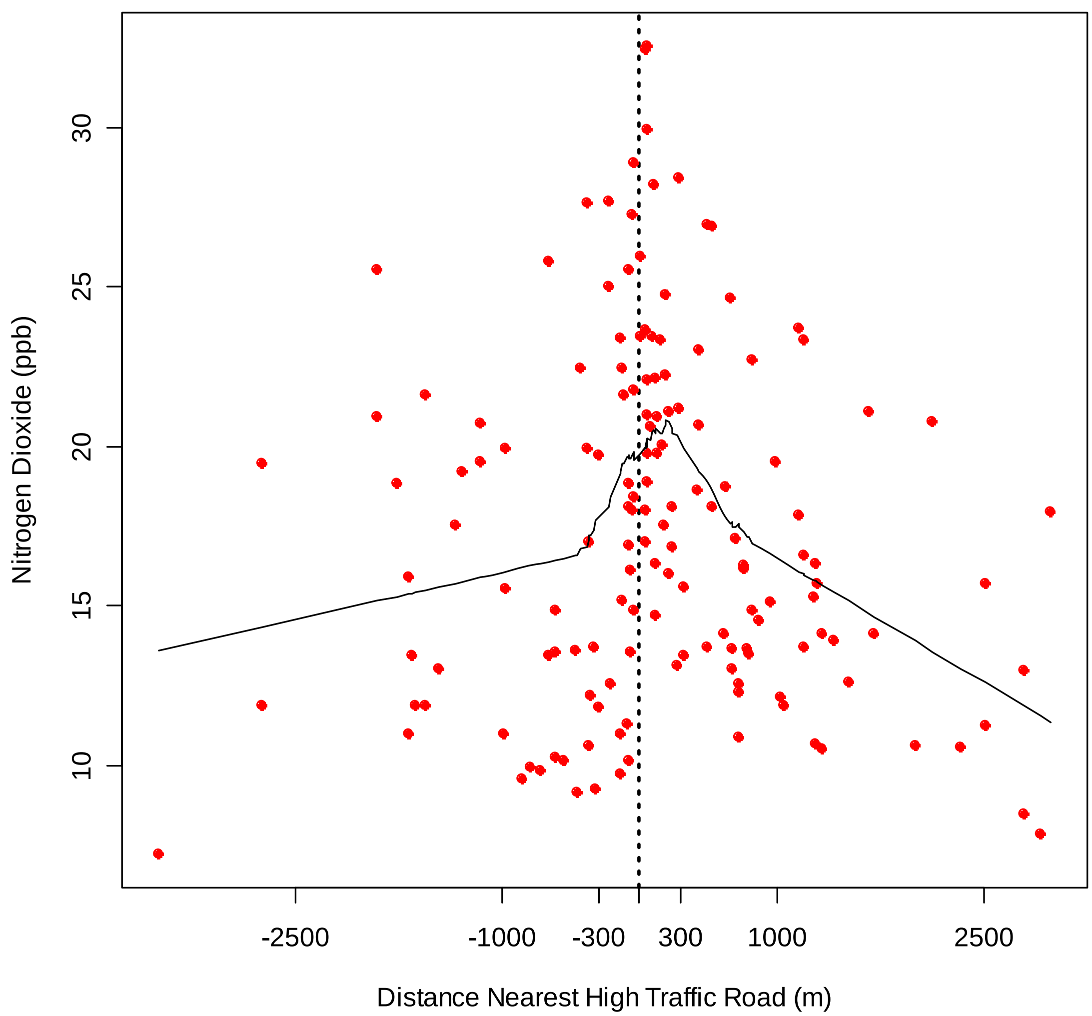
Appendix 2: Figure 8

Predictions against actual nitrogen dioxide concentrations based on the geographically limited weighted least squares model.



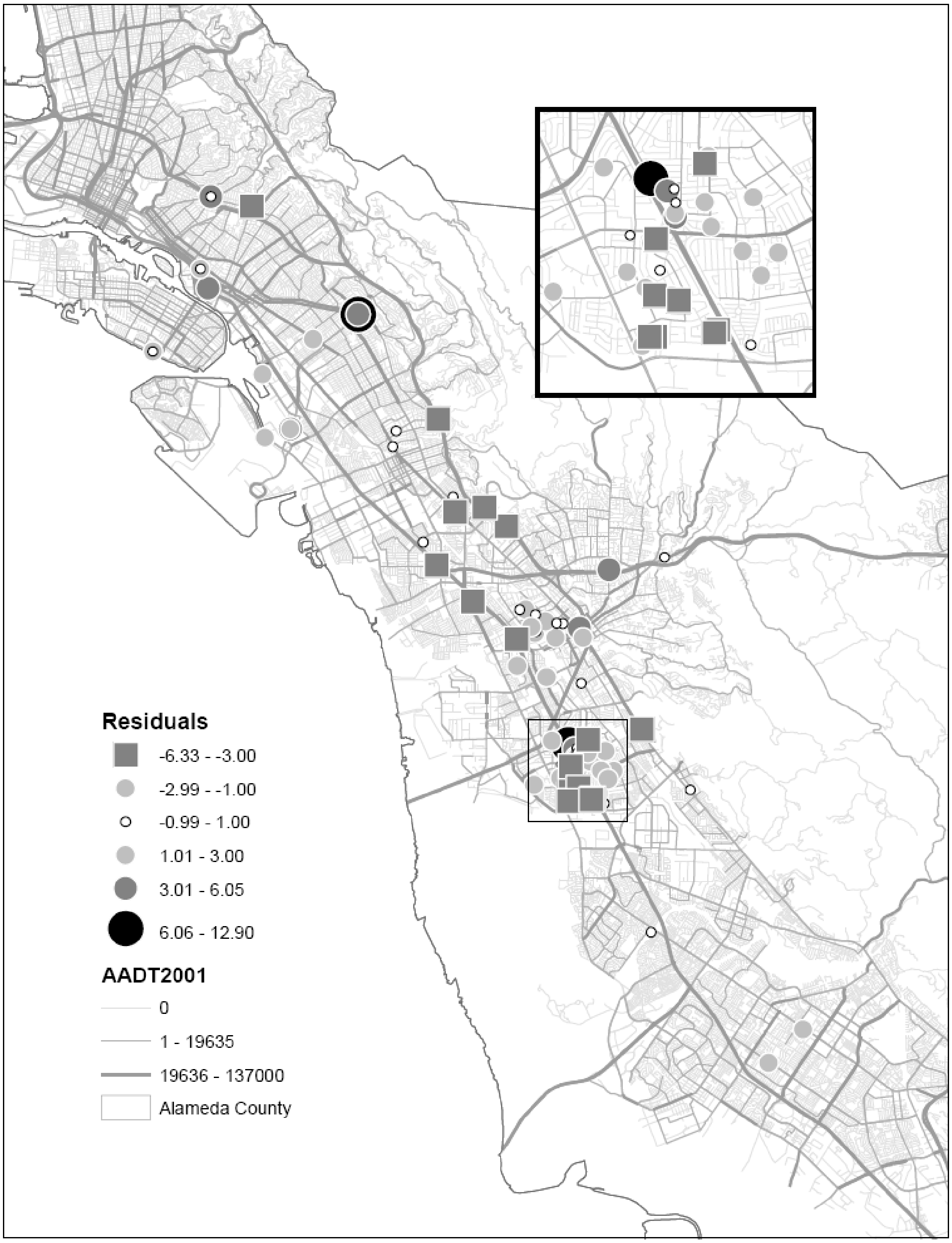
Appendix 2: Figure 9

Distance Decay Curve with a Lowess local smooth. The proportion of data used for smoothing at each x point is 0.4.



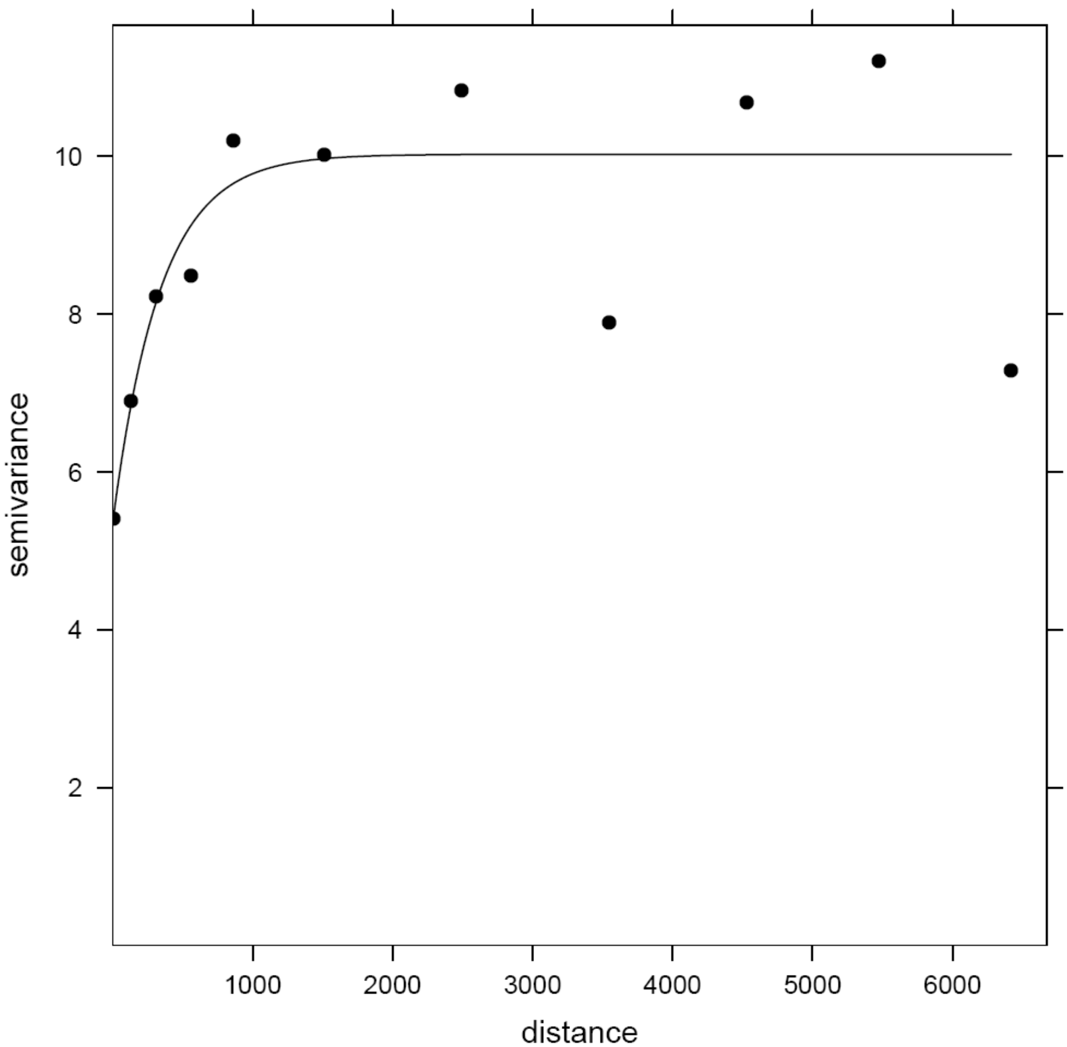
Appendix 2: Figure 10

This map shows the strong correlation in the residuals from the geographically limited model.



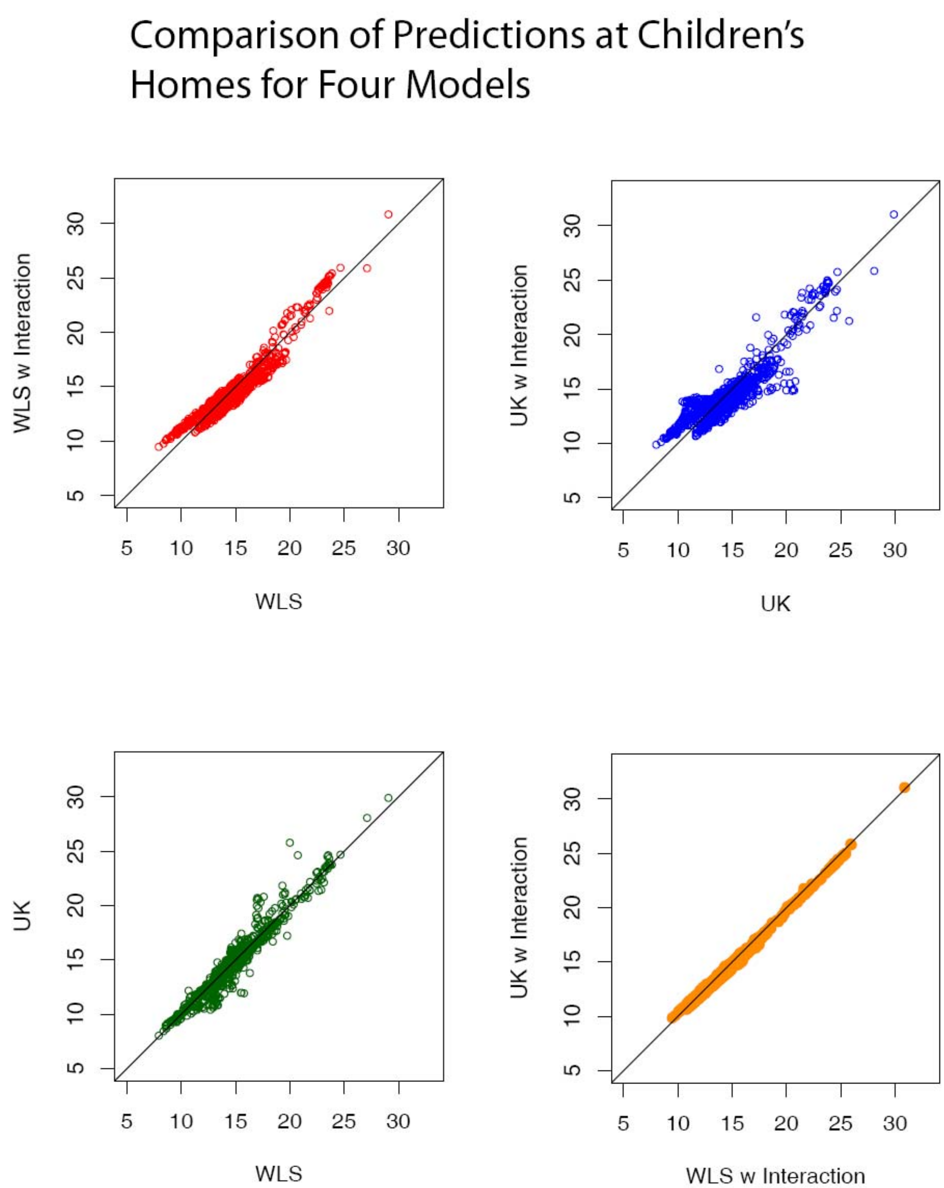
Appendix 2: Figure 11

Variogram:



Appendix 2: Figure 12

Comparison of Predictions at Children's Homes for Four Models. Weighted least squares (WLS), Weight least squares with a wind-traffic interaction term (WLS w interaction), Universal kriging (UK) and Universal Kriging with Interaction (UK w interaction).



Appendix 3:

Classroom Indoor Air Quality—East Bay Children's Respiratory Health Study

1. Introduction

Other factors at the schools with higher traffic pollutant concentrations (e.g. co-incidental mold/dampness) could confound the children's respiratory outcomes in the East Bay Children's Respiratory Health Study (EBCRHS). At a minimum, during primary data collection for our EBCRHS, we wanted to determine whether there were any obvious indoor air quality problems at the schools which might be contributing to the children's respiratory symptoms. To accomplish this, we surveyed teachers on indoor air quality problems in the classroom and had a technician walk-through survey as part of the study. The majority of teachers found the overall environmental quality adequate or good and the technician walk-through survey did not identify and major indoor environment concerns. However, the survey data had not been formally analyzed.

In this project, we examine the data previously collected in the two surveys assessing indoor air quality (IAQ) at the schools—the teacher questionnaire and the technician walk-through survey—for associations between children's respiratory outcomes and potential classroom exposures. We report the prevalence of selected classroom exposures from both surveys and compare our results with those from other studies that used the same or very similar surveys, including CARB's Portable Classroom Survey (PCS).

Finally, we evaluate whether there was evidence that traffic pollutant concentrations at the schools were confounded by IAQ factors at the school that were associated with children's respiratory outcomes in multivariate logistic regression models.

2. Methods

a. East Bay Children's Respiratory Health Study

Children's respiratory data were utilized in chi-square tests for association and in univariate and multi-variate logistic regression models. The data on children's respiratory outcomes were collected for the EBCRHS.

b. Teacher Questionnaire

OEHHA asked the 64 teachers whose students had participated in the EBCRHS to complete the teacher questionnaire developed by the ARB and DHS for use in the California Portable Classrooms Study (PCS).[1] A copy of the four-page teacher questionnaire is provided in

[1] The methodology and results of the PCS are available from ARB reports: http://www.arb.ca.gov/research/indoor/pcs/pcs.htm.

Appendix 3.A. The teacher questionnaire collected information about the presence of potential pollutant sources in the classroom, such as chemicals and furniture that emit volatile organic compounds (VOCs). Teachers provided their observations about moisture, air quality, and water damage in the room. The questionnaire also asked teachers if they had certain chronic conditions of if they had experienced acute symptoms in the previous two weeks while at school.
In the spring of 2001, an introductory letter, the teacher questionnaire and a return envelope were mailed to teachers. Teachers who did not respond to the first mailing were sent a reminder letter. Teachers mailed the questionnaire in the included envelope to OEHHA, where the data were entered into a Microsoft Access database by a student intern.
In the Results section and Appendix 3.C, we provide a summary of the teacher questionnaire results (n = 58), including the classroom features associated with IAQ. Since the same questionnaire was also used in the PCS, we were able to compare our results with a larger statewide sample (n=1181). However, all the teachers in the EBCRHS were elementary school teachers, while the PCS questionnaire included elementary, middle, and high school teachers. Results from the PCS stratified by school level are not publicly available. It is reasonable to expect that some exposures (e.g. paints and glues used in arts and crafts) are distributed differently at the three school levels. Therefore, comparisons between the results of our study and those of the PCS should be made cautiously.

One caveat in interpretation, the PCS questionnaire answered by the teacher has not been extensively validated with objective measures of poor indoor air quality. The current IAQ survey in this report also did not include objective measures of indoor air quality during normal operating conditions, limiting interpretation.

Technician Walk-Through Survey

LBNL conducted a walk-through survey of participating classrooms that recorded indoor and outdoor items with the potential to influence IAQ.[2] A single external technician (D. Shendell) who had been involved previously in other IAQ school projects performed the survey. The surveys were conducted after school hours in April and May 2001, and the data were entered into a Microsoft Access database. The walk-through survey consisted of two checklists: the Qualitative Assessment by Technician of Indoor Physical Environment (also referred to as the Classroom Checklist) and the Qualitative Walk-Through Assessment by Technician (also referred to as the Classroom Description – Source Information Checklist). Copies of the checklists are included in Appendix 3A.2 and A.3, respectively. The checklists are also available online from the website of the California Interagency Working Group on Indoor Air Quality: Informal Group on School Studies on Environmental Health.[3] The Qualitative Assessment by Technician of Indoor Physical Environment checklist was modified from an instrument used in the UCLA School of Public Health Portable Classrooms Study.[4] Both

---

[2] Singer, B.C., Hotchi, T., and Hodgson, A.T. November 2002. Air Pollutant Monitoring for The East Bay Children's Respiratory Health Study. Final Project Report. OEHHA Agreement No. 00-E0018.
[3] http://www.cal-iaq.org/ISG/
[4] Shendell, D., A.M. Winer, T.H. Stock, L. Zhang, J. Zhang, S. Maberti and S. Colome. "Air Concentrations of VOC's in Portable and Traditional Classrooms in Los Angeles County." J. Exposure Analysis and Environmental

checklists were used in the LBNL/Davis Energy Group/California Energy Commission Relocatable Classroom Study. [5]

The first checklist, the Qualitative Assessment by Technician of Indoor Physical Environment, was completed by the technician for all participating classrooms and repeated two additional times for ten classrooms (one at each school) selected for additional indoor pollutant measurements made by LBNL. The checklist characterized operational parameters for the classrooms. Observations were recorded with respect to type of classroom (i.e. portable or permanent), doors and windows open, HVAC system on, and subjective description of odor.

The second checklist, the Qualitative Walk-Through Assessment by Technician, recorded the presence of potential indoor and outdoor sources of contamination. The outdoor observations included proximity to traffic, garbage dumpsters, exposed soil and construction activities. Indoor observations were made in all of the participating classrooms and janitorial staff was interviewed. The indoor assessments included evidence of water damage, cleaning procedures and frequency, presence of carpets and rugs, and presence of cleaning and other solvent-containing products.

In the Results section and Appendix 3.C, we provide a summary of the prevalence of items in the classroom environment with the potential to affect IAQ. Since the Qualitative Assessment by Technician of Indoor Physical Environment checklist was conducted in both the UCLA and LBNL studies and reported elsewhere[6], we report the results of select outcomes from those studies as a comparison. However, those surveys were conducted at different times of the year and in different cities in California, so the disparate weather conditions most likely influenced these results from a one-time observation.

3. a. Indoor Air Pollution Monitoring

LBNL performed preliminary measurements of indoor levels of traffic pollutants inside a small subset of classrooms and results were compared with outdoor levels at the school. These data are limited and are presented here for completeness of documentation. The data are insufficient

---

Epidemiology, 14: 44-59, 2004. This pilot study reported the indoor air concentrations and sources of VOCs in portable and permanent classrooms.

[5] Apte, M G.; Hodgson, A.; Shendel, D.G.; Dibartolomeo, D.; Hotchi, T.; Lee, S-M; Liff, S.; Rainer, L.; Sullivan, D; Fisk, W.J. "Simultaneous Improvements in Relocatable Classrooms." ASHRAE IAQ Applications, Pages 7-10. 2003. LBNL-54870. This study evaluated the effects of new technologies (i.e. improved heating, ventilation, and air condition systems [HVAC] and interior materials) on energy efficiency and indoor environmental quality in portable classrooms.

[6] Shendell, DG. 2003. Assessment of Organic Compound Exposures, Thermal Comfort Parameters, and HVAC System-Driven Air Exchange Rates in Public School Portable Classrooms in California. D.Env. dissertation. University of California, Los Angeles, School of Public Health, Environmental Sciences and Engineering Program. LBNL-53804. http://repositories.cdlib.org/lbnl/LBNL-53804/

and not used in a health analysis. Briefly, simultaneous indoor-outdoor measurements were made by LBNL over two one-week periods in the spring of 2001.[7] Indoor-outdoor sampling occurred at EBCRHS schools 2, 3, 4, 7, and 8 during week 7 of the spring schedule and at the remaining five schools during week 9 of the spring schedule. A combination of passive and active sampling methods were used to measure time integrated concentrations of fine particle mass, black carbon (BC), nitrogen oxides (NO_X), and nitrogen dioxide (NO_2). Particulate matter was sampled with programmable pumps using inlet devices that limited collection to particles with aerodynamic diameters smaller than 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$). Fine particle mass and black carbon were determined from the collected filter samples. Indoor and outdoor measurements results for NO_X, NO_2, PM_{10}, PM_{25}, and BC for the weeks with simultaneous indoor-outdoor measurement are presented in the 3 E. The ratio of indoor to outdoor concentrations of air pollutants is reported along with the ratio multiplied by the average relative air pollution concentration for the school over the entire measurement period (see EBCRHS methods for a description of how the average relative air pollution concentration was measured and calculated).

c. Data Analysis

In the Results section, we describe the prevalence of classroom exposures. We examined the association between selected classroom exposures and/ children's health outcomes. We used the chi-square test or Fisher exact test to compare baseline characteristics. A 2-sided p-value less than 0.15 indicated statistical significance. If statistical significance was found, then the odds ratio was also calculated. The three outcomes evaluated are defined below in Table 2.1. These outcome variables were tested against 99 exposure variables, which are listed in Appendix 3.D. All analyses were performed with SAS software version 9.1 (SAS Institute, Cary, NC).

Table 2.1. Definition of health outcomes used in the analysis

Group	Health outcome	Definition	Variable name
Children	Current Asthma	A doctor has *ever* said the child has asthma -and- either the most recent asthma episode or the most recent wheezing occurred in last 12 months	asthma3
Children	Bronchitis symptoms in the past 12 months	Child had bronchitis in past 12 months -or- the child seemed congested in the chest or brought up phlegm –or- (child had cough first thing in morning lasting for at least 3 moths in a row –and- child had congestion phlegm, or mucus present for at least 3 months in a row, either during the past 12 months only or during the past 12 months and in other years)	gen_bronch

[7] Singer, B.C., Hotchi, T., & Hodgson, A.T. November 2002. Air Pollutant Monitoring for The East Bay Children's Respiratory Health Study. Final Project Report. OEHHA Agreement No. 00-E0018.

Children	Asthma (alternate definition)	In the past 12 months, a doctor said that the child had asthma.	q29b

Table 2.2 Definition of covariates in original model used in multivariate logistic models with IAQ covariates

Covariate	Definition	Variable name
Maternal asthma	Yes to following: Has your child's biological mother ever been diagnosed by a doctor or other health care professional with any of the following conditions?	Q63a1
Chest illness less than 2 years	Yes to following: Other than colds or flue, was your child seen by a doctor or other health practitioner for asthma before the age of 2 years?	Q16a
HH mold/ moisture	Yes to any of following: (1) During the time your child has lived in his/her current home, has there been water damage from a leaky roof or pipe or flooding indoors? (q54a) (2) During the past 12 months, have you seen any mold or mildew on any walls, ceiling, floors, or around bathroom fixtures inside the home? (q55a) (3) During the past 12 months, have you seen water pooled on the windowsills of the living room or any bedroom in your child's home? (q56) (4) During the past 12 months, has any part of your child's home had a moldy or musty smell? (q57)	Mold_ind
Pests in home in last year	Yes to any of following: During the past 12 months, have any of the following pests been I your child's home? Rats, cockroaches, spiders, mice, ants, termites	Q46
Crowding	Number of individuals in the household divided by the number of bedrooms in home (hhold/q43)	Crowd
Mother smoke	Positive response to either of following: Did this child's biological mother smoke while she was pregnant with this child? Include any period of time before she knew she was pregnant. (1) Yes, smoked during the whole pregnancy (2) Yes, smoked for part of the pregnancy	Mom_smoke

4. Results

a. Response Rate

The EBCRHS distributed 1,574 questionnaires in 64 participating classrooms in the 10 schools. After exclusion due to language, 1,111 of 1,571 (70.7%) children responded.

For the teacher questionnaire on school indoor air quality, OEHHA received 58 responses from the 64 teachers contacted, resulting in a response rate of 90.6%. One substitute teacher completed the survey instead of the original teacher.

The technician walk-through survey was conducted in 66 classrooms, all 64 classrooms that participated in the EBCRHS and two extra classrooms. The two extra classrooms were deleted from the data set prior to analysis.

During one week LBNL placed outdoor monitors at all of the selected schools and in all of the selected classrooms. However, the outdoor monitor at school 9 was destroyed in an act of vandalism during week 9 so all outdoor measurements were lost.

Coding Issues

We encountered difficulty coding certain questions on the teacher questionnaire due to ambiguity in the question and/or teachers' misinterpretation of the question. Whenever possible, we followed the coding procedures performed on the PCS data.[8] The most difficult questions to resolve were a 'check all that apply' question for observed water damage (question 32) and a 'if yes, then' question about the adequacy of custodial services (question 34). Specific coding issues for the responses in our teacher questionnaire are provide in Appendix 3.B.

b. Prevalence of Exposures
    i. Teacher Questionnaire

The tables in Appendix 3.C provide the proportion of teachers who reported various classroom features, overall, by classroom type (portable or permanent). Comparable results from the Portable Classrooms Study (n=1181) are also presented when available for comparison purposes.

None of the teachers in the EBCRHS reported visible mold currently in the classroom, and only two teachers reported visible mold in the past. A musty odor in the classroom was the most common potential indicator of mold. Musty smell could also signify inadequate ventilation. A composite variable for any of the three types of water problems (leak/flood, water stain, and visible mold) found that about one-third of classrooms had either current potential water problems (14.3%) or previous potential water problems (23.2%).

Volatile organic compounds (VOCs), commonly used in building materials and classroom items such as paints, correction fluid, and adhesives, are respiratory irritants that can exacerbate asthma in sensitive individuals.[9] According to the teacher questionnaire, pressed wood furniture is commonly found in classrooms in the form of tables/desks (77.6%), bookcases (51.8%) and cabinets (47.2%). These types of furnishings are known to be important sources of

[8] California Portable Classrooms Study, Phase I: Mailed Survey; Final Report, Volume 1; Appendix C; http://www.arb.ca.gov/research/indoor/pcs/pcs-fr/pcs_v1_ph1_app_b-d_03-23-04.pdf
[9] American Academy of Pediatrics Committee on Environmental Health. Pediatric Environmental Health—2nd Edition. Etzel RA (Ed). Elk Grove Village: American Academy of Pediatrics, 2003. Pg. 526.

formaldehyde; however, data was not collected on the age of these furnishings and objective measures of VOCs in the class room were not done as part of this survey. Thirty-one% of teachers reported new furnishings in the past year, but the type was not recorded.
Another potential source of VOCs in the classroom were pesticides applied by the teachers. While the schools' facilities managers may have also applied pesticides, 19.0% of teachers reported applying pesticide themselves in the past year. The composite variable for chemicals present in the room was true if the teacher reported any of the following: lab chemicals, cleaning products, or biological specimens stored in chemicals. A higher proportion of teachers in the EBCRHS reported chemicals in the classroom (74.6%) than in the PCS (48.8%). In the EBCRHS, the only chemicals reported were cleaning products; the breakdown of chemicals in the PCS was not publicly reported.

Dust, animals, rodents, pests, and tobacco exposure can also precipitate adverse respiratory outcomes in susceptible individuals. Not many classrooms had a full carpet (5.2%), but more than half had a partial carpet in the classroom (63.8%). Interestingly, full carpets were much more common in the PCS (47.8%), and partial carpets less common (25.4%). Many teachers (61.1%) reported a bug problem in the past. Very few teachers reported experiencing tobacco smoke odor in the classroom (1.8%). Few teachers reported smoking (3.5%) or living with a smoker (1.7%).

Air conditioning in the room appears less common in the EBCRHS (42.1%) compared with the PCS (83.9%). Accordingly, more classrooms in the EBCRHS regularly open windows and doors for natural ventilation than in the PCS. Less than 15% of teachers reported unpleasant odors from vehicle exhaust, trash/dumpsters, asphalt/tar, sewer/compost, or fire/smoke. Cooking odor was reported most frequently in the EBCRHS (19.6%) and in the PCS (18.7%).

The majority of teachers found the overall environmental quality of the classroom to be adequate (41.1%) or good/excellent (44.6%). However, almost a third of teachers reported that the air in the classroom was often too stale or stuffy. Teachers' assessments of the air and overall environmental quality were similar in the EBCRHS and PCS.

As noted above, one important caveat in interpretation, the PCS questionnaire answered by the teacher has not been extensively validated with objective measures of poor indoor air quality. Additionally, the current IAQ survey in this report also did not include objective measures of indoor air quality limiting interpretation of the data. Nonetheless this survey can be compared to the results of the statewide PCS survey results.

ii. Technician Walk-Through Survey

The tables in Appendix 3.C presents the results from the technician walk-through surveys. The results must be cautiously interpreted as measures of exposure for the students or the teacher since the walk-through survey consisted of a one-time observation made outside of normal classroom operating times. Classroom conditions after school hours may not reflect conditions during school hours (e.g. the HVAC may be operational during the school day but turned off after school).

As stated above, the classroom checklist was conducted three times for classrooms in which the indoor pollutant measurements were made and once for all other classrooms. For a consistent analysis of the data, only the first visit for each classroom was used to summarize the results. However, the results from the classrooms with multiple observations were reviewed to assess the variability of the qualitative walk-through survey observations. The most variable responses were the subjective description of odor and whether the main door was left open. The record of windows being open did not vary at all from observation to observation. The percent of windows open only changed slightly for one classroom.

Approximately 1 in 5 classrooms had an open door or HVAC system on. Fewer classrooms had an open window (14.1%). When similar surveys were conducted on a sample of schools for the UCLA and LBNL studies, fewer classrooms in those studies had an open window and more were operating the HVAC. However, those surveys were conducted at different times of the year so the weather and in different locations, so the weather may have influenced these results.

The technician noted a musty smell in 20.3% of classrooms, the smell of cleaning products in 26.6% of classrooms, and a dusty smell in 31.3% of classrooms. However, the observations of odor were made after school hours and only 21.9% of classrooms had the HVAC system at the time. Pesticides were found in 7.8% of classrooms. The technician reported the same prevalence of visible water damage (14.1%) as reported in the teacher questionnaire (14.3%).

In summary, the intent of the technician IAQ survey was to rule out any major indoor air quality problem at the school using a single technician to record observations of potential IAQ problems. However, LBNL was only able to conduct the walkthrough survey during non-classroom hours when classes had been recently cleaned and HVAC systems were turned off and windows open. Thus, in retrospect, this technician walkthrough survey did not necessarily reflect indoor air quality conditions during normal classroom hours.

c. Associations Between Children's Health Outcomes and Classroom Exposures

We performed chi square tests for associations between indoor classroom features and children's health outcomes. If there was a significant chi-square association (p-value ≤ 0.15), then we performed bivariate logistic regression to explore the direction of the association between the classroom feature and children's respiratory symptoms.

The children's respiratory outcomes are described in Table 2.1 in the Methods section. Chi-square tests of associations were performed between the three children's respiratory outcomes and 99 classroom exposures. There were 69 statistically significant associations with a p-value <0.15 and 18 with a p-value <0.05. We then performed a bivariate logistic regression on each of those 69 variables to determine the direction of the association. The variables with a positive association (p-value <0.15) are presented below in Table 3.1 Of note, some of the variables that reflect poor IAQ had negative associations with respiratory symptoms, again calling into question the questionable quality of the data.

Table 3.1: Univariate analysis of school indoor air quality and respiratory symptoms.

Outcome:Current asthma	Exposed	Baseline	OR*	LL	UL	
SOIL YES vs NO	Exposed Soil	No exposed soil	1.6	1.0	2.5	
newfurn 1 vs 0	New furniture	No new furniture	1.4	0.9	2.1	
anyfresh 1 vs 0	Any air freshener	No air freshener	1.5	1.0	2.3	
Q23_PluginAF 1 vs 0	Plug-in air freshener	No plug-in air fresher	1.6	1.0	2.4	
humid 2 vs 1	Too humid	Okay humidity	3.4	1.2	10.1	

Outcome: bronchitis past 12 months	Exposed	Baseline	OR*	LL	UL	
Q19_PWoodTables 1 vs 0	Pressed wood tables/desks	No pressed wood tables/desks	1.6	0.9	2.7	
Q19_PWoodCabs 1 vs 0	Pressed wood cabinets	Pressed wood cabinets	1.5	1.0	2.3	
newfurn 1 vs 0	New furniture	No new furniture	1.4	0.9	2.1	
Q23_HangAF 1 vs 0	Hanging air freshener	No hanging air freshener	1.9	1.0	3.6	***
Q30_NewCarp sometimes vs never	New carpet odor sometimes	New carpet odor never	1.6	0.9	3.1	

*** These logit estimators use a correction of 0.5 in every cell of those tables that contain a zero.

Outcome: asthma (alternate defn)	Exposed	Baseline	OR*	LL	UL	
ddusty 1 vs 0	Technician's assessment of dusty	Technician's assessment: not dusty	1.4	1.0	2.2	
SOIL YES vs NO	Exposed Soil	No exposed soil	1.7	1.1	2.6	
Q23_Markers 1 vs 0	Markers used in room	Markers not used in room	2.5	1.2	5.3	***
anyfresh 1 vs 0	Any air freshener used	No air freshener used	1.5	1.0	2.2	***
Q23_HangAF 1 vs 0	Hanging air freshener	No hanging air freshener	1.9	1.0	3.6	

*Crude odds ratios (OR)
*** These logit estimators use a correction of 0.5 in every cell of those tables that contain a zero.

Thus exposed soil outside, the use of air fresheners, presswood and/ or new furniture, use of markers were associated with asthma symptoms or bronchitis in univariate analysis and p value < 0.15.

We examined the effect of school IAQ variables on children's respiratory health using school IAQ variables that had a pvalue <0.15 in univariate analyses in multi-variate logistic regression models that included measures of residential traffic, and other covariates as described in the main report. After adjusting for residential traffic and other covariates in multi-variate logistic regression models, the use of air fresheners in the classroom remain significant. The positive finding in our data could have been due to chance; however, there is evidence to support that air fresheners may have effects on the respiratory tract.
Finally, we also examined whether the effect estimate for traffic was affected with the addition of school IAQ variables. Using log distance to freeway/highway, we looked at the effect of

traffic on current asthma and bronchitis symptoms. The above school IAQ variables did not change the effect estimate for traffic and bronchitis. However, as shown in Table 3.2, the addition of variables (new furniture, any air freshener, or plug in air freshener) diminished associations between current asthma and traffic.

Table 3.2 School indoor air quality and associations between current asthma and traffic.

Traffic metric	p-value	OR*	LL	UL	School IAQ
ln_newdist	0.025	0.74	0.57	0.96	------
ln_newdist	0.020	0.73	0.56	0.95	Exposed soil outside
ln_newdist	0.060	0.76	0.57	1.01	New furniture
ln_newdist	0.173	0.82	0.61	1.09	any air freshener
ln_newdist	0.123	0.80	0.60	1.06	plug in air freshener

OR adjusted for crowding, pests, mold, chest illness before the age of 2 and maternal history of asthma.

Overall, the results must be interpreted with caution. The teacher survey and technician walkthrough did not identify any glaring indoor air problems, such as chronic mold/dampness. However, the technician walkthrough survey had limitations, and the data of the teacher survey appeared to be of poor quality. Most of the exposures to the potential respiratory irritants had no association with asthma and for remaining irritants, both positive and negative associations with asthma were observed. Some of these positive associations could be due to chance due to the large number of IAQ variables evaluated in this survey. When entered into the logistic regression for asthma, with a few minor exceptions, most of the IAQ school factors did not alter the point estimates and confidence intervals. Thus, we found little evidence that traffic pollutant concentrations at the schools were confounded by IAQ factors at the school.

d. Indoor Air Pollution Monitoring

The results of the indoor air pollution monitoring indicate that indoor concentrations for both NO_X and NO_2 were about half to nearly equal outdoor concentrations. Indoor PM_{10} mass concentrations were higher than outdoor concentrations at all schools with complete data. LBNL scientists hypothesized that it was unlikely that there were indoor sources of PM_{10}, and the more likely explanation of elevated indoor levels was the re-suspension of particles caused by student activity. Indoor/outdoor $PM_{2.5}$ mass concentrations were nearly the same at five schools, but higher indoors at two schools. Appendix 3.E presents tables and figures of the indoor air pollution monitoring data.

Appendix 3.A – Survey Instruments

Appendix 3.A contains the following:

3.A.1. The Teacher Questionnaire

3.A.2. Qualitative Assessment by Technician of Indoor Physical Environment, or the Classroom Checklist

3.A.3. Qualitative Walk-Through Assessment by Technician, or the Classroom Description – Source Information Checklist

N.B. Another copy of the teacher questionnaire is available in Appendix A of Volume 1 of the Final Report of the California Portable Classroom Study:
http://www.arb.ca.gov/research/indoor/pcs/pcs-fr/pcs_v1_ph1_app_a_03-23-04.pdf

N.B. All three instruments are available on the California Interagency Working Group on Indoor Air Quality, Informal Group on School Studies on Environmental Health website:
http://www.cal-iaq.org/ISG/

Appendix 3A.1
The Teacher Questionnaire

Thank you for participating in this Study. Please complete the following.

Section A. Respondent Information - Please fill in today's date (mm-dd-yy) □□□□□□□□

1. Your gender and current age: □male □female years □□
2. Your job category: □teacher □aide □administrator □office staff □facility staff □other
3. How long have worked in this <u>room</u>? □less than all year □all year □2 □3+
   - •in this <u>school</u>? (years) □1 □2-5 □6-10 □11-16 □16+
   - •in the <u>teaching profession</u>? □1 □2-5 □6-10 □11-16 □16+
4. How much time do you typically spend in this classroom?
   - •days of the week □1 □2 □3 □4 □5
   - •hours of the day □less than 3 □3-6 □more than 6

Section B. Room Description - Please fill in room number/name: □□□□□□□□□□□□

5. Which term <u>best</u> describes this classroom? *Choose <u>one</u>:*
   □art room □auto/metal shop □ceramic studio □computer lab
   □general instructional classroom □library □music room
   □office □science lab □wood shop □none of these
6. Which student grade level(s) are taught within this room? *Check <u>all</u> that apply:*
   □K □1 □2 □3 □4 □5 □6 □7 □8 □9 □10 □11 □12 □not applicable
7. Do students generally stay in this room or change rooms during the day? □stay □change
8. How many students per class <u>typically</u> occupy this room? □□
9. The building this classroom is in: □portable or relocatable □permanent □don't know.
10. Which best describes flooring in this room? *Check <u>all</u> that apply:*
    - •Carpet: □entire room □partial □area rug □sitting pads
    - •Hard: □vinyl/linoleum □wood □rubber □concrete/ceramic □walk-off mat(s)
11. What is the primary wall material in this room? *Choose <u>one</u>*
    □sheetrock/plaster □vinyl-coated tackable wallboard □painted cinderblock □other/don't know
12. What, if any, plumbing is in this room? □none □sink □toilet □fountain
13. How many sides of this room have windows? □none □1 □2 □3 □4

14. What kinds of windows are in this room? *Check all that apply:*
□none □windows up to door height (7 ft) □windows up to 9 ft
□windows above 9 ft □skylights

15. How often do you open windows for natural ventilation, in general? □none openable
□rarely □occasionally □frequently □most of the time □all of the time

16. Does a door into this room open directly to the outdoors? □yes □no
•If yes, how often do you leave this door open during the school day, in general?
□rarely □occasionally □frequently □most of the time □all of the time

17. Does this room have air conditioning (AC)? □yes □no

18. Is there a thermostat in this room? □yes □no □don't know
•If yes, indicate which is the case: □I can adjust it □it is kept locked □it does not work

Section C. Room Contents & Activities

19. Indicate what kinds of furnishings are in this room. *Check all that apply:*
•Tables & Desks: □none □metal □solid wood □pressed wood* □plastic □don't know
•Bookcases: □none □metal □solid wood □pressed wood* □plastic □don't know
•Cabinets: □none □metal □solid wood □pressed wood* □plastic □don't know

**Materials such as plywood and particle/fiber board; some may have a thin laminate.*

20. Has the room acquired new furnishings during this school year? *Check all that apply:*
□none □carpet □tables □desks/chairs
□bookcases □cabinets □don't know

21. Do you keep any of the following living items in this room? *Check all that apply:*
□potted plants or terrarium □birds □mammals
□reptiles/amphibians □fish □bugs

22. Do you have any of the following items in this room? *Check <u>all</u> that apply:*
- •Copiers: □none □photocopy machine □mimeograph machine
  □laser printers □carbonless copy paper □laminator
- •Appliances: □none □stove or oven □lab burners
  □refrigerator □washing machine □microwave oven
- •Chemicals: □none □lab chemicals □cleaning products
  □biological specimens stored in chemicals

23. Are any of the following items ever used in this room? *Check <u>all</u> that apply:*
- •Paints/pens: □never □oil/acrylic paints □permanent markers/art pens
  □whiteboard markers
- •Glues/fluids: □never □rubber cement □correction fluid □epoxy
- •Air freshener: □never □hanging freshener □plug-in deodorizer □spray can
- •Candles: □never □unscented candles □scented candles □incense
- •Air cleaner: □never □portable air (filter) purifier □ozone or ion-generating air purifier

24. Have <u>you</u> applied any of the following pesticides in this room this school year? *Check <u>all</u> that apply:*
- •Sprays □never □in the past □currently
- •Powders □never □in the past □currently
- •Traps □never □in the past □currently

Section D. Observations & Impressions

25. Which is your classroom preference at your school? □permanent □portable □no opinion

26. Characterize each of the following as it applies to your room. *Check <u>all</u> that apply:*
- •Temperature: □generally acceptable □often too cold □often too hot
- •Humidity: □generally acceptable □often too humid □often too dry
- •Air: □generally acceptable □often too drafty □often too stale or stuffy
- •Light: □generally acceptable □too dim □too bright
  □glare from lights □too much direct sun

27. Are there noises that generally disrupt teaching activities in this room? *Check all that apply:*

•Inside: ☐none ☐ventilation (fan) ☐lighting (buzz) ☐next-room voices ☐other

•Outside: ☐none ☐playground ☐mower/blower ☐traffic ☐aircraft ☐other

28. Do you ever turn off the heater or air conditioner in this room because of excessive noise?

☐never ☐rarely ☐occasionally ☐frequently ☐most or all of the time

29. Are you aware of past or current pest problems in this room? *Check all that apply:*

•Bugs (ants, etc.) ☐never ☐in the past ☐currently

•Rodents (mice, etc.) ☐never ☐in the past ☐currently

30. Indicate if you have experienced any of the following odors in this room. *Check one for each:*

	never	**sometimes**	**often**		**never**	**sometimes**	**often**
•Musty odor	☐	☐	☐	•Cleaning products	☐	☐	☐
•Bus/auto exhaust	☐	☐	☐	•New carpet/furniture	☐	☐	☐
•Fresh paint	☐	☐	☐	•Pesticides	☐	☐	☐
•Cooking odor	☐	☐	☐	•Asphalt/tar	☐	☐	☐
•Tobacco smoke	☐	☐	☐	•Sewer/compost	☐	☐	☐
•Trash or dumpster odor	☐	☐	☐	•Fire/smoke odor	☐	☐	☐

31. Have you observed construction activities during school hours this year? *Check all that apply:*

•When: ☐never ☐in the past ☐currently ☐don't know

•Where: ☐your room ☐same building ☐nearby or new building ☐outdoors

•Type: ☐painting ☐carpentry ☐plumbing ☐flooring ☐roofing ☐other

32. Have you observed water leaks, flooding, water stains or visible mold in this room?

Check all that apply:

•Leak or flood ☐never ☐in the past ☐currently ☐don't know

•Type: ☐roof ☐window ☐sink/toilet overflow ☐sprinkler ☐plumbing ☐other

•Water stains: ☐never ☐in the past ☐currently ☐don't know

•Where: □walls □ceiling □window sills □carpet/rug/floor □furniture □other

•Visible mold: □never □in the past □currently □don't know

•Where: □walls □ceiling □window sills □carpet/rug/floor □furniture □other

33. How often are the floors in this room swept or vacuumed?

□daily □2-3/week □weekly □1-2/month □less than 1/month □don't know

34. Do you feel the room receives adequate custodial services? □yes □no

•If not, what do you feel is needed? □more frequent □more effective □both

35. To whom do teachers direct questions or complaints about temperature, odors, or hygiene in their rooms? *Check all that apply:*

□custodian □facility staff □principal/administrator □health & safety staff □IAQ coordinator

36. How many times have you made complaints about such conditions in this room during this school year?

□never □1-2 □3-5 □6-10 □11 or more

37. How would you generally characterize the overall environmental quality in this classroom?

□excellent □good □adequate □poor □very poor

Section E. Symptoms & Related Questions

38. Were you absent in the past two weeks? □no □1-2 days □3-5 days □more than 5 days

•Chief cause: □cold or flu □allergies □asthma □other respiratory □any other reason

39. In the past two weeks, did you experience any of the following symptoms at school? Indicate if they continued or improved when you were home.

	At school			At home	
	none	**occasional**	**frequent**	**same/worse**	**improves**
•Nose (congestion, runny nose, dry nose)	□	□	□	□	□
•Throat (irritation, sore throat, dryness)	□	□	□	□	□
•Eyes (irritation, redness, watering, puffiness)	□	□	□	□	□
•Skin (dryness, flaking, rash, other irritation)	□	□	□	□	□
•Headaches or sinus pain	□	□	□	□	□
•Drowsiness or difficulty concentrating	□	□	□	□	□

•Dizziness or faintness	□	□	□	□	□
•Shortness of breath, wheeze, difficulty breathing	□	□	□	□	□
•Upset Stomach	□	□	□	□	□

40. Do you have any of the following chronic medical conditions? *Check all that apply:*
□hay fever or other allergies □asthma □bronchitis □hypertension □heart disease

•If you have asthma, how often did you use inhaled asthma medication in the past two weeks?

□never □1-2x per week □most days □every day

41. How many students in your class currently take medication for asthma?
□don't know □none □1-2 □3-5 □6-10 □11 or more

42. Are you currently smoker? □yes □no

43. Do you live with a smoker? □yes □no

Additional comments or concerns?

Appendix 3.A.2

Qualitative Assessment by Technician of Indoor Physical Environment or the Classroom Checklist

Field Data Spreadsheet-->

Qualitative Assessment by Technician of Indoor Physical Environment
including lights, doors, HVAC functioning, and odors. Summary of sentence(s) written on data sheets.

School District (*circle one*): Hayward San Leandro Oakland
School Name: ____________________

Day of Week (*circle one*): Monday Tuesday Wednesday Thursday Friday
SAMPLING PERIOD: ________ to ________, 2001.

		(on/off; if on and not all on, %**)**	**(open/closed)**	**(on/off, by sound)**	**(open/closed;** if open and not all, _ of _ = %**)**	**(Comments from technician)**	**(degrees F)**	**Y/N (If Y, # and left on?)**
1st VISIT, SETUP or TAKEDOWN	**Classroom Number**	LIGHTING FIXTURES	DOORS (MAIN, TO OTHER ROOMS)	HVAC SYSTEM	WINDOWS	Description of Odors	Thermostat Reading	Computers & Monitors?

Appendix 3A.3

Qualitative Walk-Through Assessment by Technician, or the Classroom Description – Source Information Checklist

LBNL/CEC Relocatable Classrooms Study

Field Data Spreadsheet--> Modified for use in the OEHHA./LBNL East Bay Children's Respiratory Health Study, I/O air monitoring

Qualitative Walk-Through Assessment by Technician (DGS) of RC environment and potential sources of indoor and outdoor target chemical and physical pollutants, and biological contaminants.

*all sampling conducted in Spring 2001

School District (*circle one*): Hayward San Leandro Oakland

SAMPLING PERIOD: ________ to ________, 2001. **School Name**: ____________________

Day of week (*circle one*): Monday Tuesday Wednesday Thursday Friday

		OUTDOOR SOURCES IN IMMEDIATE VICINITY				**VISIBLE, OR POTENTIAL FOR, H2O DAMAGE**				
Classroom ID /#	Garbage Dumpsters	Exposed soil, e.g., "garden" area near back door/windows?	Freeways, I.e., heavier motor vehicle traffic	Construction Activities (dust, noise, etc.)	Truck (or bus/car) loading/ unloading area	What is RC sited on? (asphalt pad, concrete slab/pad, grass turf, soil, gravel)	RC raised above the ground? (If Y, estimate height from front door/ramp or stairs)	Current leaks? (If Y, state where: roof, walls, floor, sink, etc.)	Visible water damage or stains? (If Y, state where: carpet, walls, ceiling tiles, wet tile areas)	Field Technician Comments
Field Technician Comments related to PM, e.g., residue on diffuser plates on ceiling?										

Qualitative Walk-Through Assessment by Technician, or the Classroom Description – Source Information Checklist, Cont'd

LBNL/CEC Relocatable Classrooms Study

Field Data Spreadsheet-->

Modified for use in the OEHHA./LBNL East Bay Children's Respiratory Health Study, I/O air monitoring

CONTINUED, Qualitative Walk-Through Assessment by Technician (DGS) of RC environment and potential sources of indoor and outdoor target chemical and physical pollutants, and biological contaminants.

*all sampling conducted in Spring 2001

School District (*circle one*): Hayward San Leandro Oakland

SAMPLING PERIOD: ________ to ________, 2001.

School Name: ____________________

Day of week (*circle one*): Monday Tuesday Wednesday Thursday Friday

INDOOR SOURCES

CLEANING BY HEAD CUSTODIAN/PLANT MGR AND/OR TEACHER

	General, e.g., dusting			Floor Cleaning-- Dry Mop			Floor Cleaning-- Wet Mop			Vacuum Carpet/Area Rug				What cleaning materials used?	Where are cleaning materials stored inside RC?
Classroom ID / #	(Y or N)	(# times/ week)	AM or PM	(Y or N)	(# times/ week)	AM or PM	(Y or N)	(# times/ week)	AM or PM	(Y or N)	Area or Full Cover	(# times/ week)	AM or PM	(Label name, key ingredient if available)	(Note location: cabinet, under sink,)

* < 1 = only if spill/emergency*

Field Technician comments, e.g., teacher/custodial staff discrepancies on first four categories, teacher has own broom and/or vacuum

Appendix 3.B—Coding Decisions for Teacher Questionnaire

Response Issues for Teacher Questionnaire–

Problematic responses were recoded. by SA, For the most part, followed the methods for recoded in the California Portable Classroom Study (PCS). The SAS programs that recoded variables in the PCS can be found in Appendix C of the Final Report, Volume I: http://www.arb.ca.gov/research/indoor/pcs/pcs-fr/pcs_v1_ph1_app_b-d_03-23-04.pdf.

*Globally, for questions 30 and 31, currently, if someone answers "never" or "don't know" for construction, leak, water stains, or mold, their responses for the subcategories (type, where) are currently still coded individually as "no." No change (Note, in the PCS, these responses were recoded from no to missing. But I do not think it is worth going back to re-enter data.)

Other coding changes on file at OEHHA.

Appendix 3.C—Distribution of Classroom Variables in Teacher Questionnaire and Technician Walk-Through Survey

Appendix C contains the following tables:
Table C.1: Estimated Distributions for Classroom Variables from Teacher Questionnaire, Overall and by Room Type, with comparisons with the Portable Classrooms Study
Table C.2: Proportion of classrooms with various indicators of ventilation as observed by a technician: EBCRHS and other studies
Table C.3: Proportion of classrooms with various indoor and outdoor factors that may affect IAQ

Table 3C.1: Estimated Distributions for Classroom Variables from Teacher Questionnaire, Overall and by Room Type with Comparisons with the Portable Classrooms Study percent

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
All	Carpet	carpet	Full	3	5.2	47.8
			Partial	37	63.8	25.4
			None	18	31.0	26.8
Portable			Full	3	12.5	70.7
			Partial	9	37.5	18.4
			None	12	50.0	10.9
Traditional			Full		0	34.3
			Partial	27	81.8	29.6
			None	6	18.2	36.1
All	Vinyl flooring: Q10	q10_vinyl	No	7	12.1	54.3
			Yes	51	87.9	45.7
Portable			No	2	8.3	70.7
			Yes	22	91.7	29.3
Traditional			No	5	15.2	44.7
			Yes	28	84.8	55.3
All	Wall covering: Q11	q11_wall	Other/Dk	11	19.6	n/a
			Painted Cinderblock	1	1.8	n/a
			Sheetrock/Plaster	24	42.9	n/a
			Vinyl-Coated Tackable Wallboard	19	33.9	47.0
Portable			Other/Dk	4	18.2	n/a
			Sheetrock/Plaster	1	4.5	n/a
			Vinyl-Coated Tackable Wallboard	17	77.3	78.6
Traditional			Other/Dk	7	21.2	n/a
			Painted Cinderblock	1	3.0	n/a
			Sheetrock/Plaster	22	66.7	n/a
			Vinyl-Coated Tackable Wallboard	2	6.1	28.4
All	Natural ventilation: Q15	q15_openwin	All Of The Time	4	6.9	n/a
			Frequently	16	27.6	n/a
			Most Of The Time	9	15.5	n/a
			None Openable	1	1.7	n/a
			Occasionally	16	27.6	n/a
			Rarely	12	20.7	n/a

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Portable			All Of The Time	2	8.3	n/a
			Frequently	8	33.3	n/a
			Most Of The Time	1	4.2	n/a
			None Openable	1	4.2	n/a
			Occasionally	6	25.0	n/a
			Rarely	6	25.0	n/a
Traditional			All Of The Time	2	6.1	n/a
			Frequently	8	24.2	n/a
			Most Of The Time	8	24.2	n/a
			Occasionally	9	27.3	n/a
			Rarely	6	18.2	n/a
All	How often door open: Q16	q16_opendoor	All Of The Time	1	1.8	n/a
			Frequently	21	36.8	n/a
			Most Of The Time	11	19.3	n/a
			Occasionally	17	29.8	n/a
			Rarely	7	12.3	n/a
Portable			Frequently	9	37.5	n/a
			Most Of The Time	2	8.3	n/a
			Occasionally	9	37.5	n/a
			Rarely	4	16.7	n/a
Traditional			All Of The Time	1	3.1	n/a
			Frequently	12	37.5	n/a
			Most Of The Time	8	25.0	n/a
			Occasionally	8	25.0	n/a
			Rarely	3	9.4	n/a
All	Room have air conditioning: Q17	q17_ac	No	33	57.9	16.1
			Yes	24	42.1	83.9
Portable			No	1	4.2	4.6
			Yes	23	95.8	95.4
Traditional			No	31	96.9	22.9
			Yes	1	3.1	77.1
All	Is there a thermostat in room: Q18	q18_thermostat	Don't Know	2	3.4	0.8
			No	6	10.3	15.6
			Yes	48	82.8	83.6
			Not Applicable	1	1.7	0.0

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Portable			Don't Know	1	4.2	1.0
			No		0.0	4.2
			Yes	23	95.8	94.8
Traditional			Don't Know	1	3.0	0.0
			No	5	15.2	22.2
			Yes	25	75.8	77.1
			Not Applicable	1	3.0	0.7
All	Pressed wood tables/desks in room: Q19	q19_pwoodtables	No	13	22.4	22.1
Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
			Yes	45	77.6	77.9
Portable			No	7	29.2	18.2
			Yes	17	70.8	81.8
Traditional			No	5	15.2	24.4
			Yes	28	84.8	75.6
All	Pressed wood bookcase in room: Q19	q19_pwoodbc	No	27	48.2	49.4
			Yes	29	51.8	50.6
Portable			No	8	34.8	44.7
			Yes	15	65.2	55.3
Traditional			No	18	56.3	47.8
			Yes	14	43.8	52.2
All	Pressed wood cabinets: Q19	q19_pwoodcabs	No	28	52.8	56.1
			Yes	25	47.2	43.9
Portable			No	8	38.1	53.0
			Yes	13	61.9	47.0
Traditional			No	19	61.3	58.0
			Yes	12	38.7	42.0
All	Any pressed wood furniture	presswood	No	8	13.8	13.1
			Yes	50	86.2	86.9
Portable			No	4	16.7	10.0
			Yes	20	83.3	90.0
Traditional			No	3	9.1	14.9
			Yes	30	90.9	85.1
All	Any new furniture	newfurn	No	40	69.0	74.2
			Yes	18	31.0	22.0

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Portable			No	14	58.3	69.7
			Yes	10	41.7	26.3

Traditional			No	25	75.8	76.8
			Yes	8	24.2	19.5
All	Any chemical	anychem	No	14	25.5	51.2
			Yes	41	74.5	48.8
Portable			No	5	23.8	56.0
			Yes	16	76.2	44.0
Traditional			No	9	27.3	48.4
			Yes	24	72.7	51.6
All	Any paint	anypaint	No	1	1.7	6.9
			Yes	57	98.3	93.1
Portable			Yes	24	100.0	96.6
Traditional			No	1	3.0	9.0
			Yes	32	97.0	91.0
All	Any glue	anyglue	No	7	12.5	33.7
			Yes	49	87.5	66.3
Portable			No	1	4.3	33.2
			Yes	22	95.7	66.8
Traditional			No	6	18.8	33.9
			Yes	26	81.3	66.1
All	Any air freshener	anyfresh	No	29	53.7	65.7
			Yes	25	46.3	34.3
Portable			No	7	33.3	60.7
			Yes	14	66.7	39.3
Traditional			No	22	68.8	68.7
			Yes	10	31.3	31.3
All	Any pests	anypest	No	44	75.9	n/a
			Yes	14	24.1	n/a
Portable			No	18	75.0	n/a
			Yes	6	25.0	n/a
Traditional			No	25	75.8	n/a
			Yes	8	24.2	n/a
All	Overall Air Quality	q37_overalleq	Excellent	2	3.6	16.8
			Good	23	41.1	36.9
			Adequate	23	41.1	33.8
			Poor	8	14.3	10.6
			Very Poor	0	0.0	1.9

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Portable			Excellent	0	0.0	16.5
			Good	9	37.5	33.7
			Adequate	12	50.0	33.6
			Poor	3	12.5	13.1
			Very Poor	0	0.0	3.0
Traditional			Excellent	2	6.5	16.9
			Good	13	41.9	38.8
			Adequate	11	35.5	33.9
			Poor	5	16.1	9.1
			Very Poor	0	0.0	1.3
All	Temperature	tqtemp	Okay	47	82.5	n/a
			Cold	4	7.0	n/a
			Hot	6	10.5	n/a
Portable			Okay	20	87.0	n/a
			Cold	2	8.7	n/a
			Hot	1	4.3	n/a
Traditional			Okay	26	78.8	n/a
			Cold	2	6.1	n/a
			Hot	5	15.2	n/a
All	Humidity	humid	Okay	50	92.6	n/a
			Humid	1	1.9	n/a
			Dry	3	5.6	n/a
Portable			Okay	19	90.5	n/a
			Dry	2	9.5	n/a
Traditional			Okay	30	93.8	n/a
			Humid	1	3.1	n/a
			Dry	1	3.1	n/a
All	Air quality	cair	Okay	35	63.6	n/a
			Drafty	2	3.6	n/a
			Stuffy	18	32.7	n/a
Portable			Okay	13	56.5	n/a
			Drafty	2	8.7	n/a
			Stuffy	8	34.8	n/a
Traditional			Okay	21	67.7	n/a
			Stuffy	10	32.3	n/a
All	Bug problem	bugprob	Current	5	9.3	14.4
			Previous	33	61.1	42.3
			Never	16	29.6	43.3
Portable			Current	2	9.1	13.9
			Previous	11	50.0	39.7
			Never	9	40.9	46.4

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Traditional			Current	2	6.5	14.7
			Previous	22	71.0	43.9
			Never	7	22.6	41.5
All	Rodent Problem	rodprob	Current	1	1.9	1.9
			Previous	9	16.7	17.8
			Never	44	81.5	80.3
Portable			Previous	2	9.1	15.0
			Never	20	90.9	82.6
Traditional			Current	1	3.2	1.6
			Previous	7	22.6	19.4
			Never	23	74.2	79.0
All	Musty odor	q30_musty	Never	22	40.0	37.4
			Often	7	12.7	n/a
Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
			Sometimes	26	47.3	n/a
Portable			Never	10	45.5	30.7
			Often	5	22.7	n/a
			Sometimes	7	31.8	n/a
Traditional			Never	12	37.5	41.5
			Often	2	6.3	n/a
			Sometimes	18	56.3	n/a
All	Bus/auto exhaust	q30_auto	Never	50	87.7	94.2
			Sometimes	7	12.3	n/a
Portable			Never	19	82.6	93.5
			Sometimes	4	17.4	n/a
Traditional			Never	30	90.9	94.6
			Sometimes	3	9.1	n/a
All	Fresh paint	q30_paint	Never	52	91.2	88.1
			Sometimes	5	8.8	n/a
Portable			Never	22	95.7	93.4
			Sometimes	1	4.3	n/a
Traditional			Never	29	87.9	88.1
			Sometimes	4	12.1	n/a
All	Cooking odor	q30_cook	Never	45	80.4	81.3
			Sometimes	11	19.6	n/a
Portable			Never	19	86.4	88.0
			Sometimes	3	13.6	n/a

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Traditional			Never	25	75.8	77.4
			Sometimes	8	24.2	n/a
All	Tobacco smoke odor	q30_cigs	Never	55	98.2	97.9
			Sometimes	1	1.8	n/a
Portable			Never	22	100.0	98.3
Traditional			Never	32	97.0	97.7
			Sometimes	1	3.0	n/a
All	Trash or dumpster odor	q30_trash	Never	49	87.5	91.1
			Often	2	3.6	n/a
			Sometimes	5	8.9	n/a
Portable			Never	18	81.8	89.9
			Often	2	9.1	n/a
			Sometimes	2	9.1	n/a
Traditional			Never	30	90.9	91.8
			Sometimes	3	9.1	n/a
All	Cleaning products odor	q30_cleaner	Never	33	62.3	62.7
			Often	1	1.9	n/a
			Sometimes	19	35.8	n/a
Portable			Never	10	50.0	68.5
			Often	1	5.0	n/a
			Sometimes	9	45.0	n/a
Traditional			Never	23	71.9	59.3
			Sometimes	9	28.1	n/a
All	New carpet or furniture odor	q30_newcarp	Never	50	90.9	88.3
			Sometimes	5	9.1	n/a
Portable			Never	18	85.7	83.6
			Sometimes	3	14.3	n/a
Traditional			Never	31	93.9	91.0
			Sometimes	2	6.1	n/a
All	Pesticide odor	q30_pest	Never	47	85.5	91.0
			Sometimes	8	14.5	n/a
Portable			Never	18	85.7	90.4
			Sometimes	3	14.3	n/a
Traditional			Never	28	84.8	91.3
			Sometimes	5	15.2	n/a

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
All	Asphalt/tar odor	q30_asph	Never	48	87.3	92.0
			Sometimes	7	12.7	n/a
Portable			Never	18	85.7	91.9
			Sometimes	3	14.3	n/a
Traditional			Never	29	87.9	92.1
			Sometimes	4	12.1	n/a
All	Sewer/compost odor	q30_sewer	Never	51	92.7	94.4
			Sometimes	4	7.3	n/a
Portable			Never	19	90.5	94.7
			Sometimes	2	9.5	n/a
Traditional			Never	31	93.9	94.2
			Sometimes	2	6.1	n/a
All	Fire/smoke odor	q30_fire	Never	50	90.9	91.8
			Sometimes	5	9.1	n/a
Portable			Never	19	86.4	93.1
			Sometimes	3	13.6	n/a
Traditional			Never	30	93.8	91.0
			Sometimes	2	6.3	n/a
All	Water problems	watrprb	Current	8	14.5	24.0
			Previous	12	21.8	27.5
			Never	33	60.0	46.9
			Unknown	2	3.6	1.6
Portable			Current	1	4.5	25.2
			Previous	2	9.1	23.8
			Never	18	81.8	48.4
			Unknown	1	4.5	2.6
Traditional			Current	7	21.9	23.2
			Previous	10	31.3	29.7
			Never	14	43.8	46.0
			Unknown	1	3.1	1.0
All	Water leak	watrlek	Current	4	7.3	11.5
			Previous	13	23.6	33.7
			Never	33	60.0	51.5
			Unknown	5	9.1	3.3
Portable			Previous	2	9.1	11.3
			Never	18	81.8	31.3
			Unknown	2	9.1	52.0

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent
Traditional			Current	4	12.5	5.5
			Previous	11	34.4	11.6
			Never	14	43.8	35.2
			Unknown	3	9.4	51.2
All	Water stain	watrstn	Current	6	11.5	2.1
			Previous	10	19.2	21.5
			Never	32	61.5	53.0
			Unknown	4	7.7	5.1
Portable			Current	1	5.0	22.7
			Previous	1	5.0	21.5
			Never	16	80.0	51.7
			Unknown	2	10.0	4.1
Traditional			Current	5	16.1	19.0
			Previous	9	29.0	21.6
			Never	15	48.4	53.8
			Unknown	2	6.5	5.7
All	Visible mold	vismolt	Current	0	0.0	3.9
			Previous	1	1.9	5.5
			Never	45	84.9	77.5
			Unknown	7	13.2	13.1
Portable			Current	0	0.0	5.6
			Previous	0	0.0	5.0
			Never	19	95.0	75.5
			Unknown	1	5.0	13.9
Traditional			Current	0	0.0	2.8
			Previous	1	3.1	5.8
			Never	25	78.1	78.7
			Unknown	6	18.8	12.6
All	Mold indicator	moldind1	No	24	41.4	n/a
			Yes	34	58.6	n/a
Portable			No	12	50.0	n/a
			Yes	12	50.0	n/a
Traditional			No	12	36.4	n/a
			Yes	21	63.6	n/a
All	Mold indicator	moldind2	No	21	36.2	n/a
			Yes	37	63.8	n/a
Portable			No	12	50.0	n/a
			Yes	12	50.0	n/a
Traditional			No	9	27.3	n/a
			Yes	24	72.7	n/a

Classroom Type	Classification variable	Codename	Category	Frequency	Percent	PCS Percent

All	Lung problem	lungprb	No	53	91.4	89.7
			Yes	5	8.6	10.3
Portable			No	22	91.7	88.3
			Yes	2	8.3	11.7
Traditional			No	30	90.9	90.5
			Yes	3	9.1	9.5
All	Wheeze	wheeze	No	48	90.6	n/a
			Yes	5	9.4	n/a
Portable			No	17	85.0	n/a
			Yes	3	15.0	n/a
Traditional			No	30	93.8	n/a
			Yes	2	6.3	n/a
All	Upper air way	upperair	No	14	24.1	n/a
			Yes	44	75.9	n/a
Portable			No	4	16.7	n/a
			Yes	20	83.3	n/a
Traditional			No	10	30.3	n/a
			Yes	23	69.7	n/a
All	Smoker/lives with smoker	smoke	No	55	94.8	n/a
			Yes	3	5.2	n/a
Portable			No	22	91.7	n/a
			Yes	2	8.3	n/a
Traditional			No	32	97.0	n/a
			Yes	1	3.0	n/a

Table 3.C.2. Proportion of classrooms with various indicators of ventilation as observed by a technician: EBCRHS and other studies

	EBCRHS April and May	UCLA Cooling Season, early June	UCLA Heating Season, late Feb-early March	LBNL Heating Season, Jan-March School District 3	LBNL Heating Season, Jan-March School District 4
Main door open	18.8	18	15	25	11
Back/side door open	4.7	13	20	N/A: No back door	N/A: No back door
Window open	14.1	0	0	5	0
HVAC on	21.9	38	19	56	58

Table 3.C.3. Proportion of classrooms with various indoor and outdoor factors that may affect IAQ

	EBCRHS
Odor assessment-musty*	20.3
Odor assessment-dusty*	31.3
Odor assessment-cleaning product*	26.6
Odor assessment-chemical*	23.4
Garbage dumpster in immediate vicinity	6.3
Exposed soil in immediate vicinity (e.g. garden area near back door/windows?)	18.8
Freeways in immediate vicinity (i.e. heavier motor vehicle traffic)	35.9
Construction activities in immediate vicinity (dust, noise, etc.)	0.0
Truck loading/unloading area in immediate vicinity	0.0
Bus/Car loading/unloading area in immediate vicinity	12.5
Current water leaks	4.7
Visible water damage or leaks	14.1
Rugs—full	7.8
Rugs—area	56.3
Cleaning materials--dry erase board cleaner	15.6
Pesticides stored in classroom	7.8
Some chemical stored in classroom (cleaner, pesticide, paint, etc.)	85.9
Room dusting by custodian	54.7
Floor dry mop by custodian	95.3
Floor wet mop by custodian	53.1
Vacuuming by custodian	53.1

*See text about subjective field

Table 3.C.4: Percent of classrooms in each school with covariate of interest present

		School Number									
Variable	Codename	1	2	3	4	5	6	7	8	9	10
Any air freshener	anyfresh	50	87	83	25	50	55	33	71.4	25	33
Dusty smell (technician)	ddusty	28	12	16	20	25	50	16	0	0	28
Humid (teacher)	humid	0	0	0	0	0	12	0	0	0	28
HVAC	hvacon	14	25	66	20	0	0	50	14	0	0
New furniture	newfurn	14	25	66	75	75	33	20	14	0	0
Pressed wood cabinets	q19_pwoodcabs	50	66	60	25	66	33	60	28	25	75
Pressed wood tables/desks	q19_pwoodtables	71.4	87	83	75	75	55	60	100	100	75
Hanging air freshener	q23_hangaf	0	37	0	25	0	0	0	0	0	0
Markers	q23_markers	85	75	100	50	100	77.8	80	100	75	100
Plug-in air freshener	q23_pluginaf	0	25	50	0	50	55	33	0	0	0
Musty odor (teacher)	q30_musty	57.1	37	33	0	66	44.4	50	85	33	50
New carpet	q30_newcarp	0	0	0	25	0	11.1	0	14	0	66
Exposed soil	soil	57.1	0	0	0	100	40	0	0	0	0
Water stain (current)	watrstn	16	0	0	0	0	11.1	20	42	0	0
Musty odor--often		14	38	0	25	0	0	25	14	33	0
Musty odor--sometimes		57	38	33	0	67	44	50	86	0	50
Water Leak--current		0	0	0	0	0	22	0	14	25	67
Water Leak--past		57	13	0	25	0	0	40	43	50	0
Water stain--current		17	0	0	0	0	11	20	0	0	0
Water stain--past		33	0	0	25	33	0	40	43	75	0
Visible mold--past		14	0	0	0	0	0	0	14	0	0
Water problem--current		14	0	0	0	0	22	20	43	25	0
Water problem--past		43	13	0	25	33	0	40	29	50	0
Mold indicator		86	75	33	25	50	44	60	100	25	50
Mold indicator		86	75	33	50	50	44	60	100	75	50
Pressed wood (any)		100	88	83	75	75	56	100	100	100	100
Pesticide (any)		43	38	0	25	0	11	40	43	25	0
New Carpet Odor--sometimes		0	0	0	25	0	11	0	14	0	67

Appendix 3.D—Variables Tested For Bivariate Association with Children Health Outcomes

	Variable Description	Variable Name	Data Source
1	Full carpet	q10_allcarp	Teacher Questionnaire
2	Partial carpet	q10_partcarp	Teacher Questionnaire
3	Carpet 1-3	carpet	Teacher Questionnaire
4	Any carpet	q10_anycarp	Teacher Questionnaire
5	Vinyl-coated tackable wallboard	vctw	Teacher Questionnaire
6	Natural-ventilation-window	q15_winvent	Teacher Questionnaire
7	Natural ventilation door	q16_doorvent	Teacher Questionnaire
8	Natural ventilation -- door/window	natvent	Teacher Questionnaire
9	Air conditioning in room	Q17_AC	Teacher Questionnaire
10	Pressed wood table/desk	q19_pwoodtables	Teacher Questionnaire
11	Pressed wood bookcases	q19_pwoodbc	Teacher Questionnaire
12	Pressed wood cabinets	q19_pwoodcabs	Teacher Questionnaire
13	Pressed wood furniture (any)	presswood	Teacher Questionnaire
14	New carpet	q20_new_carpet	Teacher Questionnaire
15	New furnishings	newfurn	Teacher Questionnaire
16	Potted plants/terrarium	q21_plants	Teacher Questionnaire
17	Birds	q21_birds	Teacher Questionnaire
18	Mammals	q21_mammals	Teacher Questionnaire
19	Reptiles/amphibians	q21_reptiles	Teacher Questionnaire
20	Fish	q21_fish	Teacher Questionnaire
21	Bugs	q21_bugs	Teacher Questionnaire
22	Cleaning chemicals	q22_cleaners	Teacher Questionnaire
23	Any paints/pens	anypaint	Teacher Questionnaire
24	Any chemical	anychem	Teacher Questionnaire
25	Paints	q23_oils	Teacher Questionnaire
26	Pens	q23_markers	Teacher Questionnaire
27	Whiteboard markers	q23_whiteboard	Teacher Questionnaire
28	Any glues/fluids	anyglue	Teacher Questionnaire
29	Correction fluid	q23_whiteout	Teacher Questionnaire
30	Rubber cement	q23_rubcement	Teacher Questionnaire
31	Air freshener-any	anyfresh	Teacher Questionnaire
32	Air freshener- plug in	q23_hangaf	Teacher Questionnaire
33	Air freshener - hanging	q23_pluginaf	Teacher Questionnaire
34	Air freshener-spray	q23_sprayaf	Teacher Questionnaire
35	Pesticide-any	anypest	Teacher Questionnaire
36	Pestuse (current, past, never)	pestuse	Teacher Questionnaire
37	Pesticide -- Spray	Q24_NoSpray	Teacher Questionnaire
38	Pesticide-Powder	Q24_NoPowd	Teacher Questionnaire
39	Pesticide-traps	Q24_NoTrap	Teacher Questionnaire
40	Bug problem past	q29_bugspast	Teacher Questionnaire
41	Bug problem now	q29_bugsnow	Teacher Questionnaire
42	Rodent problem past	q29_micepast	Teacher Questionnaire
43	Rodent problem now	q29_micenow	Teacher Questionnaire
44	Bug problem (current, past, never)	bugprob	Teacher Questionnaire

45	Rodent problem (current, past, never)	rodprob	Teacher Questionnaire
46	Musty odor	q30_musty	Teacher Questionnaire
47	Bus/auto exhaust odor	q30_auto	Teacher Questionnaire
48	Fresh paint odor	q30_paint	Teacher Questionnaire
49	Cooking odor	q30_cook	Teacher Questionnaire
50	Tobacco smoke odor	q30_cigs	Teacher Questionnaire
51	Trash/dumpster odor	q30_trash	Teacher Questionnaire
52	Cleaning products odor	q30_cleaner	Teacher Questionnaire
53	New carpet/furniture odor	q30_newcarp	Teacher Questionnaire
54	Pesticides odor	q30_pest	Teacher Questionnaire
55	Asphalt/tar odor	q30_asph	Teacher Questionnaire
56	Sewer/compost odor	q30_sewer	Teacher Questionnaire
57	Fire/smoke odor	q30_fire	Teacher Questionnaire
58	Leak/flood in room	watrlek	Teacher Questionnaire
59	Water stains in room	watrstn	Teacher Questionnaire
60	Visible mold in room	vismolt	Teacher Questionnaire
61	Water problem (current, past, never)	watrprb	Teacher Questionnaire
62	Teacher’s assessment of temperature	tqtemp	Teacher Questionnaire
63	Teacher’s assessment of air quality	cair	Teacher Questionnaire
64	Teacher’s assessment of humidity	humid	Teacher Questionnaire
65	Overall air quality	q37_overalleq	Teacher Questionnaire
66	Current smoker	q42_smoker	Teacher Questionnaire
67	Live with smoker	q43_wsmoker	Teacher Questionnaire
68	Mold Indicator - mold/musty odor/leak/stain	moldind1	Teacher Questionnaire
69	Mold Indicator - mold/musty odor/leak/stain	moldind2	Teacher Questionnaire
70	Main Door Open?	dropen	Walk-through Survey 1
71	Doors to Adjacent Room/Playground Open?	dropenplay	Walk-through Survey 1
72	HVAC System Heard On?	hvacon	Walk-through Survey 1
73	Windows Open?	winopen	Walk-through Survey 1
74	Derek's assessment of musty odor	dmusty	Walk-through Survey 1
75	Derek's assessment of dusty	ddusty	Walk-through Survey 1
76	Derek's assessment of cleaning odor	dclean	Walk-through Survey 1
77	Derek's assessment of chemical odor	dchem	Walk-through Survey 1
78	Garbage dumpsters immediately outside near HVAC?	garbage_hvac	Walk-through Survey 2
79	Exposed soil (re: garden) near back door/windows?	soil	Walk-through Survey 2
80	Construction activities in close proximity?	bus_car	Walk-through Survey 2
81	Truck loading/unloading area outside near HVAC?	leaks	Walk-through Survey 2
82	Bus/car drop-off/pick-up area?	h2o_damage	Walk-through Survey 2
83	Pm residue on ceiling diffuser plates (0,1,2)	pm_ceiling	Walk-through Survey 2
84	General dusting?	dust	Walk-through Survey 2
85	Frequency per week (A)	dust_freq	Walk-through Survey 2
86	AM or PM (A)	dust_time	Walk-through Survey 2
87	Floor cleaning-dry mop?	floor_drymop	Walk-through Survey 2
88	Frequency per week (B)	drymop_freq	Walk-through Survey 2
89	AM or PM (B)	drymop_time	Walk-through Survey 2
90	Floor cleaning-wet mop?	floor_wetmop	Walk-through Survey 2
91	Frequency per week (C)	wetmop_freq	Walk-through Survey 2

92	AM or PM (C)	wetmop_time	Walk-through Survey 2
93	Vacuuming?	vaccum	Walk-through Survey 2
94	Area rug(s) or full carpet?	rugs	Walk-through Survey 2
95	Frequency per week (D)	vac_freq	Walk-through Survey 2
96	AM or PM (D)	vac_time	Walk-through Survey 2
97	Any cleaning/chemical/pain materials in classroom	dclean2	Walk-through Survey 2
98	Dry erase cleaner	derase	Walk-through Survey 2
99	Pesticide	dpest	Walk-through Survey 2

Appendix 3.E – Indoor Air Monitoring Tables and Figures

Appendix E contains the following table and graphs:

Table 3E.1 Indoor air pollutant monitoring results for NO_2 and NOx

School	NO_2					NO_x				
	Indoor	Outdoor	Ratio	Avg. Concentration*	Ratio x Avg.**	Indoor	Outdoor	Ratio	Avg. Concentration*	Ratio x Avg.**
1	--	18	--	22	--	--	26	--	42	--
2	12	22	0.56	24	14	23	39	0.60	55	33
3	13	17	0.76	21	16	18	35	0.52	49	26
4	10	15	0.67	19	12	16	26	0.62	41	25
5	20	21	0.94	26	25	41	47	0.87	62	54
6	11	14	0.76	21	16	16	26	0.61	39	23
7	20	20	1.00	20	20	26	27	0.98	33	32
8	19	27	0.70	23	16	26	33	0.77	45	35
9***	17	--	--	26	--	24	--	--	57	--
10	16	26	0.65	31	20	36	47	0.78	69	54

Table 3E.2 Indoor air pollutant monitoring results for PM_{10} and $PM_{2.5}$

	PM_{10}					$PM_{2.5}$				
School	Indoor	Outdoor	Ratio	Avg. Concentration*	Ratio * Avg.	Indoor	Outdoor	Ratio	Avg. Concentration*	Ratio * Avg.
1	97	68	1.43	30	43	27	23	1.16	12	14
2	59	29	2.03	29	59	18	17	1.08	13	14
3	101	30	3.32	32	106	23	--	--	12	--
4	115	30	3.85	30	114	30	17	1.77	12	20
5	--	40	0.00	30	--	--	20	--	12	--
6	140	43	3.26	30	99	31	21	1.45	12	17
7	75	30	2.53	29	73	18	18	1.01	11	11
8	61	28	2.14	29	62	21	18	1.14	12	14
9***	75	--	--	30	--	26	--	--	12	--
10	48	39	1.25	32	40	20	22	0.92	15	14

Table 3E.3 Indoor air pollutant monitoring results for BC_{10}

	BC10				
School	Indoor	Outdoor	Ratio	Avg.Concentration*	Ratio* mean
1	2.9	2.6	1.14	0.7	0.8
2	1.3	1.4	0.96	0.9	0.8
3	1.8	1.0	1.83	0.8	1.5
4	2.0	1.3	1.54	0.8	1.2
5	--	3.1	--	0.9	--
6	2.5	2.2	1.13	0.7	0.8
7	1.4	1.0	1.41	0.7	0.9
8	1.5	1.4	1.03	0.7	0.7
9***	2.9	--	--	0.9	--
10	3.4	4.4	0.77	1.1	0.8

* Avg. Concentration is the study-average air pollution concentration calculated for each school. For methods, see Kim et al. 2004.

** Ratio x Avg. Is the ratio of indoor/outdoor pollution multiplied by the average concentration.

***The outdoor monitor at school 9 was destroyed in an act of vandalism during week 9 so the outdoor measurements were lost.

Figure 3E.1. NO_X concentrations measured in one classroom and outdoors at each school. Schools were monitored five at a time during two different one-week periods.

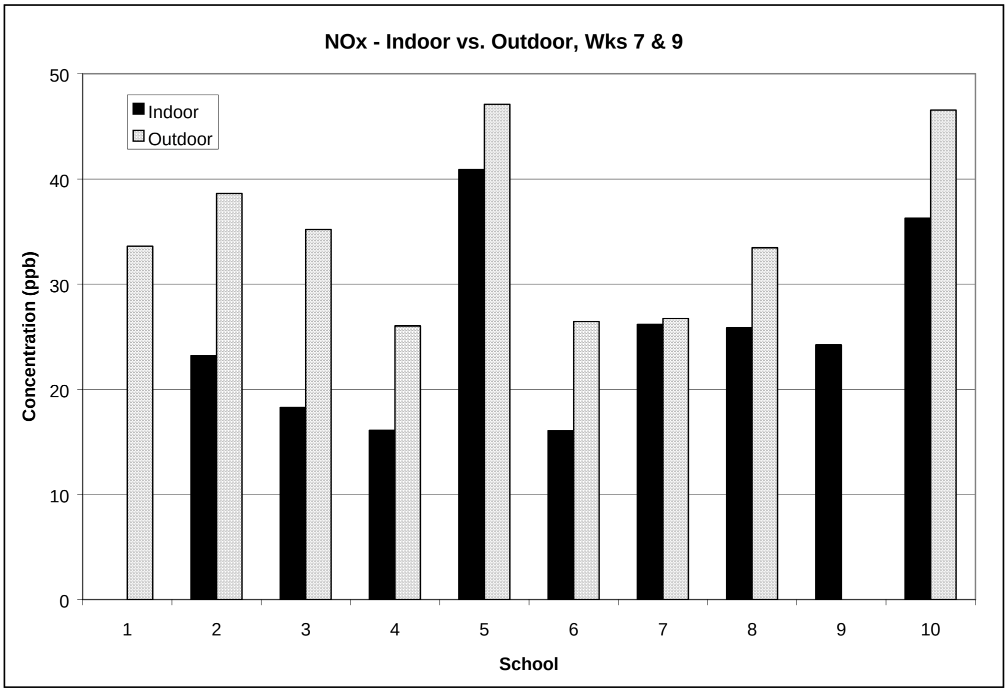


Figure 3E.2. NO_2 concentrations measured in one classroom and outdoors at each school. Schools were monitored five at a time during two different one-week periods.

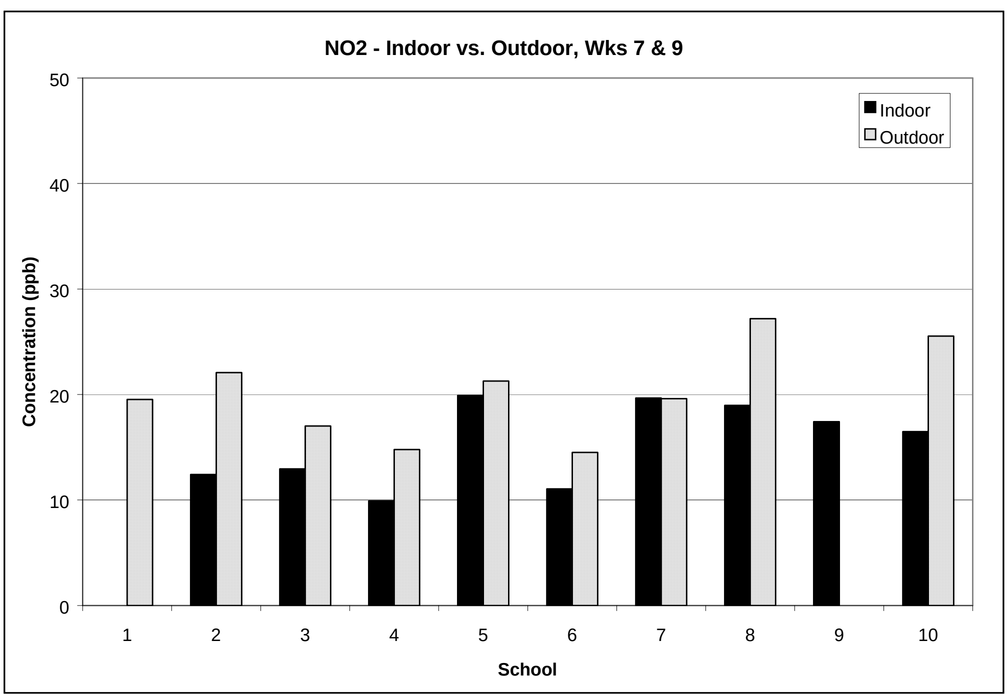


Figure 3E.3. $PM_{2.5}$ mass concentrations measured in one classroom and outdoors at each school. Schools were monitored five at a time during school hours of two one-week periods.

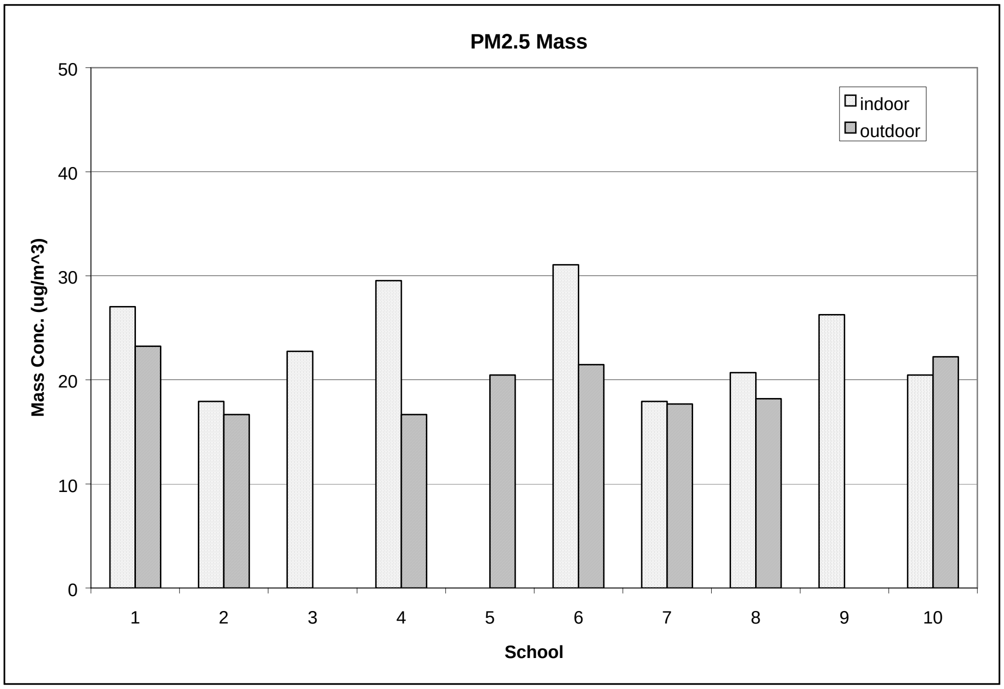


Figure 3E.4. PM_{10} mass concentrations measured in one classroom and outdoors at each school. Schools were monitored five at a time during school hours of two one-week periods.

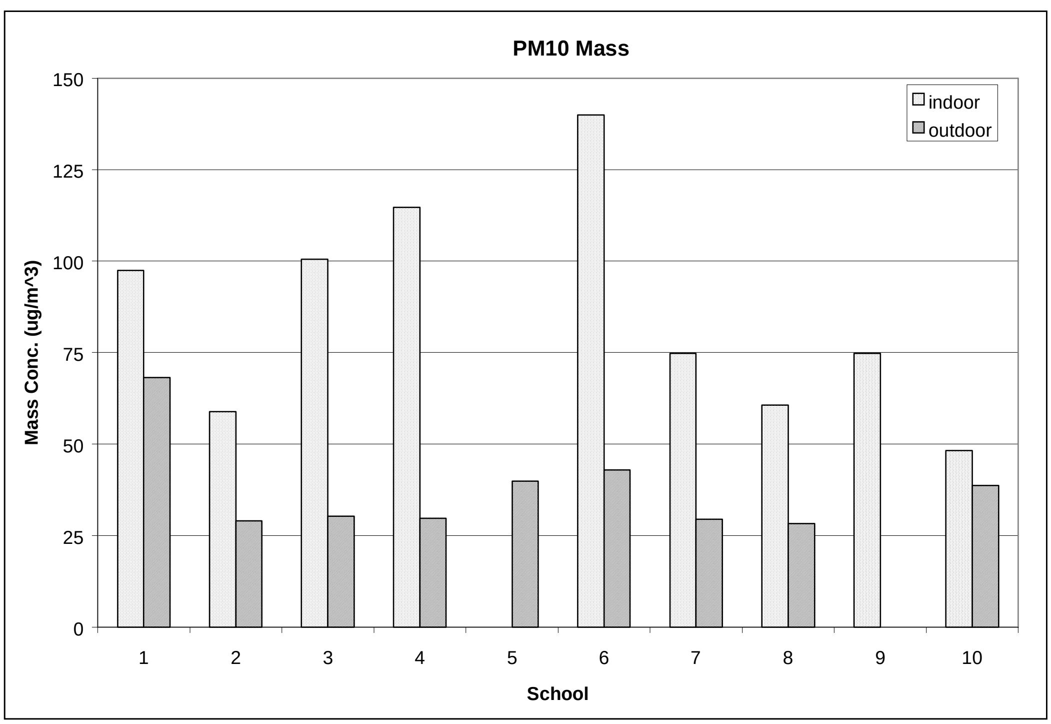
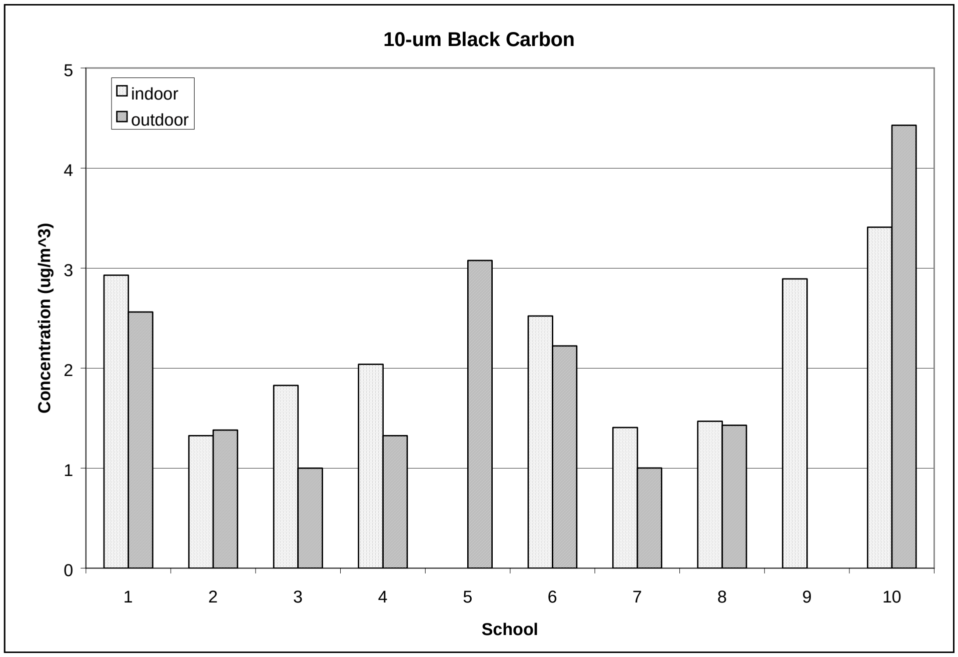


Figure E.35. 10-µm BC concentrations measured in one classroom and outdoors at each school. Schools were monitored five at a time during school hours of two one-week periods.



Appendix 4:

Questionnaire: East Bay Children's Respiratory Health Study

EAST BAY CHILDREN'S RESPIRATORY HEALTH QUESTIONNAIRE

Thank you for your help!
Here's how to fill out the survey

- Please try to answer each question.
- Most questions should be answered by checking a box (X) or writing a number or a few words on a line.
- Never check more than one box, except where it says "Mark all that apply."
- Sometimes we ask you to skip a question. An arrow will tell you what question to answer next, like this:

  1 Yes → **Go to Q1**
  2 No

- If none of the boxes are just right, please check the one that fits the best. If you can, write a note telling us more.
- If you need help with the survey or would like to do the survey by telephone, please call Alex Roberts collect at (510) 643-5220

$$ for your effort
The last page of the survey asks for your mailing information so we can send you a check for $10. Please be sure to fill it out.

NOTE: If you start the survey and decide you need help, please return the survey with a note on the cover listing your phone number. We'll call you and complete the questionnaire over the phone

Please read this before starting.

- It's your choice whether or not to do the survey. Only a few schools in the East Bay were selected to take part in the study. It is important that we hear from all parents or guardians of the children who were chosen.
- You can skip questions you don't want to answer.
- Your answers will be kept confidential.

If you need help with the survey or want to do it by telephone, please call Alex Roberts collect at (510) 643-5220.

CHILD'S PERSONAL DATA

1. What is today's date?

______________, __________, __________
day year

2. What is your child's gender?

1 Female 2 Male

3. What is your child's age (as of his/her last birthday)?

____

4. What is your child's date of birth?

______________, __________, __________
day year

5. Is your child Hispanic/Latino?

1 Yes

(Mark all that apply.)

- 1 Mexican, Mexican-American, Chicano
- 1 Central or South American
- 1 Other Hispanic/Latino

2 No

6. What is your child's race/ethnicity? (Mark all that apply.)

- 1 White
- 1 Black, African American
- 1 Hispanic/Latino
- 1 American Indian or Alaskan Native
- 1 Asian

Which?

1 Asian Indian	1 Japanese
1 Chinese	1 Korean
1 Filipino	1 Vietnamese
1 Other Asian	

(**Specify**): ________________________

- 1 Pacific Islander
- 1 Some other race

(**Specify**): ______________________________

CHILD'S MEDICAL HISTORY

These questions are about your child's medical history.

7. What did your child weigh when he/she was born? (Choose the one best answer.)

- 1 Under 3 pounds (under 1.3 kg)
- 2 Between 3 and 4 pounds (1.3-1.8 kg)
- 3 Over 4 pounds - 5 pounds (1.8-2.3 kg)
- 4 Over 5 pounds - 5.5 pounds (2.3-2.5 kg)
- 5 Over 5.5 pounds (At least 2.5 kg)
- 6 Don't know → **Go to Question 9A**

8. Please write in the exact birth weight in either pounds and ounces *or* kilograms. Use whichever weight measurements (pounds/ounces or kilograms) are easiest for you.

Weight:

________ ______ OR ______.______
pounds ounces kilograms

0 Don't Know

9. A. Was your child born more than one week early, more than one week late, or on time? (For this question "on time" means within one week of the due date.)

- 1 More than one week early
- 2 More than one week late } **Go to Q9B**
- 3 On time
- 4 Don't Know } **Go to Q10**

9. B. If your child was born more than one week early or late, how many weeks early or late was it?

_______weeks early OR ________weeks late
(number of weeks early) (number of weeks late)

0 Don't Know

10. As a newborn, was your child kept in an intensive care unit or special care unit for a breathing problem?

1 Yes → (**Specify breathing problem**): ______________________

2 No

3 Don't Know

11. As a newborn, was your child on a respirator (tube placed in his/her windpipe that was connected to a breathing machine) to help him/her breathe?

1 Yes

2 No

3 Don't Know

12. As a newborn, did your child need oxygen while in the hospital? (Choose the one best answer.)

1 Yes, for less than 2 weeks

2 Yes, for 2 to 4 weeks

3 Yes, for more than 4 weeks

4 No

5 Don't Know

13. A. Was your child ever breast-fed?

1 Yes → **Go to Q13B**

2 No } **Go to Q14**

3 Don't Know } **Go to Q14**

13. B. How old was your child when he/she completely stopped breast-feeding?

1 Less than one month old

2 Greater than one month old

↓ How many months old was your child when he/she stopped breast feeding?

____________ months

3 Don't Know

CHILD CARE

14. Before your child turned one year old, were there other children living in the same household as your child? (Include anyone who was less than 18 years old at that time.)

1 Yes → How many? __________

2 No

3 Don't Know

15. A. Before starting kindergarten, did your child attend a day-care or a child-care center with <u>other</u> children? (Do not count those children who lived in the same household as your child.)

1 Yes → **Go to Q15B**

2 No } **Go to Q16A**

3 Don't Know } **Go to Q16A**

15. B. Where did your child go to day care or child care? (Mark all that apply.)

1 Your home

2 Someone else's home

3 Day-care center that was not part of someone's home

15. C. How old was your child when he/she started going to day care or child care? (Choose the one best answer.)

1 0 to 6 months old

2 Over 6 months to 1 year old

3 Over 1 year old to 2 years old

4 Over 2 years old to 3 years old

5 Over 3 years old

15. D. Did your child go to day care at all when he/she was 0 to 6 months old?

1 Yes → How many days a week? ____________
2 No
3 Don't Know

How about when he/she was over 6 months old to 1 year old?

1 Yes → How many days a week? ____________
2 No
3 Don't Know

How about when he/she was over 1 year old to 2 years old?

1 Yes → How many days a week? ____________
2 No
3 Don't Know

How about when he/she was over 2 years old to 3 years old?

1 Yes → How many days a week? ____________
2 No
3 Don't Know

How about when he/she was over 3 years old?

1 Yes → How many days a week? ____________
2 No
3 Don't Know

15. E. For each of the following ages, about how many OTHER children were usually at day-care or child-care with your child?

Your child's age:	Number of other children at day care				
	None	1-2	3-4	5 or more	Don't know
	1	2	3	4	5
0 - 6 mos.					
Over 6 mos. to 1 yr.					
Over 1 yr. to 2 yrs.					
Over 2 yrs. to 3 yrs.					
Over 3 yrs. old					

CHILD'S RESPIRATORY (LUNG OR BREATHING) HEALTH

16. A. Other than colds or the flu, was your child seen by a doctor or other health practitioner for any of the following chest (respiratory) illnesses BEFORE the age of 2 years?
(Mark all that apply.)

1 Asthma
1 Bronchiolitis
1 "RSV" viral infection
1 Bronchitis
1 Croup
1 Reactive Airway Disease
1 Pneumonia
1 Other chest illness (**Specify**):

____

1 No chest illness
1 Don't Know } **Go to Q17A**

16. B. Was your child kept in the hospital overnight for any chest illness (BEFORE the age of 2 years)?

1 Yes
2 No
3 Don't Know

17. A. Other than colds or the flu, was your child seen by a doctor or other health practitioner for any of the following chest (respiratory) illnesses AFTER the age of 2 years? (Mark all that apply.)

1 Asthma
1 Bronchiolitis
1 "RSV" viral infection
1 Bronchitis
1 Croup
1 Reactive Airway Disease
1 Pneumonia
1 Other chest illness (Specify):

____

1 No chest illness
1 Don't Know
} **Go to Q18**

17. B. Was your child kept in the hospital overnight for any chest illness (AFTER the age of 2 years)?

1 Yes
2 No
3 Don't Know

18. Has your child EVER had an operation on his or her chest?

1 Yes → (**Specify operation**):

____

2 No
3 Don't Know

19. Has your child EVER had a serious chest injury?

1 Yes → (**Specify chest injury**):

____

2 No
3 Don't Know

20. Has a doctor or other health practitioner EVER said that your child has cystic fibrosis?

1 Yes
2 No
3 Don't Know

ALLERGIES

The next few questions ask about respiratory symptoms your child might have that may be related to allergies.

21. A. Has your child EVER had problems with sneezing, or a runny or blocked nose that lasted more than a few days THAT WAS NOT a cold or the flu?

1 Yes → **Go to Q21B**
2 No
3 Don't Know
} **Go to**

21. B. <u>During the past 12 months</u>, has your child had problems with sneezing, or a runny or blocked nose that lasted more than a few days THAT WAS NOT a cold or the flu?

1 Yes → **Go to Q21C**
2 No
3 Don't Know
} **Go to Q22**

21. C. <u>During the past 12 months</u>, did your child also have itchy or watery eyes?

1 Yes
2 No
3 Don't Know

21. D. <u>During the past 12 months</u>, when did the problems with sneezing, or a runny or blocked nose occur (other than when the child had a cold or the flu)? (Mark all that apply.)

1 Fall
1 Winter
1 Spring
1 Summer
1 Most of the year
1 Don't Know

22. Has a doctor or other health professional ever said that your child has or had hayfever or allergic rhinitis?

1 Yes
2 No
3 Don't Know

23. A. Has your child ever had skin testing or a blood test to check for allergies?

1 Yes → **Go to Q23B**
2 No
3 Don't Know } **Go to**

23. B. Based on the allergy tests, what did the doctor say your child is allergic to?
(Mark all that apply.)

1 Not allergic to anything
1 Food or medicine
1 House dust or house dust mites
1 Pollens (for example, grasses, trees, flowers)
1 Molds
1 Animal fur or dander (for example, cats or dogs)
1 Cockroach or other insects
1 Insect bites or stings
1 Feathers (for example, in pillows or comforters)
1 Things which come in contact with the skin (for example, wool). Do not count poison ivy, poison oak or poison sumac
1 Other (**Specify**): ____________________
1 Don't Know

24. A. Has a doctor or other health professional ever said that your child has eczema or atopic dermatitis?

1 Yes → **Go to Q24B**
2 No
3 Don't Know } **Go to Q25**

24. B. At what age did eczema or atopic dermatitis first occur?

1 Under 2 years
2 Age 2-4 years
3 Age 5 or more

24. C. During the past 12 months, has your child had eczema or atopic dermatitis at any time?

1 Yes
2 No
3 Don't Know

CHILD'S CURRENT RESPIRATORY (LUNG OR BREATHING) HEALTH

These next questions are about your child's health during the PAST 12 MONTHS.

25. <u>During the past 12 months</u>, has your child had a cough first thing in the morning that lasted for at least 3 months in a row?
(Choose the one best answer.)

1 Yes, during the past 12 months **only**
2 Yes, during the past 12 months and in other years
3 No
4 Don't Know

26. <u>During the past 12 months</u>, has your child had a cough at other times of the day or night that lasted for at least 3 months in a row?
(Choose the one best answer.)

1 Yes, during the past 12 months **only**
2 Yes, during the past 12 months and in other years
3 No
4 Don't Know

27. A. Other than with colds or the flu, does your child often seem congested in the chest or bring up phlegm (phlegm is also called mucus or sputum)?

1 Yes → **Go to Q27B**
2 No
3 Don't Know } – - -

27. B. <u>During the past 12 months</u>, has this congestion, phlegm, or mucus been present for at least 3 months in a row? (Choose the one best answer.)

1 Yes, during the past 12 months **only**
2 Yes, during the past 12 months and in other years
3 No
4 Don't Know

28. A. <u>During the past 12 months</u>, did your child have bronchitis?

1 Yes → **Go to Q28B**
2 No
3 Don't Know } **Go to Q29**

28. B. <u>During the past 12 months</u>, how many times did your child have BRONCHITIS?

1 Never
2 Once
3 More than once
4 Don't know

28. C. <u>During the past 12 months</u>, did your child take any of the following medications when he or she had BRONCHITIS? If your child had more than one bout of bronchitis, answer for the WORST bout. (Mark all that apply.)

1 Antibiotics, by pill or shot
1 Inhaled medications
1 Steroids (for example, prednisone pills or prelone liquid)
1 Other breathing medications (**Specify**): ______________________
1 Other medications (**Specify**): ______________________
1 No medication for bronchitis
1 Don't Know

28. D. <u>During the past 12 months</u>, was your child kept overnight in the hospital for BRONCHITIS?

1 Yes
2 No
3 Don't Know

29. <u>During the past 12 months</u>, did a doctor say that your child had any of the following chest illnesses? (Mark all that apply.)

1 Pneumonia
1 Asthma
1 Reactive Airway Disease
1 Other chest illness (Do not include colds or the flu) (**Specify**): ______________________
1 Don't Know

30. <u>During the past 3 MONTHS</u>, about how many times has your child had a cold or the flu?

1 None
2 1-2 times
3 3-4 times
4 5 or more times

WHEEZING

These next questions ask about wheezing. Wheezing or whistling is a **high-pitched** sound that you (or the doctor) may hear when your child breathes out. Wheezing or whistling is NOT noisy breathing because of a stuffy nose.

31. A. Has your child's chest EVER sounded wheezy or whistling, including times when he/she had a cold? (Choose the one best answer.)

1 Yes → **Go to Q31B**
2 No } **Go to Q33A**
3 Don't know } **Go to Q33A**

31. B. Since birth, how many times has your child's chest sounded wheezy or whistling, including times when he/she had a cold?

1 Once only
2 2-3 times
3 4 or more times

31. C. When was the FIRST TIME this wheezing occurred? (Choose the one best answer.)

1 Under age 2
2 Age 2 or older, but before starting first grade
3 Since starting first grade, but not within the past 12 months
4 Within the past 12 months
5 Don't know

31. D. When was the most recent or last time this wheezing occurred? (Choose the one best answer.)

1 Under age 2
2 Age 2 or older, but before starting first grade
3 Since starting first grade, but not within the past 12 months
4 Within the past 12 months
5 Don't know

31. E. Has your child EVER wheezed with colds? (Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. F. Has your child EVER wheezed when he/she did NOT have a cold?
(Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. G. Has your child EVER had episodes of shortness of breath with wheezing?
(Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. H. Has your child EVER been wakened at night by wheezing? (Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. I. Has your child EVER had episodes of wheezing after he/she has been playing hard or exercising? (Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. J. Has your child EVER required medication for wheezing? (Choose the one best answer.)

1 Yes, within the past 12 months
2 Yes, but not within the past 12 months
3 No
4 Don't Know

31. K. Has your child ever been taken to a hospital emergency room or a same-day doctor's visit for wheezing? (Choose the one best answer.)

1 Yes, within the past 12 months → **Go to Q31L**
2 Yes, but not within the past 12 months
3 No
4 Don't Know
} **Go to**

31. L. How many times has your child been taken to a hospital emergency room or a same-day doctor's visit for wheezing?

1 None in the past 12 months
2 Once during the past 12 months
3 2-3 times during the past 12 months
4 4-6 times during the past 12 months
5 More than 6 times during the past 12 months

31. M. Has your child ever been kept overnight in the hospital for wheezing?
(Choose the one best answer.)

1 Yes, within the past 12 months → **Go to Q31N**
2 Yes, but not within the past 12 months
3 No
4 Don't Know
} **Go to Q32A**

31. N. How many times has your child been kept overnight in the hospital for wheezing <u>in the past 12 months</u>?

_____ times (write in number of times)

If your child has NOT had any wheezing or whistling in the chest in the past 12 months, please go to Q33A.

32. A. Not counting when your child had a cold or flu, or had just recovered, has your child wheezed at <u>night</u> during the past 12 months?

1 Yes → **Go to Q32B**
2 No
3 Don't Know
} **Go to Q32C**

32. B. Not counting when your child had a cold or flu, or had just recovered, how often has your child wheezed at <u>night</u> during the past 12 months?

1 Two times a MONTH or less
2 More than two times a MONTH, or up to once a week
3 More than once a week
4 Most nights during the week

32. C. Not counting when your child had a cold or flu, or had just recovered, has your child wheezed during the <u>day</u> in the past 12 months?

1 Yes → **Go to Q32D**
2 No
3 Don't Know
} **Go to Q33A**

32. D. Not counting when your child had a cold or flu, or had just recovered, how often has your child wheezed during the <u>day</u> in the past 12 months?

1 Two times a WEEK or less
2 More than two times a WEEK, but less than every day
3 Every day

32. E. <u>During the past 12 months</u>, when did your child have the most problems with wheezing?

- 1 Fall
- 2 Winter
- 3 Spring
- 4 Summer
- 5 Most of the year
- 6 Don't know

ASTHMA

These next questions ask about whether your child has had ASTHMA. Some of the questions are similar to those you may have answered earlier. However, it is important to answer the following questions specifically for 'asthma.'

33. A. Has a doctor or other health professional ever told you or your family that your child has or had asthma?

- 1 Yes → **Go to Q33B**
- 2 No
- 3 Don't Know } **Go to**

33. B. How old was your child when you were first told that he/she has asthma?

_____ years old

- 0 Don't know

33. C. When was the most recent time that your child had an episode of asthma?

- 1 Within the past 12 months
- 2 Since starting first grade, but not within the past 12 months
- 3 Age 2 or older, but before starting first grade
- 4 Under age 2
- 5 Don't know

34. Which best describes your child's current level of asthma symptoms? Please read all answers before choosing the best response.

- 1 No symptoms of asthma during the past 12 months. → **Go to Q36**
- 2 Some asthma during the past 12 months. No medication taken for asthma.
- 3 Some asthma during the past 12 months. Medication taken only for occasional episodes.
- 4 Asthma during the past 12 months. Asthma medication on a regular basis. No episodes while on medication.
- 5 Asthma in the past 12 months. Asthma medication on a regular basis and also had one or more episodes requiring additional treatment.

35. A. <u>During the past 12 months</u>, how many times did your child have an episode of asthma or an asthma attack?
(Choose the one best answer.)

- 1 None
- 2 Once
- 3 2-3 times
- 4 4 or more times

35. B. <u>During the past 12 months</u>, was your child taken to a doctor for an urgent (same day) appointment or to the emergency room (ER) for ASTHMA?

- 1 Yes → How many times? _________
- 2 No
- 3 Don't Know

35. C. <u>During the past 12 months</u>, was your child kept overnight in the hospital for ASTHMA?

- 1 Yes → How many times? _________
- 2 No
- 3 Don't Know

35. D. <u>During the past 12 months</u>, how many times was your child prescribed steroids, by pills, liquid, or shot (for example, Prednisone pills or Prelone or Pediapred liquid) for an episode of asthma or asthma attack?
(Choose the one best answer.)

1 None
2 Once
3 2-3 times
4 4 or more times
5 Don't Know

35. E. Has a physician or other health care provider given a *written* plan for managing your child's asthma? (This is sometimes called an asthma action plan or asthma management plan.)

1 Yes, my child has a *written* plan
2 No, no written plan
3 No, no written plan but we have discussed a plan
4 Don't know

HOME CHARACTERISTICS

These next questions ask about the city and home where your child is currently living. If your child lives in more than one residence, please answer for the residence where he or she spends most of his/her time (4 days a week or more).

36. Has your child lived in this city since birth?

1 Yes
2 No
→ When did your child move to this city?
  1 Before age 2
  2 Since age 2, but before age 6
  3 Since age 6, but not in the last 12 months
  4 In the last 12 months
3 Don't know

37. A. What is the address of the home where the child spends most of his/her time (4 days a week or more)? This information is for study purposes only and will not be shared with the school or other authorities.

____
Street address

____________________, _____ _______
City State Zip code

37. B. How many days a week does your child live at this address?

________ days

37. C. Has your child lived at this address since birth?

1 Yes
2 No
→ When did your child move to this address?
  1 Before age 2
  2 Since age 2, but before age 6
  3 Since age 6, but not in the last 12 months
  4 In the last 12 months
3 Don't know

37. D. Do you also live at this address?

1 Yes
2 No

38. If your child has moved to this residence recently (within the last 12 months), what was the address of the previous residence where your child spent most of his/her time (4 days a week or more)?

____
Street address

____________________, _____ _______
City State Zip code

1 Did not move within the past 12 months
2 Moved within the past 12 months, but I do not know the previous address

For the remaining questions "your child's home" means the home where your child spends most of his/her time (4 days a week or more).

39. A. How close is your child's home to a street with heavy traffic? (For this question, "a street with heavy traffic" could be a freeway, highway, major intersection, or a city street with heavy traffic.)

1 Immediately in front, behind, or beside your child's home
2 Less than one block away
3 1-3 blocks away
4 4 or more blocks away

39. B. On <u>weekdays</u>, how often do large trucks or buses pass through on the road(s) in front, behind, or beside your child's home?

1 Never or rarely
2 Sometimes
3 Frequently throughout the day
4 Almost the whole day

40. Which best describes the building in which your child lives? Include all apartments, flats, etc., even if vacant.

11
1 A mobile home
2 A one-family house detached from any other house
3 A one-family house attached to one or more houses (such as duplex, triplex, townhouse)
4 A building with 2 apartments
5 A building with 3 or 4 apartments
6 A building with 5 to 9 apartments
7 A building with 10 to 19 apartments
8 A building with 20 to 49 apartments
9 A building with 50 or more apartments
10 Boat, RV, van, etc. → **Go to Q42**
11 Other (**Specify**):

____

41. About when was this building originally built? Do not count remodeling, additions, or conversions.

1 1990 or later
2 1970's or 1980's
3 1950's or 1960's
4 1930's or 1940's
5 Before 1930
6 Don't know

42. How many rooms are there in the house, apartment, or mobile home where your child lives? Do NOT count bathrooms, porches, balconies, entry ways, halls, or half-rooms.

1 1 room
2 2 rooms
3 3 rooms
4 4 rooms
5 5 rooms
6 6 rooms
7 7 rooms
8 8 rooms
9 9 or more rooms

43. How many bedrooms are there in your child's home? That is, how many bedrooms would you list if this house, apartment, or mobile home were on the market for sale or rent?

0 No bedrooms
1 1 bedrooms
2 2 bedrooms
3 3 bedroom
4 4 bedrooms
5 5 bedrooms

44. Is your child's home owned or rented? (The home where your child spends most of his or her time, at least 4 days a week or more)

1 Owned
2 Rented

45. Do any dogs, cats, other furry pets, or birds live in your child's home? (Include only pets kept or allowed indoors) (Mark all that apply.)

1 Dog(s)
1 Cat(s)
1 Pet mice or rat(s)
1 Hamster(s) or gerbil(s)
1 Bird(s)
1 Other furry pet(s) (**Specify**):

____
1 Don't know
1 None of the above

46. <u>During the past 12 months</u>, have any of the following pests been in your child's home? (Mark all that apply.)

1 Rats
1 Mice
1 Cockroaches
1 Ants
1 Spiders
1 Termites
1 Don't know
1 No problems with pests
1 Other (**Specify**):

____

47. <u>During the past 12 months</u>, have you or anyone else used any pesticides (for example, bug sprays or rodent poison) INSIDE YOUR CHILD'S HOME OR APARTMENT? This includes anyone who might have used pesticides, including a professional exterminator.

1 Yes
2 No
3 Don't Know

48. A. Does your child's home have a GAS cooking stove, range, or oven?

1 Yes → **Go to Q48B**
2 No
3 Don't Know

48. B. How is the gas stove lit?
(Choose the one best answer.)

1 Electronic ignition (When the stove is turned on you may hear a "click, click" before the flame appears)
2 Continuous pilot light (No match is needed. When the stove is turned on you may hear a "ssss" sound before the flame appears)
3 No pilot light (You need to light it *each* time with a match)
4 Sometimes a match is used
5 Don't know how it is lit

48. C. On average, how many hours a day is the gas cooking stove, range, or oven used FOR COOKING when your child is at home?

1 None
2 Less than one hour
3 One to three hours
4 More than three hours
5 Don't know

**48. D. <u>During the past 12 months</u>, did you or anyone else use your gas cooking stove, range, or oven
to help heat your child's home or to take the
chill off in the morning OTHER THAN WHILE COOKING?**

1 Yes → **Go to Q48E**
2 No } **Go to**
3 Don't Know

48. E. How often was the stove used to heat your child's home OTHER THAN WHILE COOKING?

1 Rarely, once or twice in the past year
2 Infrequently, three or more times in the past year
3 Frequently, on cold days in the past year

49. A. Which fuel is used MOST for heating the house, apartment, or mobile home where your child lives?

1 Gas: from the utility company through underground pipes serving the neighborhood
2 Gas: bottled, tank, or liquid propane
3 Electricity
4 Fuel oil, kerosene, etc.
5 Wood
6 Solar energy
7 Other (**Specify**):

____

8 No fuel used
9 Don't know

49. B. What is the main way your child's home is heated? (Choose the one best answer.)

1 Central heating (such as warm air coming through heater vents in individual rooms)
2 Gas wall or floor heater
3 Portable space heaters
↓
Which type?
- 1 gas
- 2 electric
- 3 kerosene

4 Wood stove
5 Fireplace (wood-burning)
6 Fireplace (gas insert)
7 Don't know
8 Other (**Specify**):

____

50. A. Does your child's home have any air conditioning?

1 Yes → **Go to Q50B**
2 No } **Go to Q51**
3 Don't Know }

50. B. Which type of air conditioning does your child's home have?

1 Central air conditioning (cool air comes through vents in individual rooms)
2 Room air conditioning (box that sticks out of window or wall)

51. Is an air cleaner ever used in your child's home? (Do not count furnace filters or air fresheners.)

1 Yes
2 No
3 Don't Know

52. Is there a gas water heater inside your child's home (do not include the basement)?

1 Yes
2 No
3 Don't Know

53. A. Is there a garage directly attached to your child's home?

1 Yes → **Go to Q53B**
2 No } **Go to**
3 Don't Know }

53. B. Is a car left to warm up in the garage with the engine running at least once a week?

1 Yes
2 No
3 Don't Know

54. A. During the time your child has lived in his/her current home, has there been water damage from a leaky roof or pipe or flooding indoors?

1 Yes → **Go to Q54B**
2 No
3 Don't Know } **Go to**

54. B. When did this water damage most recently happen? (Choose the one best answer.)

1 Past month
2 Past 6 months
3 Past year
4 Over one year ago
5 Don't know

54. C. Which rooms have had water damage or flooding? (Mark all that apply.)

1 All rooms
1 Room where your child sleeps
1 Other bedrooms or sleeping areas
1 Bathroom(s)
1 Kitchen
1 Basement
1 Don't know
1 Other (**Specify**):

________________________________)

55. A. <u>During the past 12 months</u>, have you seen any mold or mildew on any walls, ceilings, floors, or around bathroom fixtures inside the home?

1 Yes → **Go to Q55B**
2 No
3 Don't Know } **Go to**

55. B. Is the amount of mold in any of these areas at least the size of a dollar bill?

1 Yes
2 No
3 Don't Know

55. C. How much mold or mildew have you seen in each of the following rooms? (A little = the size of a dollar bill.)

	None	Little mold	Medium amount	Lot of mold
Room where your child sleeps	1	2	3	4
Other bedroom(s)				
Bathroom(s)				
Kitchen				
Living room/TV room				
Other rooms				

55. D. If you see a lot of mold in any room, please tell us where it is and how much.

____

____

56. <u>During the past 12 months</u>, have you seen water pooled on the windowsills *<u>of the living room or any bedroom</u>* in your child's home? Do <u>not</u> count water on the windowsills in the kitchen or bathroom.

1 Yes
2 No
3 Don't Know

57. <u>During the past 12 months</u>, has any part of your child's home had a moldy or musty smell?

1 Yes
2 No
3 Don't Know

58. Is a humidifier used in your child's home? Include any humidifier system built into the heating system.

1 Yes
2 No
3 Don't Know

59. A. Is there carpet in your child's bedroom or sleeping area?

1 Yes → **Go to Q59B**
2 No
3 Don't Know } **Go to**

59. B. Which type of carpet is in your child's bedroom or sleeping area?

1 An area rug
2 Wall to wall carpet

60. A. Is there carpet in the room where the child spends much of his/her time while awake (such as a TV area)?

1 Yes → **Go to Q60B**
2 No
3 Don't Know } **Go to Q61**

60. B. Which type of carpet is in the room where the child spends much of his/her time while awake?

1 An area rug
2 Wall to wall carpet

ADDITIONAL CHILD AND FAMILY HISTORY

These questions ask about your child and his/her family history.

61. Where was your child born?

1 United States → Which city and state?

______________________, ______________
city state

2 Mexico
3 Central or South America
4 China, Taiwan, Hong Kong
5 Korea
6 Philippines
7 Europe
8 Africa
9 Other (**Specify**):

____

62. If your child was born outside of the United States, in what year did he/she come to the United States?

____
(write in year)

63. A. Has your child's biological mother ever been diagnosed by a doctor or other health care professional with any of the following conditions? (Mark all that apply.)

1 Asthma
1 Eczema
1 Allergic Rhinitis or Hayfever**

63. B. Has your child's biological father ever been diagnosed by a doctor or other health care professional with any of the following conditions? (Mark all that apply.)

1 Asthma
1 Eczema
1 Allergic Rhinitis or Hayfever**

63. C. Have any of your child's biological brothers or sisters ever been diagnosed by a doctor or other health care professional with any of the following conditions? (Mark all that apply.)

1 Asthma
1 Eczema
1 Allergic Rhinitis or Hayfever**

** allergic rhinitis or hayfever: problems with sneezing, or a runny or blocked nose when he/she does not have a cold or flu. This is usually due to allergies to dust, pollens or animals.

SMOKING

These next questions ask about smoking in your child's household.

64. A. Did this child's biological mother smoke while she was pregnant with this child? Include any period of time before she knew she was pregnant.

1 Yes, smoked during the whole pregnancy → **Go to Q65**
2 Yes, smoked for part of the pregnancy → **Go to Q64B**
3 No
4 Don't Know } **Go to**

64. B. Which part or the pregancy did the biological mother smoke? (Mark all that apply.)

1 First 3 months
1 Middle 3 months
1 Last 3 months

65. Between the time your child was BORN and NOW, has anyone in your child's household ever regularly smoked cigarettes INSIDE THE CHILD'S HOME?

1 Yes → **Go to Q66A**
2 No } **Go to Q69**
3 Don't Know }

66. A. Between the time your child was BORN and when he/she turned TWO YEARS OLD, did anyone in your child's household regularly smoke cigarettes INSIDE THE CHILD'S HOME?

1 Yes → **Go to Q66B**
2 No } **Go to**
3 Don't Know }

66. B. How many people regularly smoked INSIDE THE CHILD'S HOME between the time your child was born and the time he/she turned two years old?

1 1
2 2
3 3 or more

66. C. Who regularly smoked between the time your child was born and the time he/she turned two years old? (Mark all that apply.)

1 Child's mother or female guardian
1 Child's father or male guardian
1 Other household members or regular visitors (for example, grandparents or babysitters)
1 Other (**Specify**): ______________________________

67. A. Between the time your child was TWO YEARS OLD and NOW, did anyone in your child's household regularly smoke cigarettes INSIDE THE CHILD'S HOME?

1 Yes → **Go to Q67B**
2 No } **Go to**
3 Don't Know }

67. B. How many people regularly smoked INSIDE THE CHILD'S HOME between the time your child was two years old and now?

1 1
2 2
3 3 or more

67. C. Who regularly smoked between the time your child was two years old and now?
(Mark all that apply.)

1 Child's mother or female guardian
1 Child's father or male guardian
1 Other household members or regular visitors (for example, grandparents or babysitters)
1 Other (**Specify**): ______________________________)

68. A. Does anyone in your child's household CURRENTLY smoke cigarettes INSIDE THE CHILD'S HOME?

1 Yes → **Go to Q68B**
2 No } **Go to Q69**
3 Don't know }

68. B. How many people in your child's household regularly smoke INSIDE THE CHILD'S HOME?

1 1
2 2
3 3 or more

68. C. Who regularly smokes cigarettes in your child's household? (Mark all that apply.)

1 Child's mother or female guardian
1 Child's father or male guardian
1 Other household members or regular visitors (for example, grandparents or babysitters)
1 Other (**Specify**):

____

68. D. How many cigarettes are smoked INSIDE THE CHILD'S HOME by each of the following people?

Child's mother or female guardian

1 None
2 1-10 cigarettes a day
3 11-20 cigarettes a day
4 21-40 cigarettes a day
5 More than 40 cigarettes a day

Child's father or male guardian

1 None
2 1-10 cigarettes a day
3 11-20 cigarettes a day
4 21-40 cigarettes a day
5 More than 40 cigarettes a day

Other household member(s)

1 None
2 1-10 cigarettes a day
3 11-20 cigarettes a day
4 21-40 cigarettes a day
5 More than 40 cigarettes a day

CHILD'S ACTIVITY

69. Not counting when your child is in school, how many times a week does he/she exercise, play, or participate in sports long enough to make him/her breathe hard?

1 Never or occasionally
2 Once or twice a week
3 Three or more times a week.
4 Don't know

70. During a normal SCHOOL day, how many hours a day does your child watch television or videos, play video games, or spend time on the computer?

1 Never or occasionally
2 Less than 1 hour
3 Between 1 and 2 hours
4 Over 2 hours - 3 hours
5 Over 3 hours - 5 hours
6 More than 5 hours
7 Don't know

71. During a normal WEEKEND day, how many hours a day does your child watch television or videos, play video games, or spend time on the computer?

1 Never or occasionally
2 Less than 1 hour
3 Between 1 and 2 hours
4 Over 2 hours - 3 hours
5 Over 3 hours - 5 hours
6 More than 5 hours
7 Don't know

72. A. <u>During the last 12 months</u>, did your child play in any organized *outdoor* team sports (such as Little League or Soccer League)?

1 Yes → **Go to Q72B**
2 No } **Go to Q73**
3 Don't Know } **Go to Q73**

72. B. <u>During the last 12 months</u>, what team sports did he/she play? (Mark all that apply.)

- 1 Softball/baseball
- 1 Tennis
- 1 Soccer (outdoors)
- 1 Football
- 1 Volleyball (outdoors)
- 1 Track/running
- 1 Swimming (outdoors)
- 1 Basketball (outdoors)
- 1 Other:

____

73. A. How does your child usually go to school in the MORNING? (Choose the one best answer)

- 1 Rides in a car, van or truck
- 2 Rides in a school bus
- 3 Rides in a city bus
- 4 Walks
- 5 Bikes
- 6 Other (**Specify**):

____

73. B. How much time does your child usually spend travelling from home to school in the MORNING?

- 1 Less than 10 minutes
- 2 10-19 minutes
- 3 20-29 minutes
- 4 30-45 minutes
- 5 More than 45 minutes

73. C. When your child goes to school in the MORNING, does he/she travel on the freeway?

- 1 Yes → **Go to Q73D**
- 2 No } **Go to**
- 3 Don't Know }

73. D. How much time does he/she usually spend on the freeway? (Going to school in the MORNING?)

- 1 Less than 10 minutes
- 2 10-19 minutes
- 3 20-29 minutes
- 4 30-45 minutes
- 5 More than 45 minutes

74. A. How does your child usually get home from from school in the AFTERNOON? (Choose the one best answer)

- 1 Rides in a car, van or truck
- 2 Rides in a school bus
- 3 Rides in a city bus
- 4 Walks
- 5 Bikes
- 6 Other (**Specify**):

____

74. B. How much time does your child usually spend travelling home after school in the AFTERNOON?

- 1 Less than 10 minutes
- 2 10-19 minutes
- 3 20-29 minutes
- 4 30-45 minutes
- 5 More than 45 minutes

74. C. When your child goes home from school in the AFTERNOON, does he/she travel on the freeway?

- 1 Yes → **Go to Q74D**
- 2 No } **Go to Q75**
- 3 Don't Know }

74. D. How much time does he/she usually spend on the freeway? (Going home from school in the AFTERNOON?)

1 Less than 10 minutes
2 10-19 minutes
3 20-29 minutes
4 30-45 minutes
5 More than 45 minutes

CURRENT HOUSEHOLD MEMBERS

75. Counting yourself, how many people 18 years of age OR OLDER live in your child's home?

1 1 | 3 3 | 5 5 | 7 7
2 2 | 4 4 | 6 6 | 8 8 or more

76. Counting your child, how many people UNDER 18 years of age live in your child's home?

1 1 | 3 3 | 5 5 | 7 7
2 2 | 4 4 | 6 6 | 8 8 or more

77. How many siblings does your child have? Include brothers/sisters and half-brothers/half-sisters. (Fill in the number in each category)

________ older siblings of child
________ younger siblings of child
________ same age (such as twin brother and/or sister)

Now we would like to ask some questions about you as the parent/guardian answering the questionnaire.

78. What is your gender?

1 Female 2 Male

79. What is your relationship to this child?

1 Biological mother or father
2 Adoptive mother or father
3 Step mother or father
4 Grandparent
5 Legal guardian
6 Other primary adult

80. Is English your primary language?

1 Yes 2 No

81. What is the highest grade or educational level you completed?

1 Did not graduate from high school
2 High school graduate
3 Some education after high school
4 College graduate
5 Post-college education

82. A. Is there another primary adult (for example, your spouse or your partner) living in your household?

1 Yes → **Go to Q82B**
2 No → **Go to Q83A**

82. B. What is the highest grade or educational level completed by this other adult?

1 Did not graduate from high school
2 High school graduate
3 Some education after high school
4 College graduate
5 Post-college education
6 Don't know

83. A. Is your child currently covered by health insurance?

1 Yes → **Go to Q83B**
2 No
3 Don't Know } **Go to**

83. B. Is the health insurance for your child paid for by: (Mark all that apply.)

1 Your work
1 Your spouse's work
1 The government (Medi-Cal, for example)
1 Self-pay
1 Other (**Specify**):

____

84. In which one of the following categories was your total household income for the last calendar year? (Include all income, before taxes and deductions, for all members of your family):

1 Less than $15,000
2 $15,000 to $19,999
3 $20,000 to $29,999
4 $30,000 to $39,999
5 $40,000 to $49,999
6 $50,000 to $59,999
7 $60,000 to $79,999
8 $80,000 to $99,999
9 $100,000 or more

We want to send you a check for **$10** to thank you for your help with this important study. To make sure the check can reach you, please fill in your name, address and telephone number.

Your Name: ___________________________________

Address: ________________________ Apt # ______

City: _______________ State_____ Zip code _______

Phone number: ________________________________

THANK YOU FOR COMPLETING THE EAST BAY CHILDREN'S RESPIRATORY HEALTH STUDY QUESTIONNAIRE!
