Proposed Projects for Approval at the July 2020 CARB Board Meeting

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Ambient Air Pollution and COVID-19 Disease Severity or Death among Confirmed Cases in Southern California 7

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PROJECT TITLE: Impact of Air Pollution on COVID-19 Case and Death Risk in California

PRIME CONTRACTOR: University of California, San Francisco,

SUBCONTRACTOR(s): Public Health Institute

PRINCIPAL INVESTIGATOR(s): Peggy Reynolds, Ph.D.

CONTRACT TYPE: Interagency Agreement

BUDGET: $105,493

CONTRACT TERM: 12 Months

For further information, please contact Dr. Barbara L. Weller at (916) 324-4816.

I. SUMMARY

Long-term exposure to air pollution is emerging as one of the most important risk factors for deaths from coronavirus disease 2019 (COVID-19) infections. A preliminary study from Harvard has shown that an increase in 1 μg/m^3 in PM2.5 was related to an 8% increase in COVID-19 death rates in the U.S. The Harvard study, while helpful in introducing the concern of a linkage between air pollution and COVID-19 needs to be repeated in California with more specific data at a smaller scale. Given the high levels of pollution in California and the concern for community and individual exposure to air pollution this study is critical to be able to determine the vulnerability of Californian's to COVID-19. Using more spatially refined data on case/death counts and exposure estimates, the investigators propose to study the relationship of several air pollutants: PM2.5, PM10, NO2 and ozone, with COVID-19 case/death rates in California. The University of California, San Francisco (UCSF) will focus not only on long-term exposures, but also more proximal exposures before the COVID-19 outbreak. UCSF will also be able to examine the risk of more severe cases of COVID-19 using hospitalization and Intensive Care Unit (ICU) counts, and also focus specifically on the impact of COVID-19 on environmental justice and vulnerable communities in California. After obtaining exposure estimates and address-level COVID-19 data, the investigators will assemble an analysis dataset in a Geographic Information System (GIS) platform, which will link health and exposure data with other important covariates. Covariate

datasets will include the American Community Survey (ACS), the Behavioral Risk Factor Surveillance System (BRFSS), CalEnviroscreen, U.S. Census, and other data as needed. Areas will be adjusted for testing rates as possible. Multivariable and mixed statistical models will be performed on the data as appropriate to estimate COVID-19 risk. The sensitivity of the results to additions/removals of key covariates will be examined. A final report and metadata will be provided to CARB upon completion. The Harvard study, while helpful in introducing the concern of a linkage between air pollution and COVID-19 needs to be repeated in California with more specific data at a smaller scale. Given the high levels of pollution in California and the concern for community and individual exposures to air pollution this study is critical to be able to determine the vulnerability of Californian's to COVID-19.

II. TECHNICAL SUMMARY

Objective

In April 2020, a Harvard group conducted a preliminary cross-sectional study[1] to examine whether long-term exposure to PM2.5 increased COVID-19 death risk in the U.S. There is an opportunity to significantly improve on the research from the Harvard study when examining this issue in California, the most polluted and most populated state in the U.S. Therefore, UCSF proposes to conduct a study with a design that is similar to the Harvard study, except with more spatially refined exposure estimates for multiple air pollutants, and will examine COVID-19 deaths, confirmed/unconfirmed case counts, and counts of COVID-19 cases which have been hospitalized and in the ICU.

UCSF will use this approach to address the following hypotheses:

1) Residents living in areas with higher long-term (12-month average) ambient concentrations of air pollution will have higher COVID-19 case and death rates, and higher severity rates (as measured by hospitalization and ICU status) than residents of areas with historically better air quality.

[1]Wu X, Nethery RC, Sabath BM, Braun D, Dominici F. 2020. Exposure to air pollution and COVID-19 mortality in the United States. medRxiv (preprint and not yet peer reviewed). doi: https://doi.org/10.1101/2020.04.05.20054502

2) Residents living in areas with higher short-term (1-month averages for the last 3, 6, and 12 months) ambient concentrations of air pollution will have higher COVID-19 case and death rates, and higher severity rates than residents of areas with currently better air quality.

3) The above relationships will persist even when data are stratified by potential effect modifiers such as population density, access to health care, race/ethnicity, income, co-morbidities, obesity, other social/demographic factors, and regional differences for time of infection.

4) Disparities in exposure to air pollution may explain a significant portion of the observed disparities in COVID-19 morbidity and mortality in the African American population and other disadvantaged communities in California.

Background

Long-term exposure to air pollution is emerging as a possible important risk factor for deaths from COVID-19. In a recent study, Wu et al. (the Harvard study) using data from 3,000 U.S. counties (98% of the population) examined whether long-term exposure to PM2.5 increased COVID-19 death risk, and found that an increase in 1 $\mu g/m^3$ in PM2.5 was related to an 8% increase in COVID-19 death rates. However, the Harvard study has the following limitations: 1) using long-term county-level PM2.5 averages as the exposure, thereby introducing exposure misclassification; 2) examining COVID-19 death rates at the county level; 3) only examining one pollutant, PM2.5, while other pollutants—such as PM10, ozone, and NO2—could play an important role; 4) only examining death rates, while case counts (as a measure of incidence) and cases which have been hospitalized or in ICU (as a measure of severity) can broaden the view of impact and also increase the sample size; 5) only examining long-term exposure to PM2.5, given the well-established short-term effects of air pollution on a number of health outcomes, it may be instructive to also investigate the impact of air pollution exposures more proximal to the COVID-19 outbreak; 6) with a much higher risk of COVID-19 deaths and cases being seen in African-American populations, direct attention should be given to the role of race/ethnicity and historic exposure to environmental toxicants on COVID-19 risk.

Proposal Summary

UCSF would like to request address data for COVID-19 cases and deaths from the California Department of Public Health (CDPH). UCSF will request data on confirmed and unconfirmed cases, number of tested cases, and if the patients have been hospitalized or in the ICU. UCSF will also request any other individual-level demographic attributes and personal/clinical characteristics of the cases that are available. The data will first be geocoded. If address-level data of cases are not obtainable, the investigators will have to use aggregated data at the census-tract level.

UCSF will work with CARB and other investigators to gather the most recent modeled statewide data on PM2.5, PM10, Ozone, and NO2 at the most spatially refined level possible. As more temporally proximate modeled exposure data may not be available, proximate exposure data may need to be kriged or interpolated from regulatory monitor data. UCSF will be accessing the following data sources for covariate/confounder data: 1) smoothed census tract estimates on obesity and smoking from the BRFSS; 2) demographic variables by census tract from the 2018 ACS; 3) data on hospitalizations and emergency room visits for relevant comorbid risk factors, such as cardiovascular disease and COPD, from the Office of Statewide Health Planning and Development (OHSPD), which will be used as covariates and linked by ZIP code to the COVID-19 case and death counts; 4) meteorological data (as a covariate, as particulate matter and COVID-19 risk is likely affected by temperature and humidity) from NASA, Google, and/or weather stations; 5) other data as needed.

UCSF will first perform data cleaning, run descriptive statistics, and calculate age-specific COVID-19 case and case fatality and case-specific death rates. Stratified analyses of data by race/ethnicity, income, population density, and other covariates will be performed. Environmental Justice analyses will be conducted, including analysis of COVID-19 case/death rates with disadvantaged communities and residential segregation. Mixed effects multivariable regression models will be used to analyze the association of exposures and COVID-19 cases and outcomes adjusting for covariates, with attention to spatial correlation.

<u>Tasks</u>

1. Project leads will obtain necessary IRB approvals from UCSF, PHI, and CPHS.
2. Project team will geocode the address level data and assign to census tracts and other political boundaries as needed.
3. Project team will assemble health, and confounder/covariate data from various data sources.
4. Project team will link all the data sources in a GIS database.
5. Project team will perform appropriate statistical analysis of the data.
6. Project team will have check-ins by phone with CARB staff every two weeks.
7. Project team will write preliminary draft report for approval for CARB.
8. Project team will perform sensitivity analyses of the data results.
9. Project team will write final report.
10. Peer review of final report.
11. Project team will write final manuscript for publication, will assemble metadata and documentation.

PROJECT TITLE:	Ambient Air Pollution and COVID-19 Disease Severity or Death among Confirmed Cases in Southern California
PRIME CONTRACTOR:	University of California, Los Angeles
SUBCONTRACTOR(s):	Kaiser Hospital Foundations, University of California, Davis University of California, Berkeley
PRINCIPAL INVESTIGATOR(s):	Michael Jerrett, PhD
CONTRACT TYPE:	Interagency Agreement
BUDGET:	$607,967
CONTRACT TERM:	12 Months

For further information, please contact Dr. Barbara L. Weller at (916) 324-4816.

I. SUMMARY

The COVID-19 pandemic represents one of the largest threats to population health in more than a century. Biologically plausible reasons suggest that air pollution may make people more susceptible to contracting COVID-19, and once they have the disease, air pollution exposure may contribute to a worse prognosis. The objective of the study is to assess whether air pollution exposures lead to worse outcomes in confirmed COVID-19 cases among members of the Kaiser Permanente Southern California (KPSC) HMO. The wealth of individual information on the members of this cohort can help to determine the role of air pollution exposure in a worsening of COVID-19 disease including admission to hospital, admission to the ICU, advanced oxygen treatment or being put on a ventilator, and death in hospital. The individual information included in the health data will enable the investigators to examine whether exposure gradients along socioeconomic status, race, and ethnicity are partly responsible for a worse prognosis of some patient groups (e.g., non-whites) as well as examining the impacts of preexisting conditions. Contractors will use advanced land use regression exposure modeling to estimate ambient concentrations of several common air pollutants, including nitrogen dioxide, fine particulate matter ($PM_{2.5}$), and ozone. Contractors will also use chemical transport models (CTMs) to estimate speciated fine and ultra-fine

particles. These CTMs also enable researchers to examine specific sources of the particles, and to link these estimates to all confirmed cases in the KPSC database. These data will be to assess whether higher chronic air pollution contributes to worse COVID-19 progression in diagnosed patients.

II. TECHNICAL SUMMARY

Objective

The main objective of the study will be to assess whether air pollution exposures such as nitrogen dioxide, fine particulate matter ($PM_{2.5}$), and ozone lead to worse outcomes in confirmed COVID-19 cases who are members of the Kaiser Permanente Southern California (KPSC) HMO.

Background

Given the high risk of death and serious debilitating complications that may result from COVID-19, it is critical to determine whether air pollution worsens the prognosis for patients infected with COVID-19. Such findings are relevant to the mission of the CARB to protect public health and provide additional support of the need for health protective air pollution standards in California.

This work is also important to the CARB because large portions of California, particularly in the Central Valley and the Southern California, continue to experience levels of air pollution that exceed California standards; thus these regions may be at higher risk of COVID-19 serious complications and death. The contractors anticipate the findings will have widespread relevance for regulatory interventions. The focus on other neighborhood and racial-ethnic susceptibilities may also supply important information on the environmental justice implications of Covid-19 and ambient air pollution exposures.

Proposal Summary

The proposed study will assess whether air pollution exposures lead to worse outcomes in confirmed COVID-19 cases who are members of the

KPSC HMO, including admission to hospital, admission to the ICU, advanced oxygen treatment or being put on a ventilator, and death in hospital. KPSC tracks all health care provided to its members through an Electronic Health Record (EHR) System, started back in 2007. This EHR data provides a wealth of longitudinal information on patients' history of diagnoses, demographics, vital signs, laboratory values, health care utilization, health insurance type (e.g., Medicare) and home addresses. For hospitalized patients, KPSC will provide nursing flow sheets and procedures codes that allow the investigators to identify patient information, such as mental or ambulatory state and various types of oxygen therapy. The investigators will assess severity of COVID-19 outcomes as (1) need for hospitalization; (2) need for ICU admission and/or intensive respiratory care, including mechanical ventilation and high flow oxygen therapy; and (3) in-hospital deaths. The investigators will also examine whether exposure gradients along socio-economic status, race, and ethnicity are partly responsible for worse prognosis of some patient groups (non-whites). The focus on other neighborhood and racial-ethnic susceptibilities may also supply important information on the environmental justice implications of Covid-19 and ambient air pollution exposures. The findings from the proposed study will be anticipated to have widespread relevance for regulatory interventions.

Tasks:

1. To compile data on all confirmed COVID-19 patients in the KPSC health system. These data will be linked to air pollution concentration data and other neighborhood factors such as social deprivation to support several statistical models.

2. To develop 1 km surfaces of ambient fine and ultrafine particles across the Southern California study domain for 2016, which includes the 5 counties of the Los Angeles metropolitan area, San Diego county, and Kern county. Particle surfaces will be developed using a well-validated chemical transport model (CTM). The model predicts mass estimates along with speciated estimates and likely source profiles.

3. To extend a land use regression model nitrogen dioxide (NO2), fine particulate matter (PM2,5) and possibly ozone to cover the 2018-2019 period. Earlier estimates from similar land use regression models produced highly accurate small-area predictions with R^2 values in the range of 75% explained variance. These models are supported by more than 500 field observations from previously completed research and from government monitors.

4. To join all the confirmed COVID-19 cases to the pollution surfaces generated in Aims 2 and 3.

5. To assess the association in two complimentary statistical modeling approaches.
    - The first would use a case-control design, where all COVID-19 cases are admitted to hospital or the ICU. Controls would be drawn from confirmed COVID-19 cases matched by age, race, and sex. The investigators will also conduct sensitivity analyses with different control criteria that include body mass index (BMI) and pre-existing systems.
    - The second approach would use a time-to-event multi-state survival model, where the investigators hypothesize the COVID-19 cases with higher air pollution exposures will progress more quickly to hospital, ICU, advanced oxygen therapy or ventilator, and ultimately death.

TITLE:	Measuring, Analyzing and Identifying Small-Area VMT Reduction
PRIME CONTRACTOR:	University of California, Davis
PRINCIPAL INVESTIGATOR(s):	Susan Handy, Ph.D.
CONTRACT TYPE:	Interagency Agreement
BUDGET:	$199,500
CONTRACT TERM:	24 Months

For further information, please contact Dr. Sarah Pittiglio at (530) 574-1402.

I. SUMMARY

A key element of the state's effort to reduce greenhouse gas (GHG) emissions from transportation is the requirement that Metropolitan Planning Organizations adopt sustainable community strategies (SCSs) that demonstrate how the regions will reduce GHG emissions from autos and light trucks. However, the adoption of SCSs does not guarantee the adoption of policy and programming changes at the local level, nor on-the-ground changes in development that would produce a reduction in vehicle miles traveled (VMT) and associated GHGs. The goal of this project is to assess the degree to which on-the-ground changes in selected communities have produced reductions in VMT. A secondary aim is to examine the degree to which local and/or regional policy change brought about the observed on-the-ground changes. This project will complete a minimum of three case studies of local communities that have experienced substantial changes in the transportation system and/or land development patterns to assess the change in VMT that has resulted; the forces contributing to transportation and land use changes, including local and/or regional policy changes, will also be examined. These case studies may provide examples of best practices to achieve SCS goals as well as insights on barriers to successful SCS implementation.

II. TECHNICAL SUMMARY

Objective

Assess the degree to which local and/or regional policy related to transportation systems and land development patterns in selected California communities have produced reductions in VMT in order to inform best practices to achieve sustainable community strategy goals.

Background

CARB's research program helps to support the implementation of SB 375 and helps pave the way for the 2050 climate goal. SB 375 encourages California transportation, land use agencies to consider the GHG impacts of their planning processes, and requires Metropolitan Planning Organizations to create "sustainable communities strategies" that describe how VMT and associated GHG emissions will be reduced to meet state climate goals.

SB 150 requires CARB to produce a report for the legislature every four years on progress made in implementing SB 375, including the status of each of California's 18 metropolitan planning organizations in meeting their regional GHG emission reduction targets. Although transportation planning efforts across the state have identified strategies intended to reduce VMT, the real world application of these strategies is not yielding the anticipated reductions.

Proposal Summary

The goal of this project is to develop an in-depth understanding of changes in travel behavior resulting from changes in land-use patterns and the transportation system in specific case study areas. In essence, the goal is a "before-and-after" study of the effects of such changes, but the study is being conducted after the fact and thus will be relying on available and/or reconstructed sources of "before" data. In this project, the Contractor will complete at least three case studies of areas where substantial transportation and land-use changes have taken place within the last decade.

The first part of the case-study analysis focuses on identifying the causal factors: what changes occurred in the area and what forces brought about those changes? An important question here is the degree to which transportation and land use changes resulted from public policies and programs versus market forces.

The second part of the case-study analysis focuses on the outcome: how did VMT change in the area over the period of time, and what conditions enhanced or dampened the change in VMT? To the degree possible, the case studies will draw on data and analysis in a companion project that is using "big data" to assess changes in VMT throughout the state (hereafter called "the companion project").

In addition, the case studies will draw on several on-going University of California, Davis (UCD) projects, including 1) a Caltrans-funded study using survey methods to examine the adoption of policies by local governments in California to support transit oriented development, and 2) a CARB-funded study to identify key metrics for tracking transportation project outcomes funded through California Climate Investment (CCI) programs. Findings from these studies will inform the analysis of case study areas and provide insights into land use changes and the availability of project-level data for assessing VMT impacts of transportation investments.

This information will help to inform the next SB 150 report, the next Scoping Plan, and support CARB's SB 375 program by informing SCS guidelines and evaluation. The work may also be used to develop guidance or inform quantification methods for projects funded by the Greenhouse Gas Reduction Fund, and may also inform CARB comments on other funding program guidelines and review of associated applications (e.g., through SB 1).