EMORY

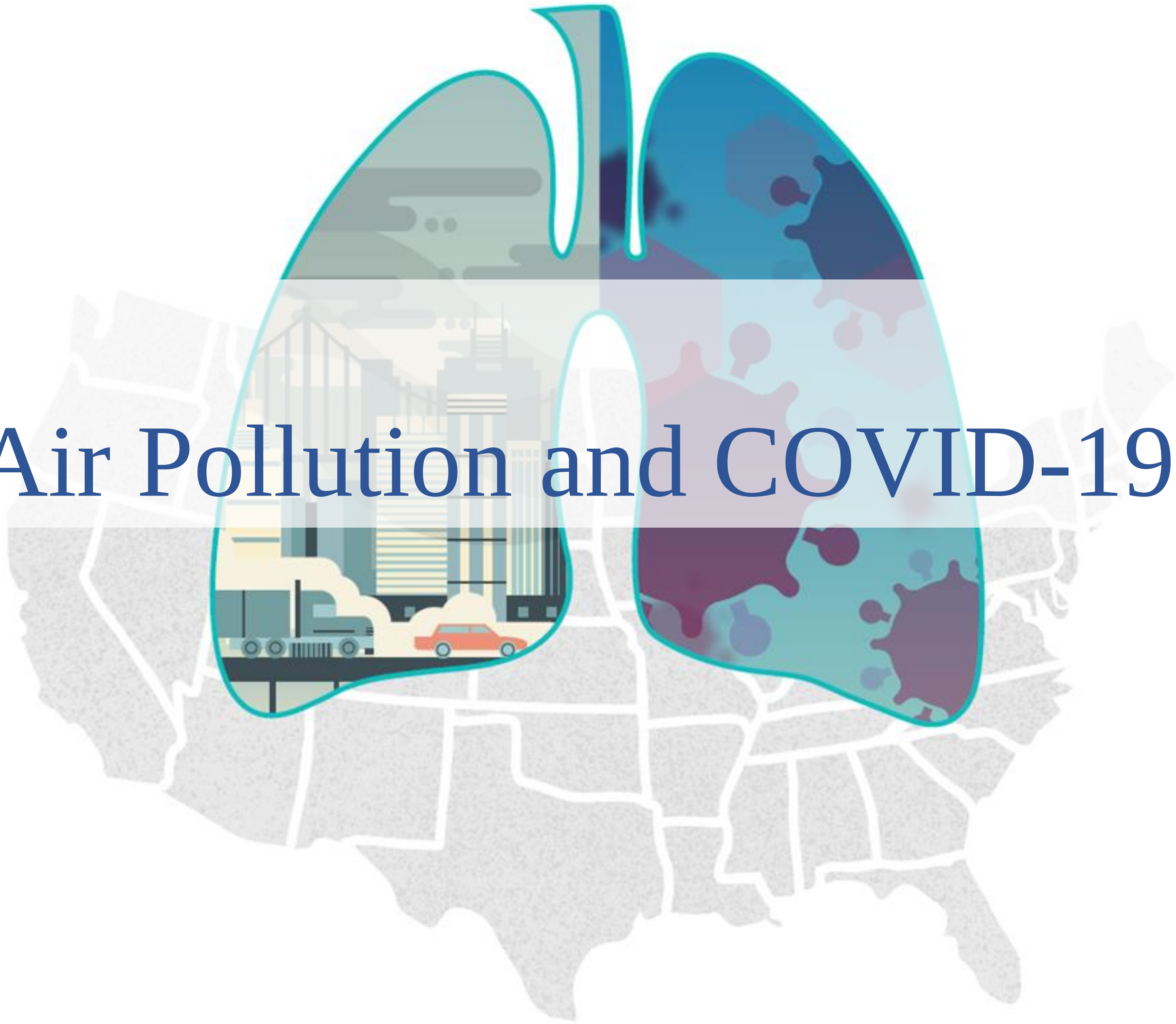
ROLLINS SCHOOL OF PUBLIC HEALTH

2022 Clean Air Council

Public Hearing

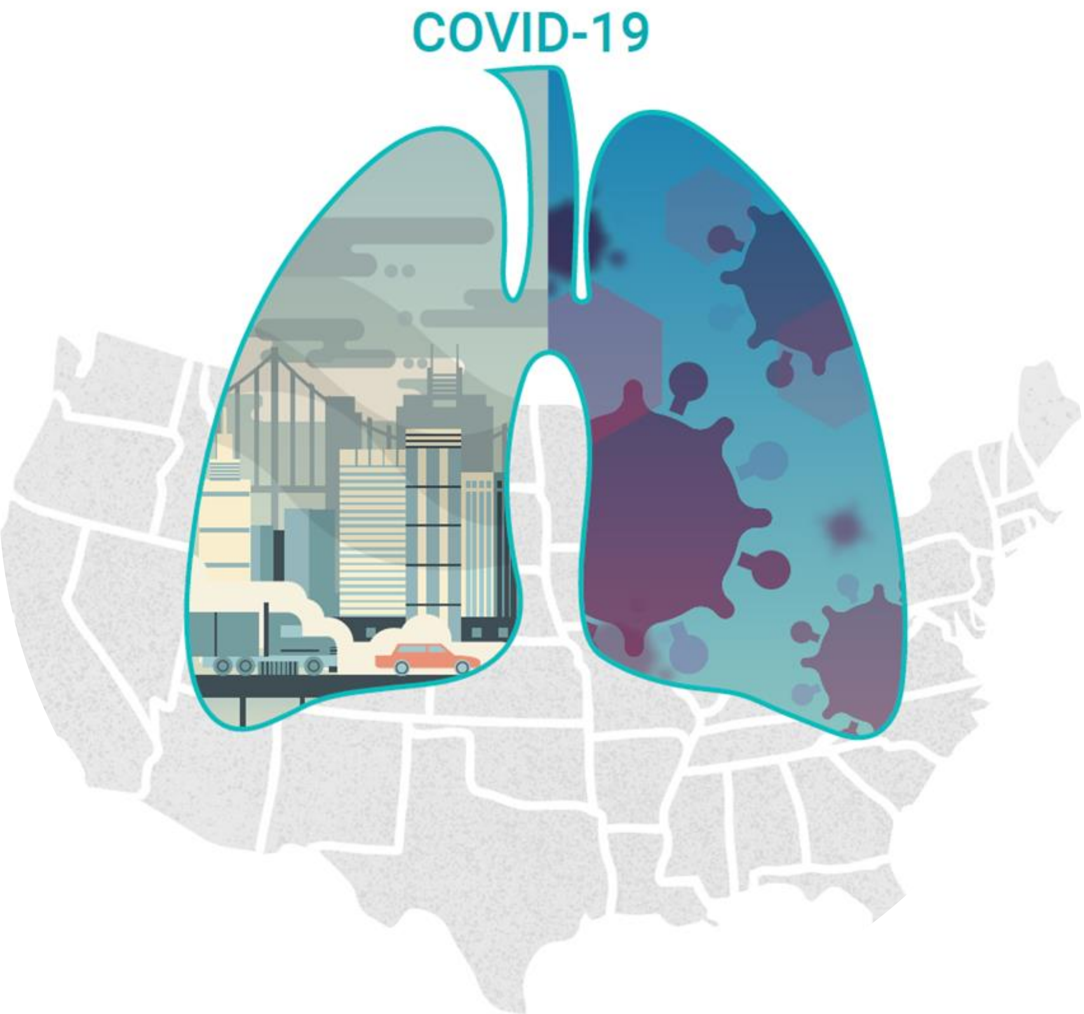
April 12, 2022

Air Pollution and COVID-19



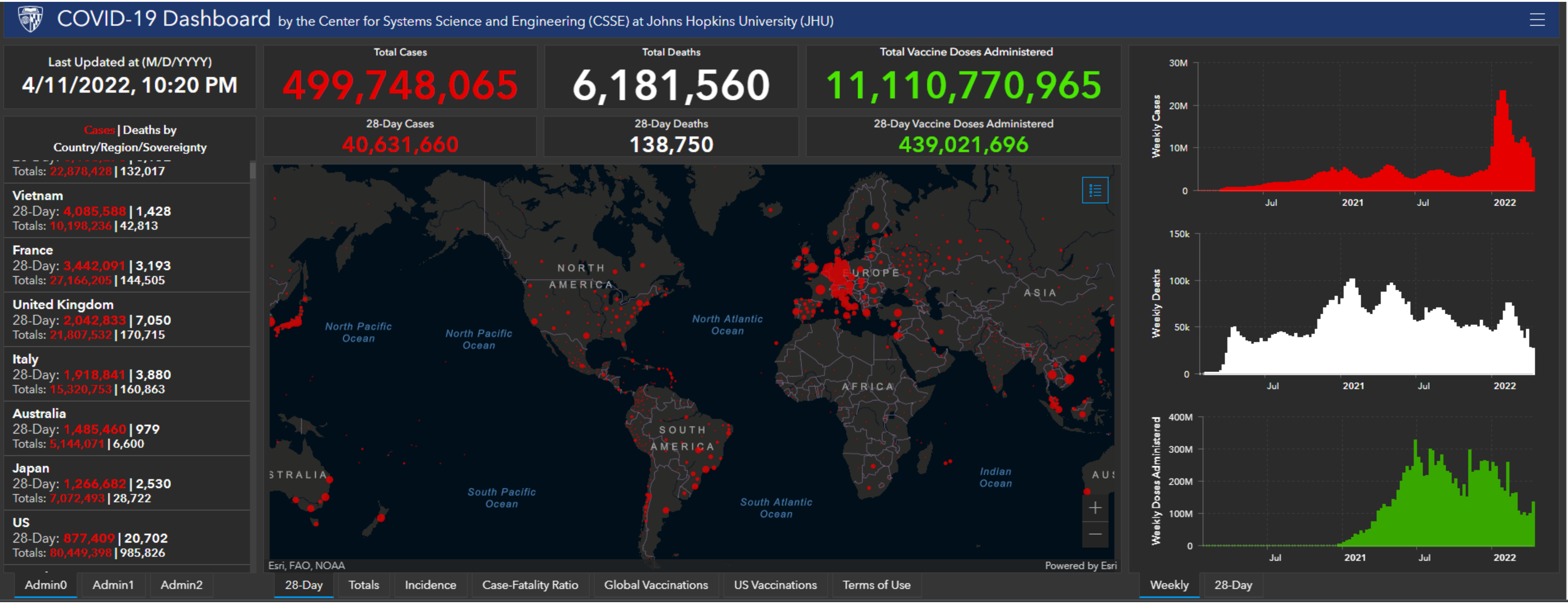
Donghai Liang, PhD

HERCULES EXPOSOME RESEARCH CENTER



Background Introduction

Background



https://coronavirus.jhu.edu/map.html

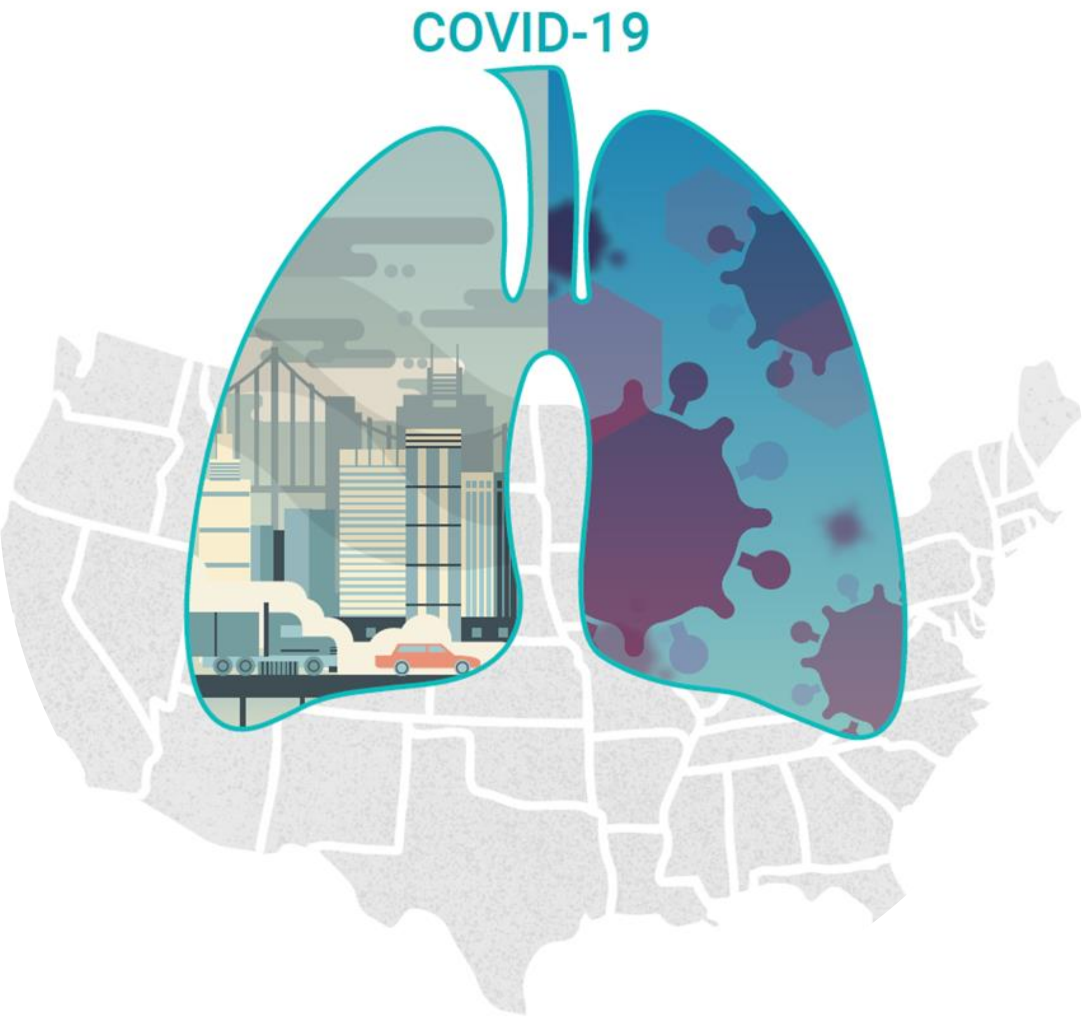
Background

Environmental factors may play an important role in increasing susceptibility to severe outcomes of COVID-19

Impact of ambient air pollution on excess morbidity and mortality has been well-established over several decades

Prolonged exposure to air pollution may have a detrimental effect on the prognosis of patients affected by COVID-19

Early findings revealed crude positive correlation between air pollution and COVID 19 mortality rate in China and Europe



Epidemiological Evidence

Objective

Conduct a nationwide study in the USA (3,122 counties) examining associations between multiple key ambient air pollutants, NO_2, $PM_{2.5}$, and O_3, and COVID-19 case-fatality and mortality rates in both single and multi-pollutant models, with comprehensive covariate adjustment

Hypothesis

Residents living in areas with higher long-term ambient air pollution levels may be more susceptible to COVID-19 severe outcomes, thus resulting in higher COVID-19 case-fatality rates and mortality rates among more heavily polluted counties

Liang and Shi et al., 2020 *The Innovation*

Method- COVID-19 Data

Official number of daily county-level COVID-19 confirmed cases and deaths that occurred from January 22, 2020 through July 17, 2020 in the US obtained from three independent databases:

The New York Times USAFACTS 1Point3Acres

COVID-19 confirmed case and death counts include both laboratory confirmed cases/deaths and presumptive positive cases/probable deaths

Data were compared and corrected across all databases for accuracy and consistency

Main outcome variables of the analysis

COVID-19 case-fatality rate = number of deaths over the number of people diagnosed for each US county with at least 1 or more confirmed case

COVID-19 mortality rate = the number of COVID-19 deaths per million population for each US county

Method- Exposure Assessment

Three major criteria air pollutants included:

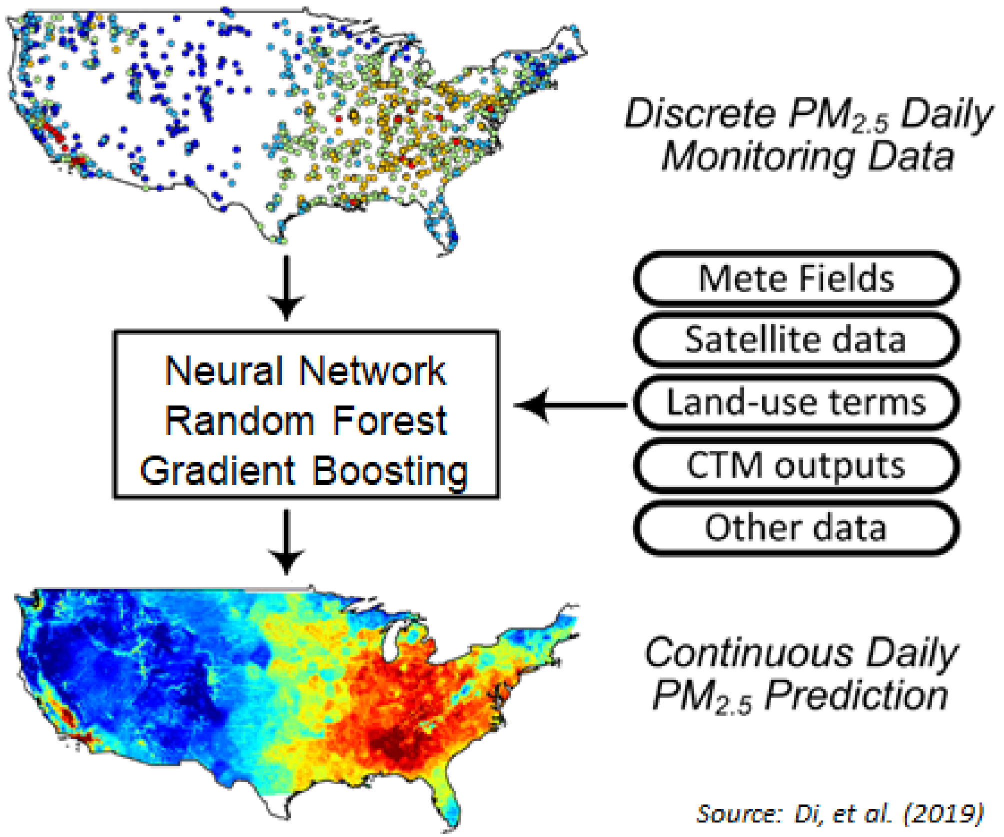
NO_2, $PM_{2.5}$, O_3

Daily ambient levels estimated at 1 km^2 spatial resolution across the Contiguous US using an ensemble machine learning model (Di, et al, 2019)

Annual mean (2010-2016) calculated for NO_2 and $PM_{2.5}$, and the warm-season mean (2010-2016) for O_3, defined as May 1 to October 31

Sensitivity analysis: annual mean between 2000-2016 as the county-level exposure estimates

High-resolution (1 km × 1 km) $PM_{2.5}$ for 2000-2016



Source: Di, et al. (2019)

Method- Statistical Analyses

Zero-inflated negative binomial mixed models (ZINB), comprising a negative binomial log-linear count model and a logit model to fit over-dispersed count data with extra zeros values

Single-pollutant, bi-pollutant, and tri-pollutant models fit separately

Control of potential confounders:
state-level test positive rate, county-level healthcare capacity, phase-of-epidemic, population mobility, population density, sociodemographics, socioeconomic status, race and ethnicity, behavioral risk factors, and meteorology

Also control for potential residual spatial trends and confounding by including spatial smoothers

Sensitivity analysis:
66 sets of sensitivity analyses to test the robustness of our results to outliers, confounding adjustment, and epidemic timing by omitting a different set of covariates for each model iteration and compared effect estimates

Results

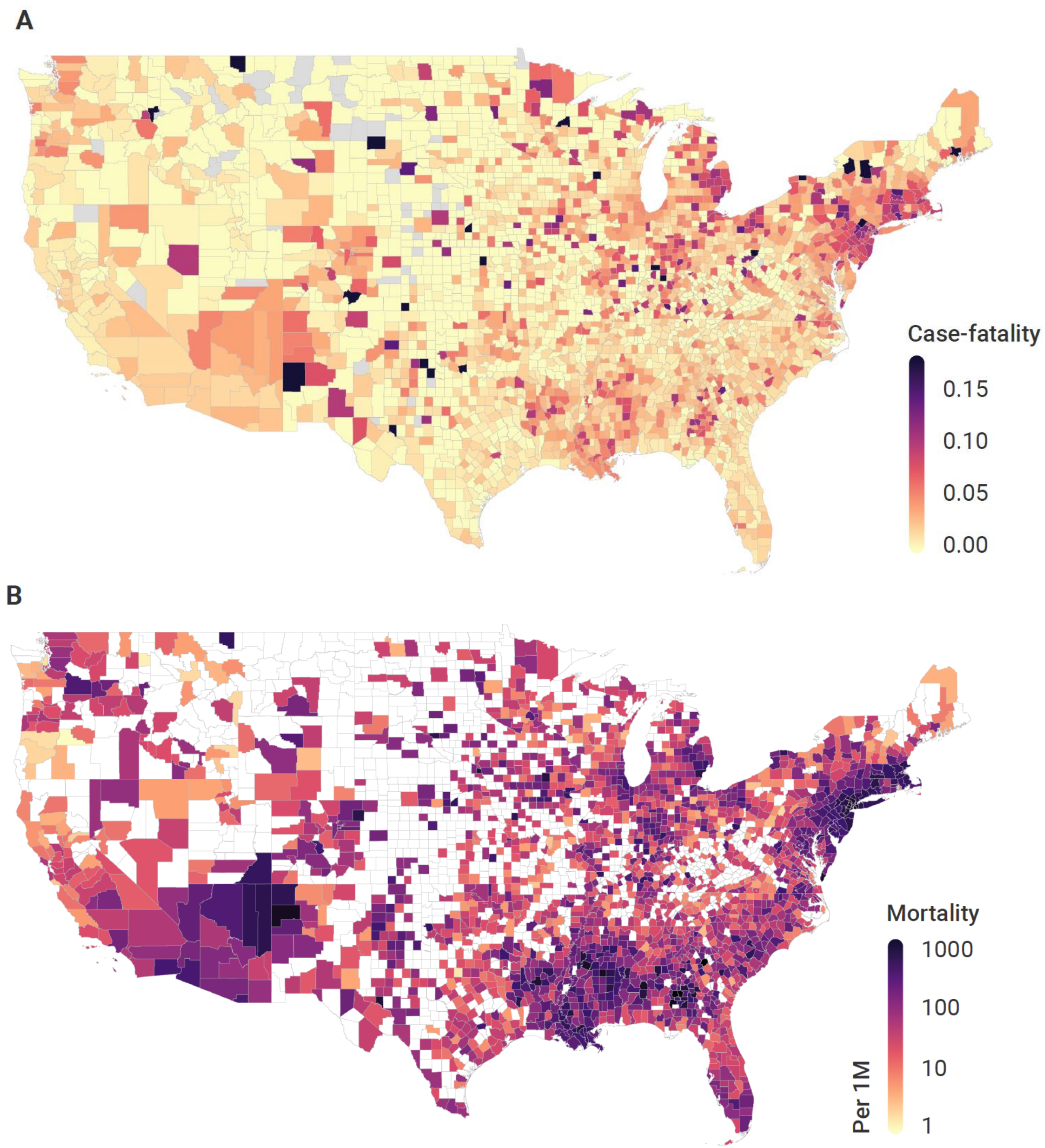
3,122 US counties considered in the current analysis

Between January 22, 2020 through July 17, 2020, 3,659,828 COVID-19 cases and 138,552 deaths reported in 3,076 (98.5%) and 2,088 (66.9%) US counties, respectively

Average county-level case-fatality rate: 2.4 ± 3.2%

Average mortality rate: 298.0 ± 412.8 per 1 million people

Spatial variations observed on COVID-19 case-fatality and mortality rates

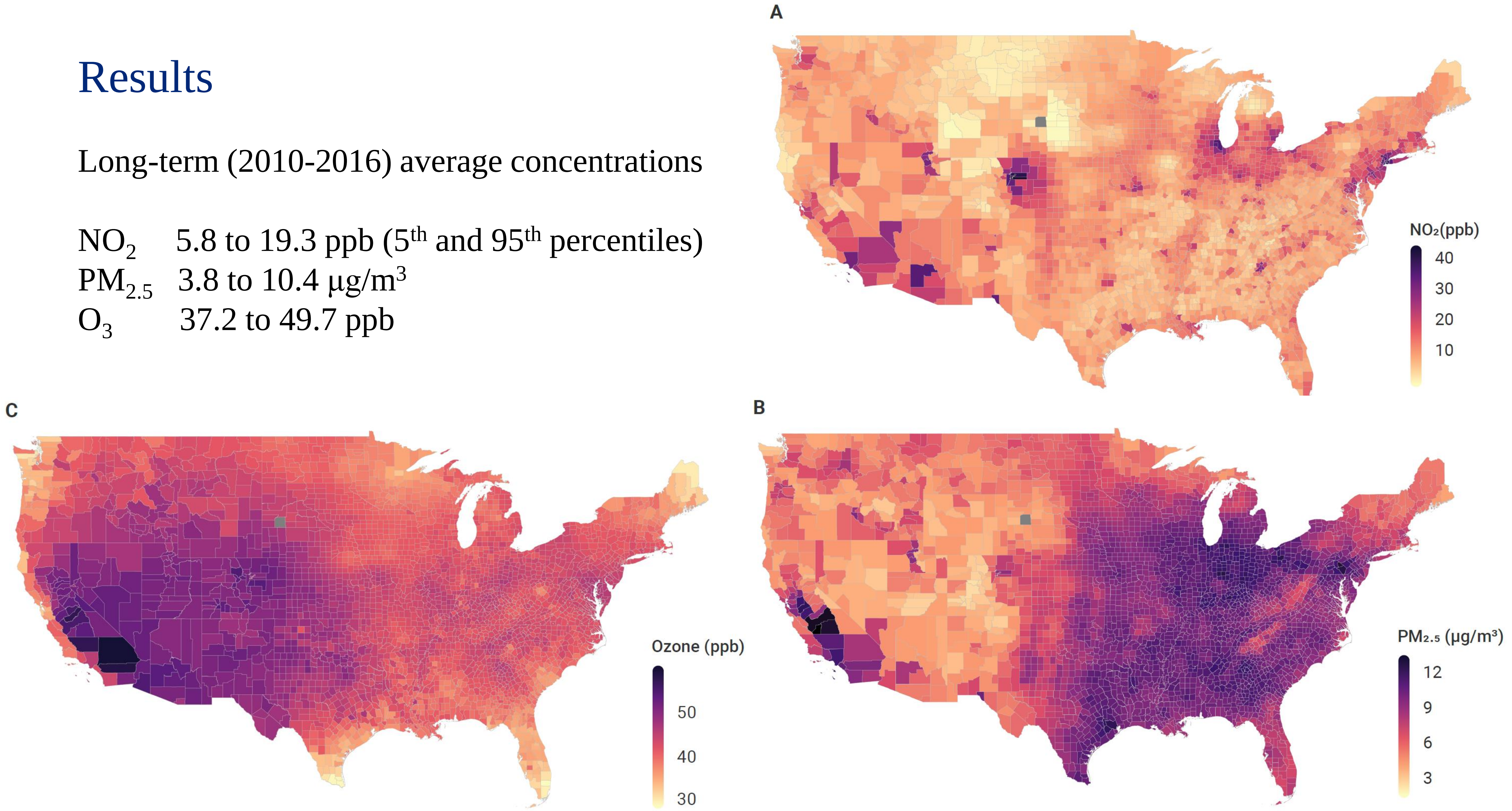


Liang and Shi et al., 2020 *The Innovation*

Results

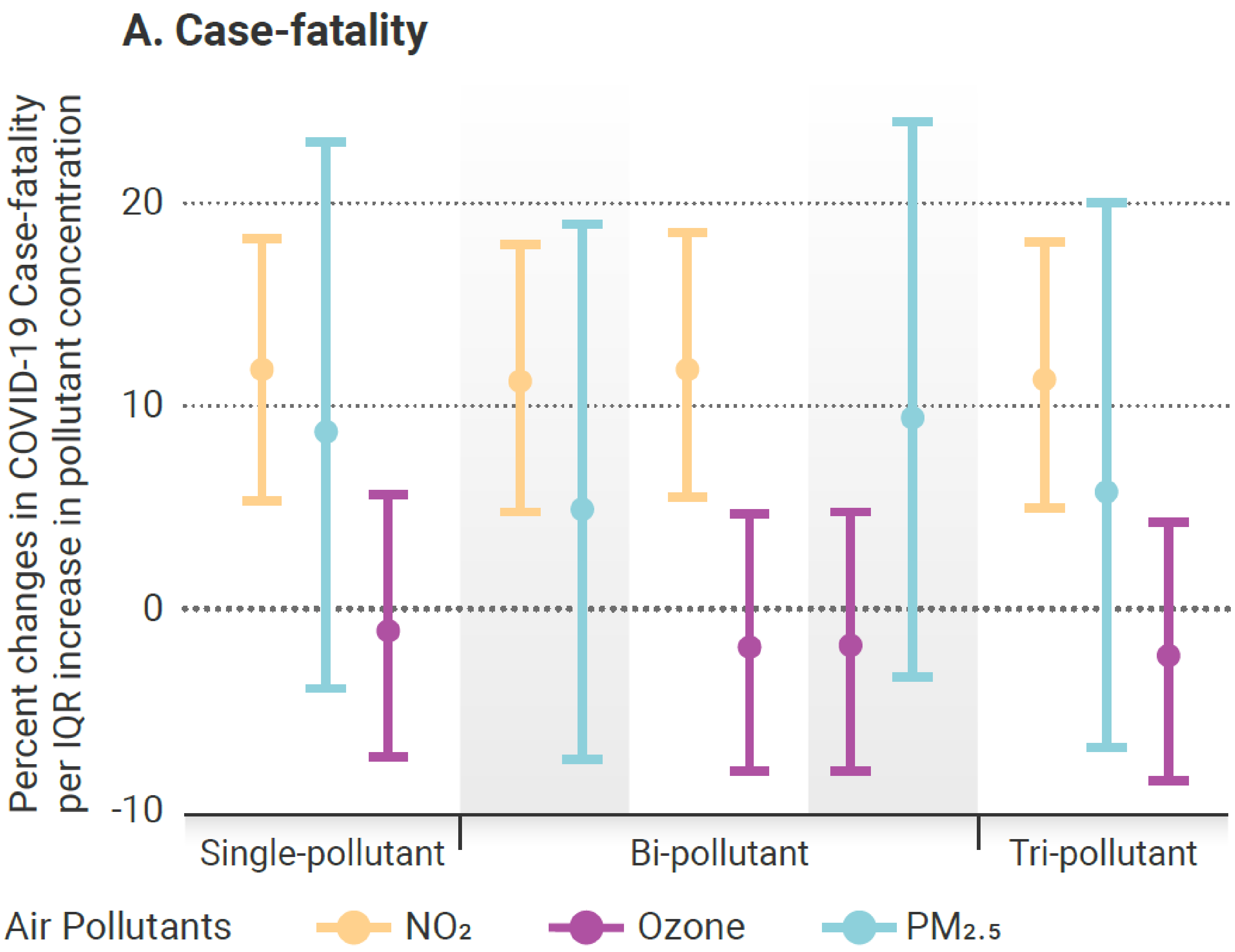
Long-term (2010-2016) average concentrations

NO_2 5.8 to 19.3 ppb (5th and 95th percentiles)
$PM_{2.5}$ 3.8 to 10.4 µg/m^3
O_3 37.2 to 49.7 ppb



Liang and Shi et al., 2020 *The Innovation*

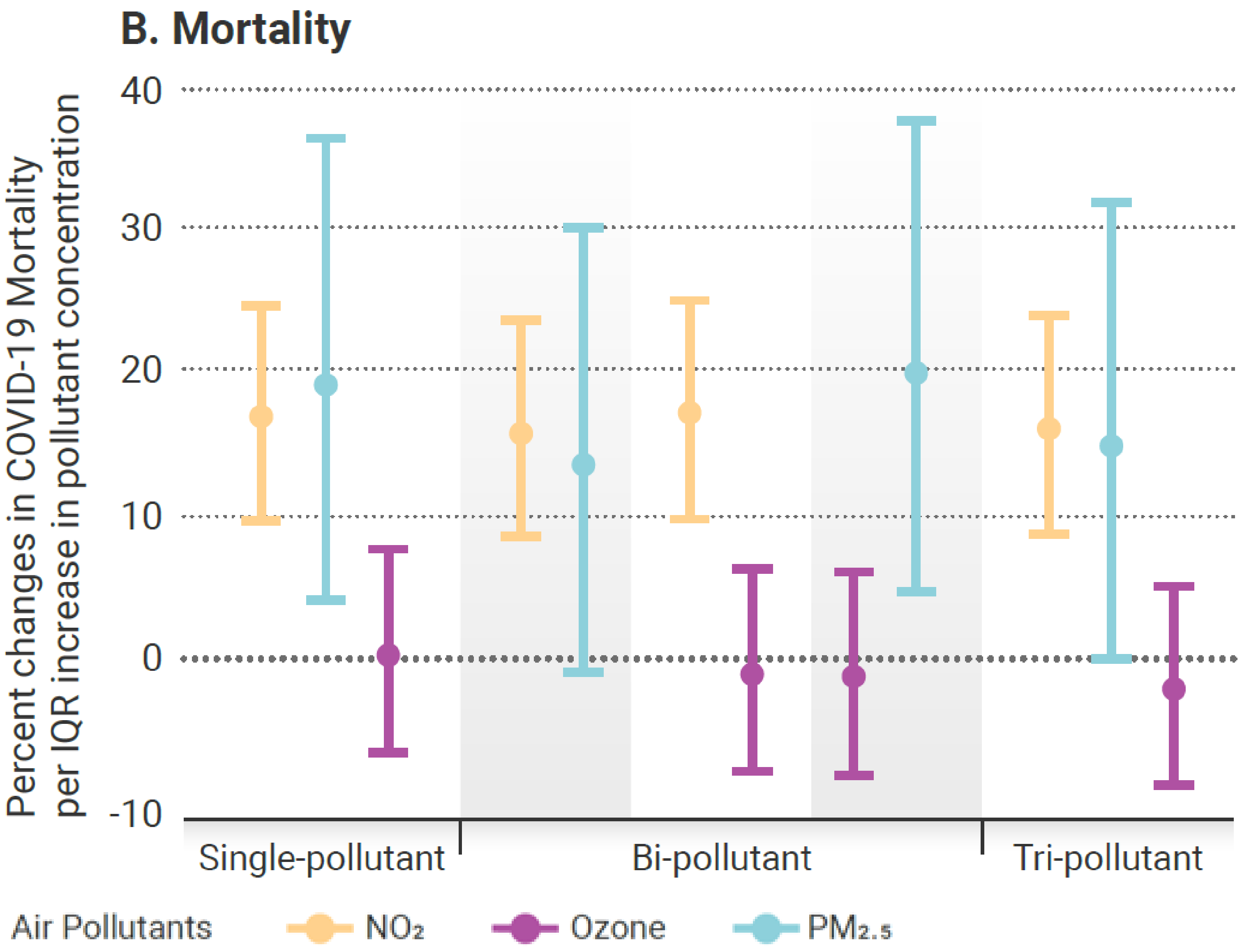
Results- Covid-19 Case Fatality and Long-term Air Pollution Exposures



- Per IQR (~4.6 ppb) increases in NO_2 was associated with 11.3% (95% CI 4.9% to 18.2%) in COVID-19 case fatality rate.
- Neither $PM_{2.5}$ (95% CI: -6.9% to 20.0%) or O_3 (95% CI: -8.6% to 4.2%) was associated with COVID-19 case-fatality rate
- One IQR reduction in long-term exposure to NO_2 level **<u>would have avoided 14,672 deaths</u>** among those tested positive for the virus.

Liang and Shi et al., 2020 *The Innovation*

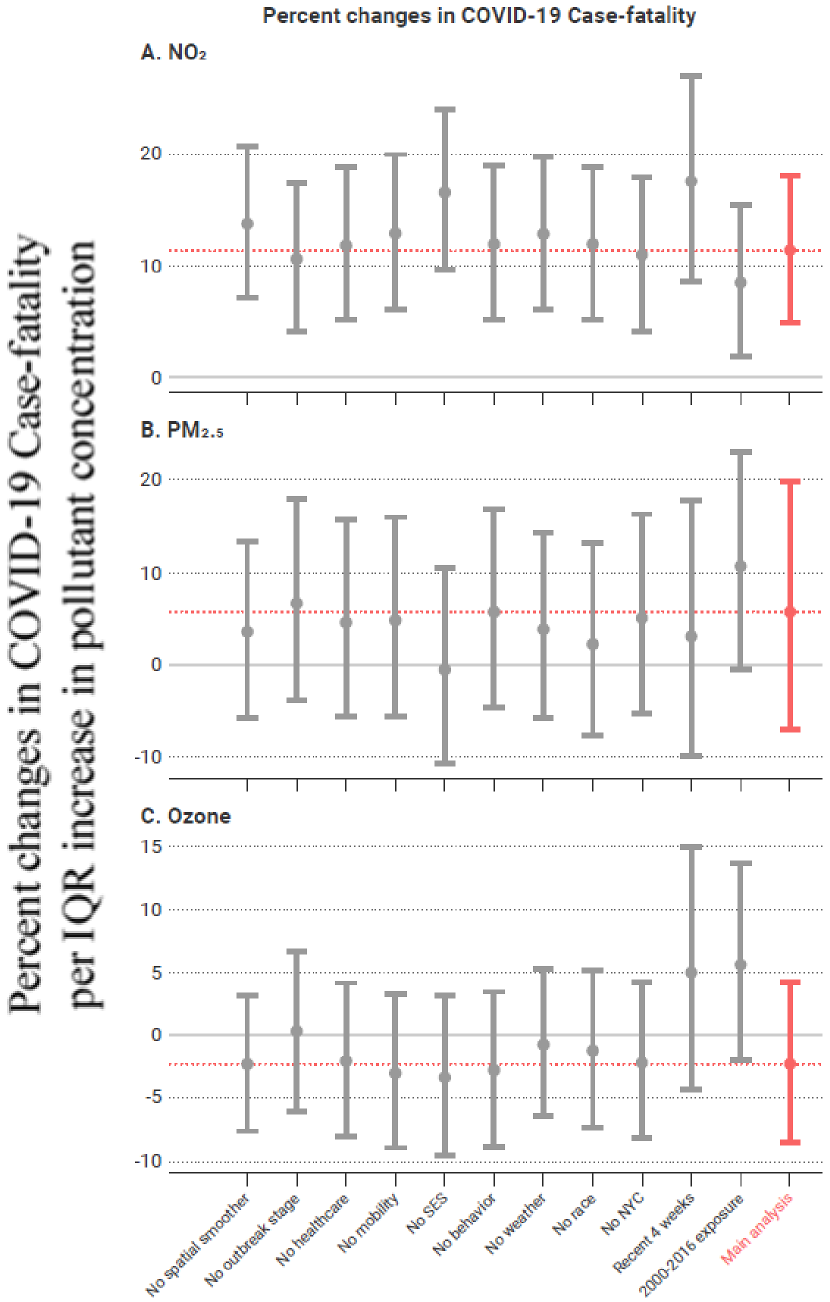
Results- Covid-19 Mortality and Long-term Air Pollution Exposures

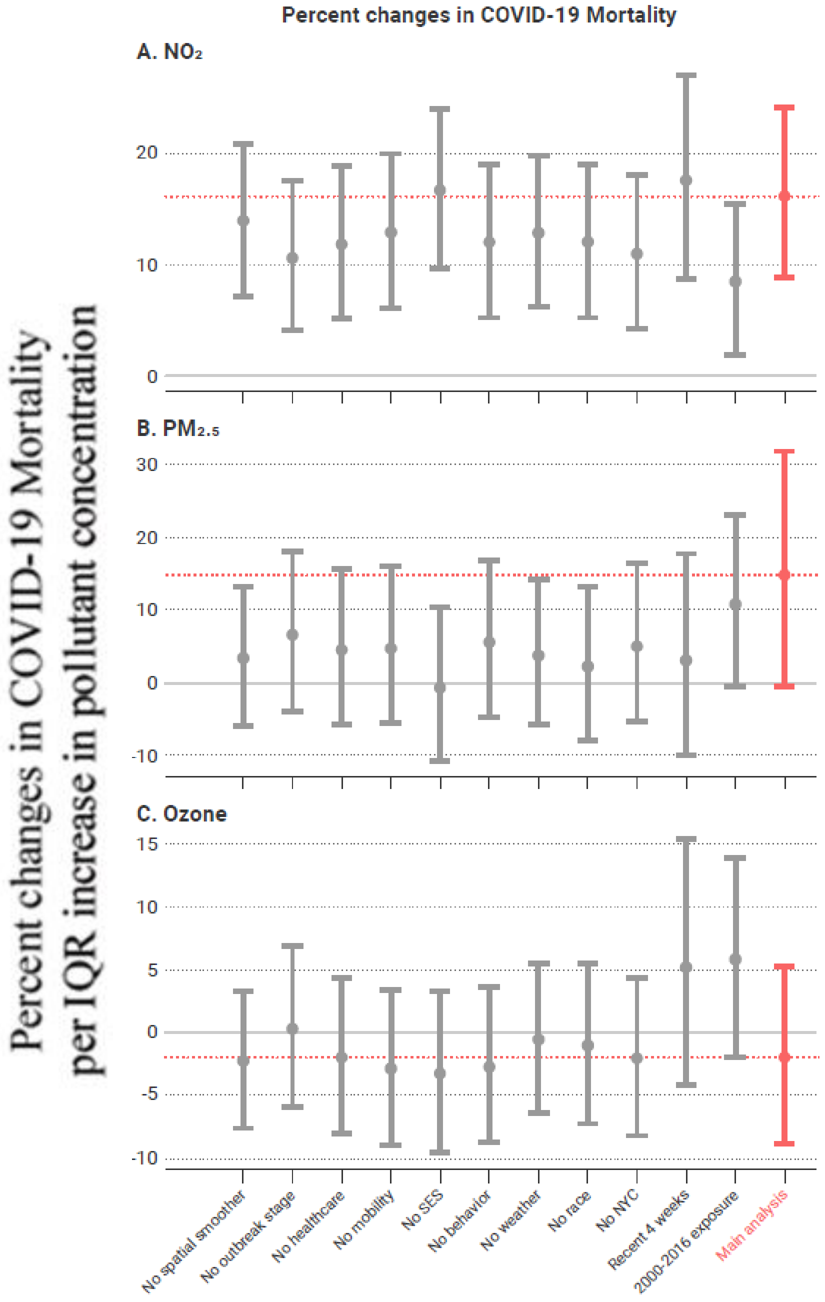


- Per IQR (~4.6 ppb) increases in NO_2 was associated with 16.2% (95% CI 8.7% to 24.0%) in COVID-19 mortality rate.
- Per IQR (~2.6 ug/m^3) increases in $PM_{2.5}$ was marginally associated with 14.9% (95% CI: 0.0% to 31.9%) in COVID-19 mortality rate.
- O_3 was not associated with COVID-19 mortality rate (95% CI: -8.9% to 5.1%)

Liang and Shi et al., 2020 *The Innovation*

Results- Sensitivity Analyses





Effect estimate in main model

Liang and Shi et al., 2020 *The Innovation*

Discussion

Potential link between urban air pollution and COVID-19 risk

- NO_2 levels associated with both county-level COVID-19 case-fatality rate and mortality rate
- Marginal association long-term $PM_{2.5}$ exposure and COVID-19 mortality rate
- Null associations were found for long-term O_3

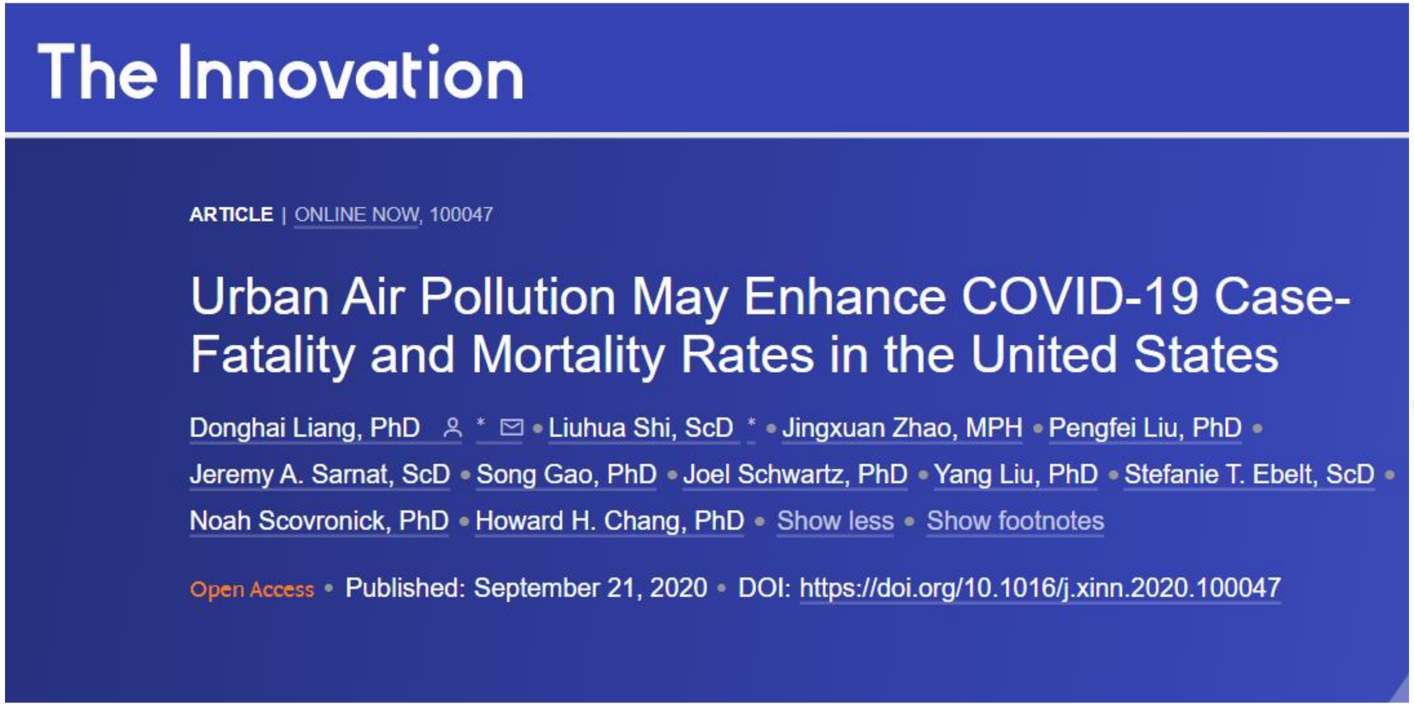
NO_2 may be an important risk factor of COVID-19 death

- NO_2 may enhance biological susceptibility to server COVID-19 outcomes

Public health actions needed to protect vulnerable populations

- Strengthened enforcement on social distancing and facial masking
- Expanding healthcare capacity
- Continuation and expansion of current efforts to lower traffic emissions and ambient air pollution

https://www.cell.com/the-innovation/fulltext/S2666-6758(20)30050-3 Liang and Shi et al., 2020 *The Innovation*



The Innovation

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Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States

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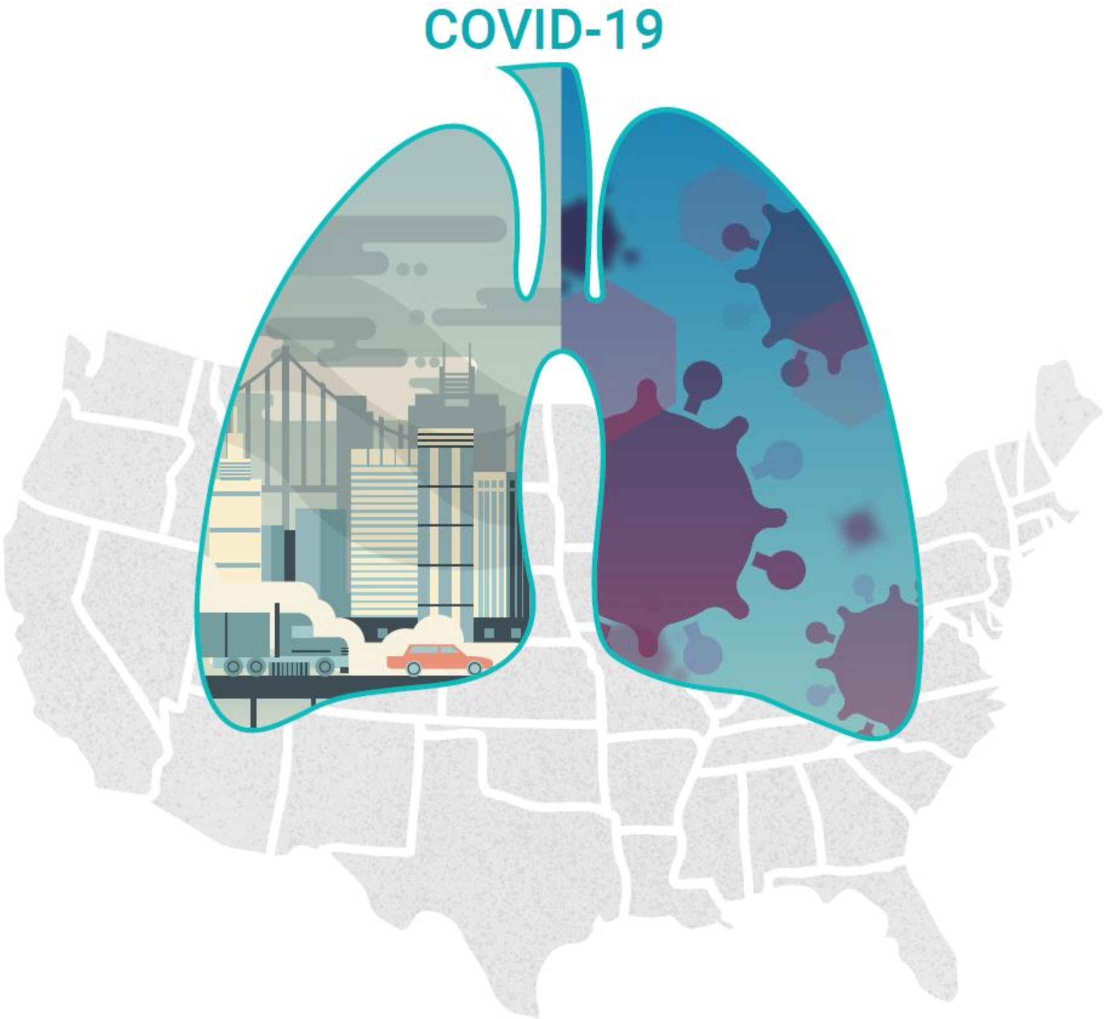

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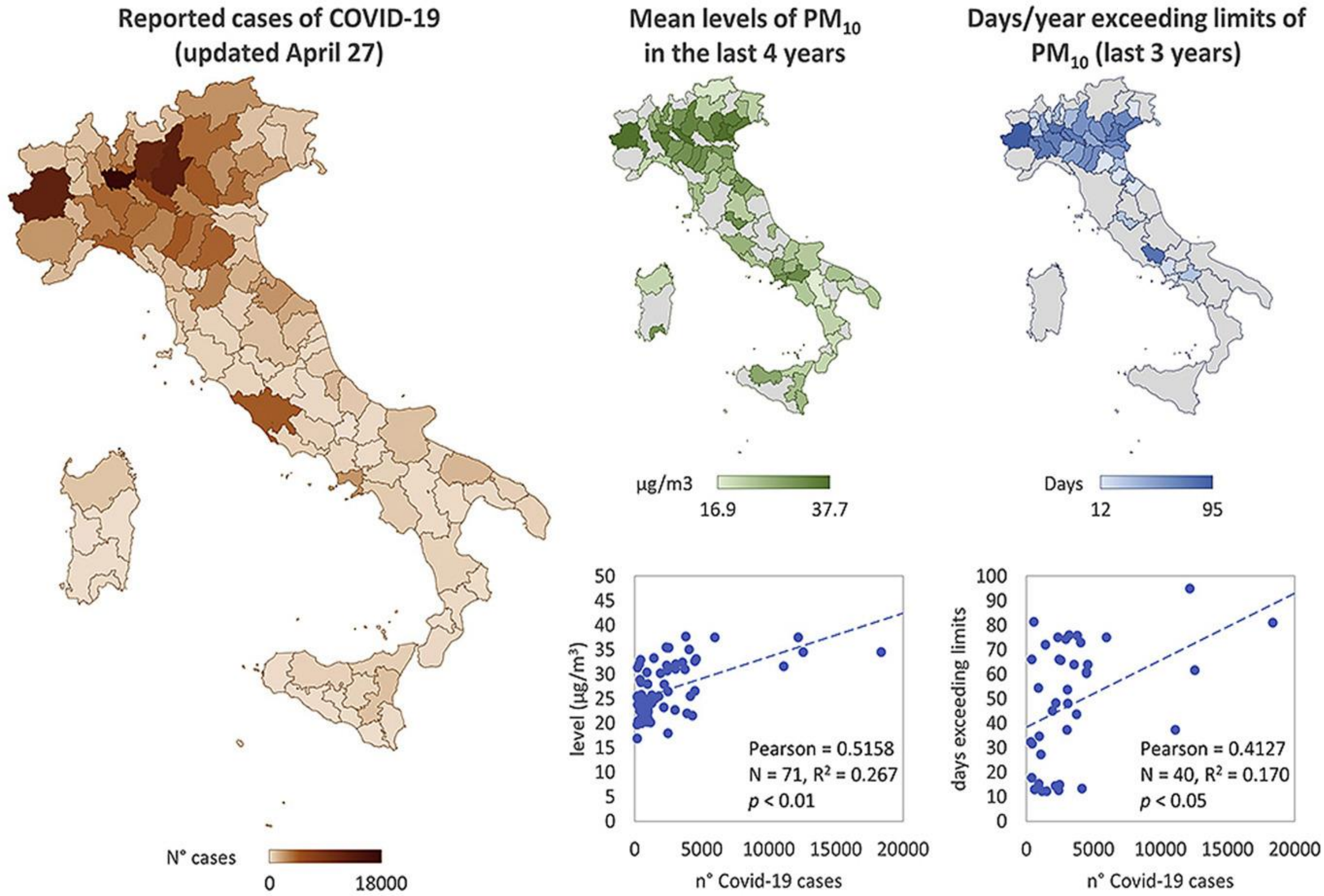
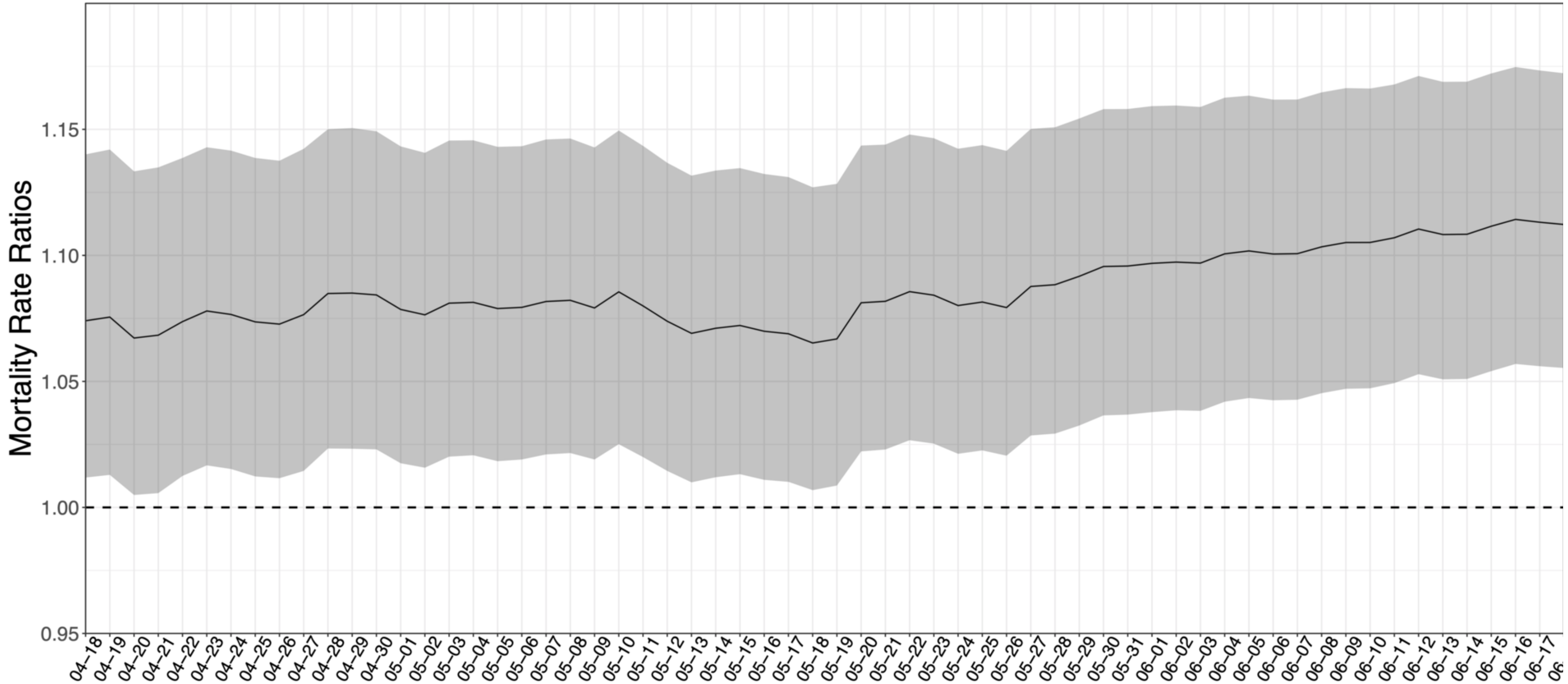
Liang and Shi et al., 2020 *The Innovation*



Fattorini et al., 2020



New Research Links Air Pollution to Higher Coronavirus Death Rates

Give this article 171

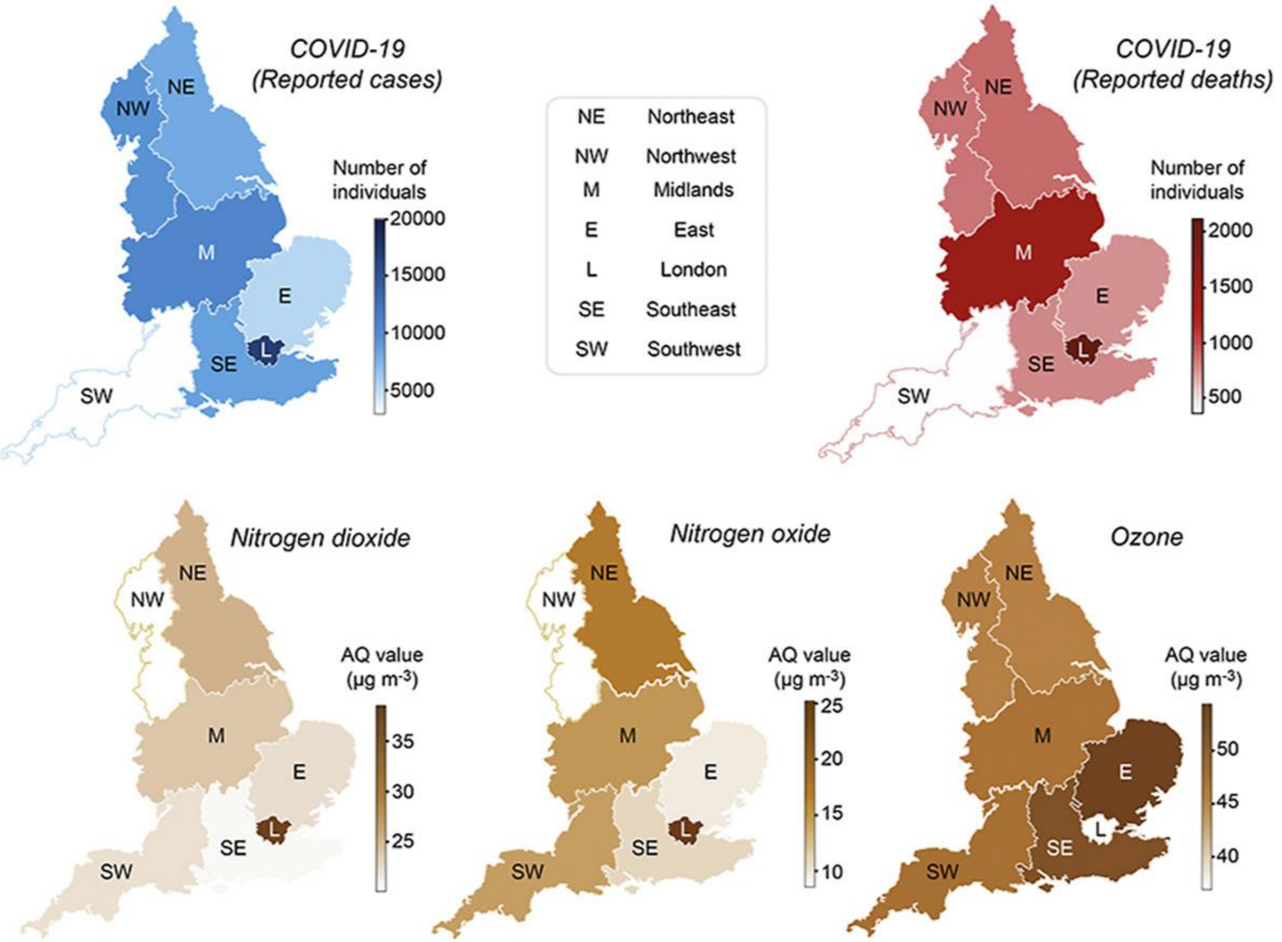
Atlanta on Saturday evening. The area is likely to suffer more deaths than the adjacent Douglas County, Ga. Kevin C. Cox/Getty Images

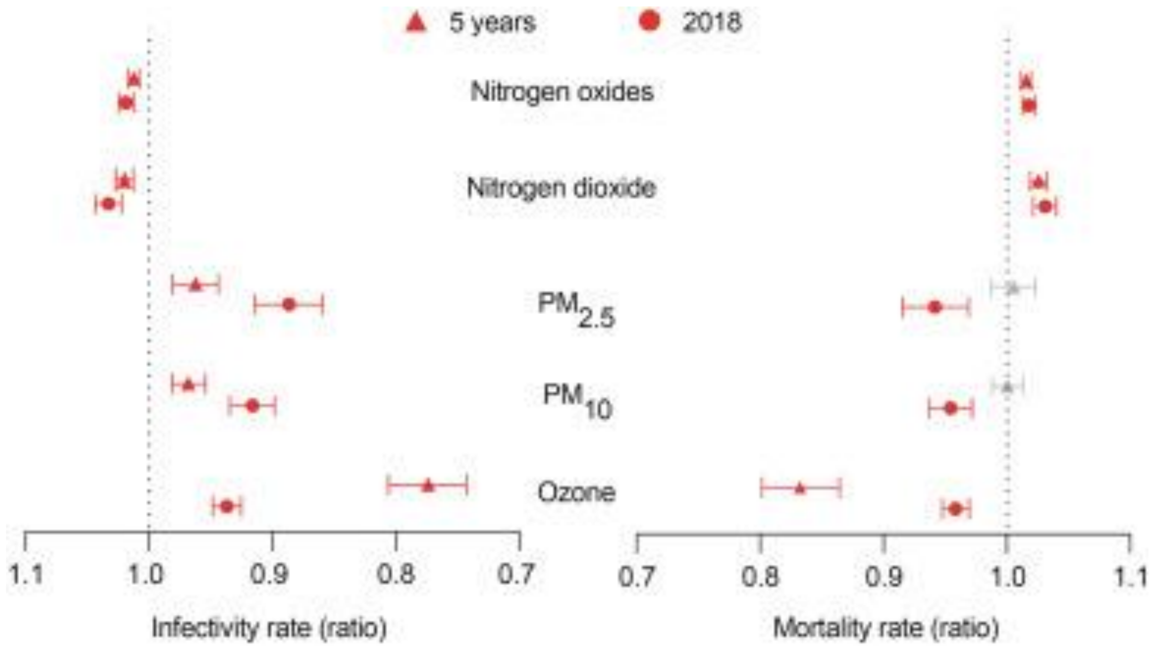
By Lisa Friedman

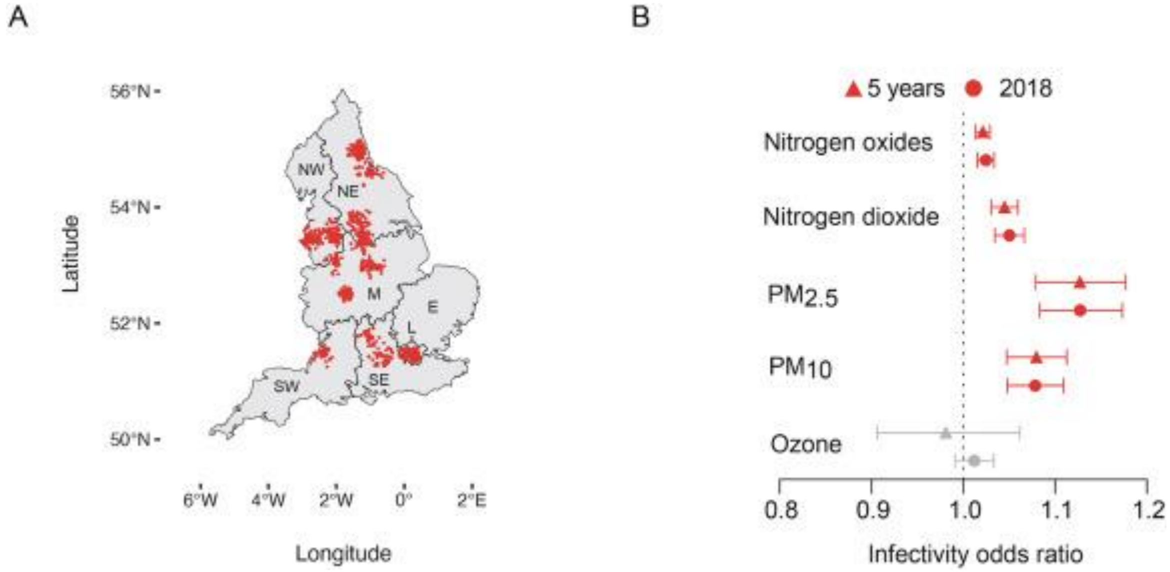
Published April 7, 2020 Updated April 17, 2020

Figure: COVID-19 mortality rate ratios (MRR) per 1 µg/m3 increase in $PM_{2.5}$ and 95% CI using daily cumulative COVID-19 death counts in US from April 18, 2020 to June 18, 2020.

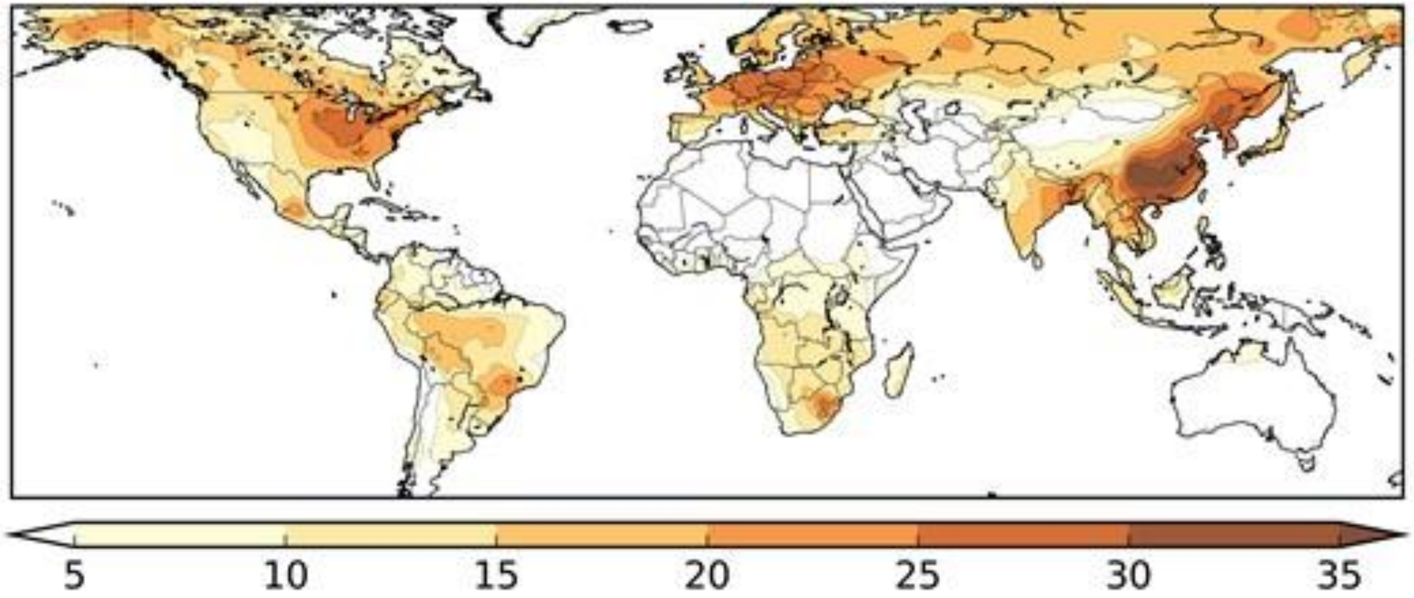
Wu et al., 2020

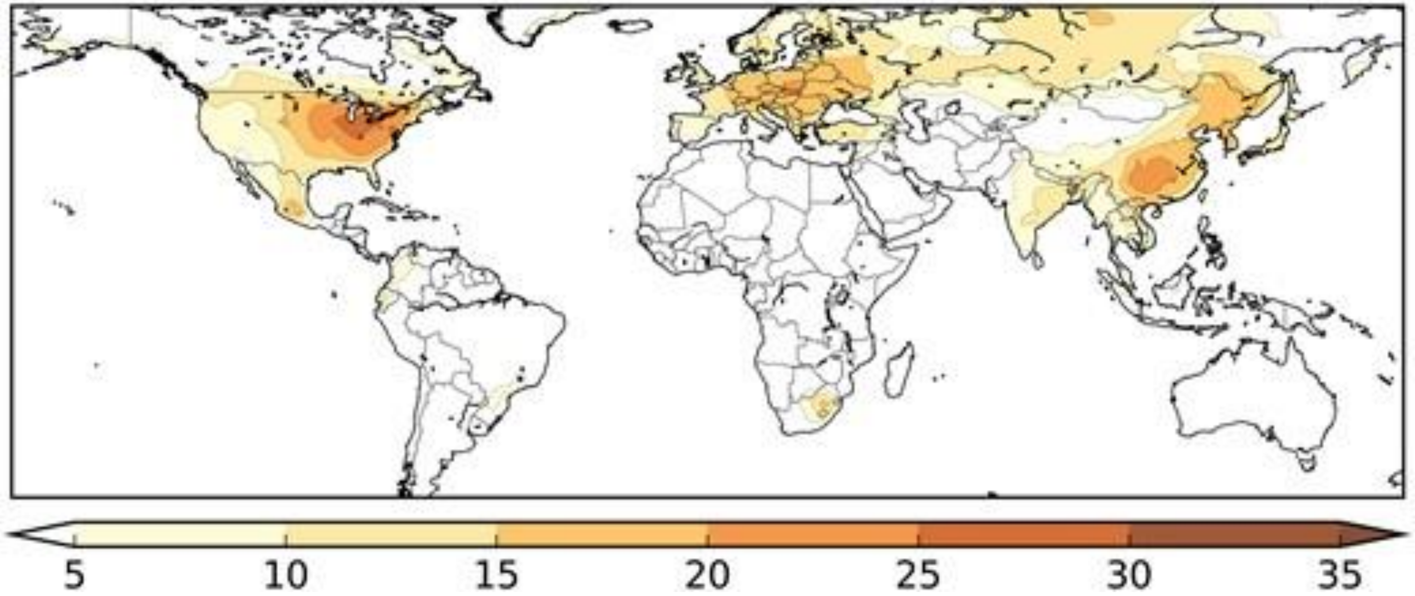






Travaglio et al., 2021





Particulate air pollution contributed ~15% (95% confidence interval 7–33%) to COVID-19 mortality worldwide
27% (13 – 46%) in East Asia
19% (8–41%) in Europe
17% (6–39%) in North America.

Globally, ~50–60% of the attributable, anthropogenic fraction is related to fossil fuel use, up to 70–80% in Europe, West Asia, and North America.

Estimated percentages of COVID-19 mortality attributed to air pollution from all anthropogenic sources (top), and from fossil fuel use only (bottom). The regions with high attributable fractions coincide with high levels of air pollution. The mapped results account for population density, thus reflecting population weighted exposure to PM2.5.

Pozzer et al., 2020

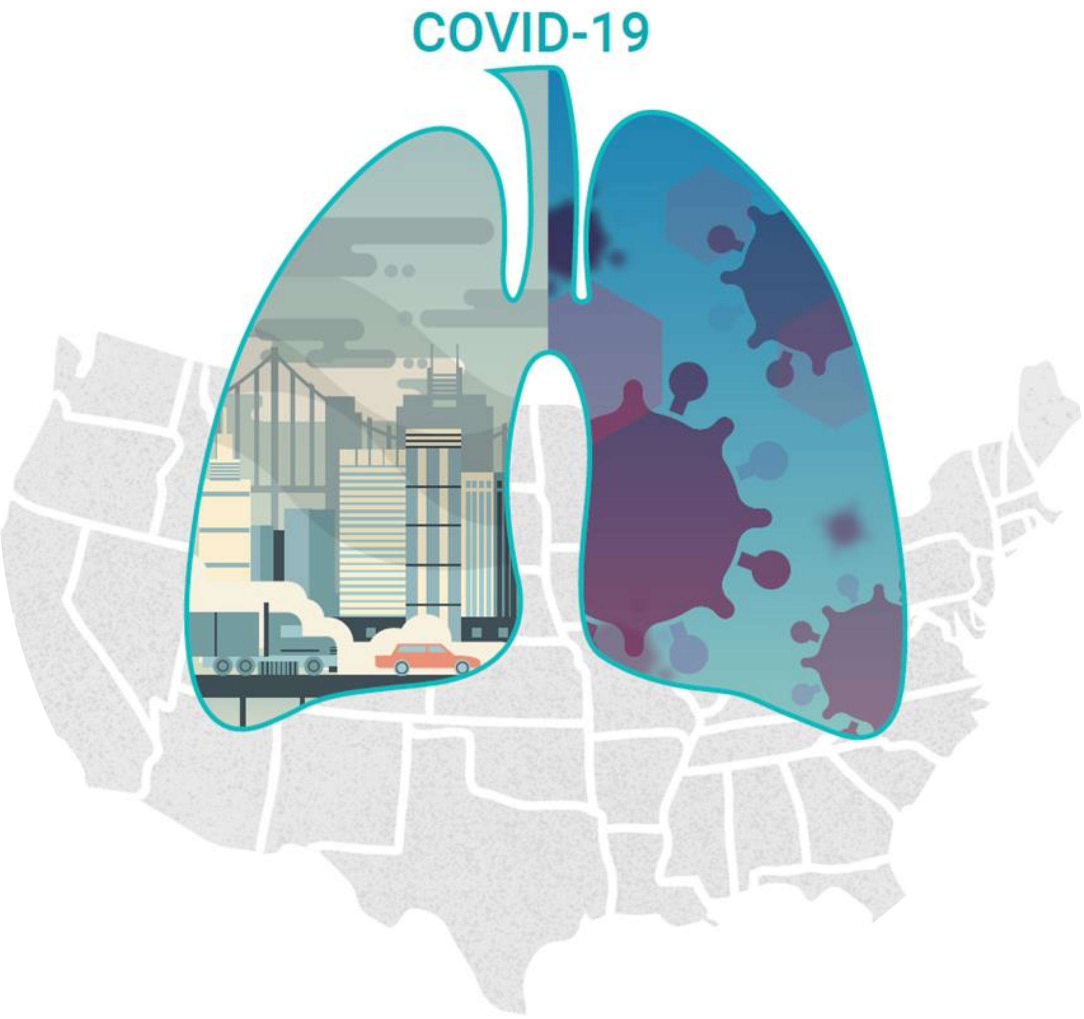
Environmental Research
Volume 203, January 2022, 111930

Positive association between outdoor air pollution and the incidence and severity of COVID-19. A review of the recent scientific evidences

Montse Marquès, José L. Domingo

Review on recent reviews on the influence of air pollution of the transmission of SARS-CoV-2 and the incidence and severity of COVID-19

- Significant association between chronic exposure to various outdoor air pollutants: $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2 and CO, and the incidence/risk of COVID-19 cases
- Significant association between chronic exposure to various outdoor air pollutants and the severity/mortality of the disease.
- Lack of evidence on other important air pollutants such as VOCs, dioxins and furans, or metals
- Some studies point to $PM_{2.5}$ and PM_{10} as potential airborne transmitters of the virus.
- Environmental air pollution plays an important negative role in COVID-19, increasing its incidence and mortality.



Potential Mechanism

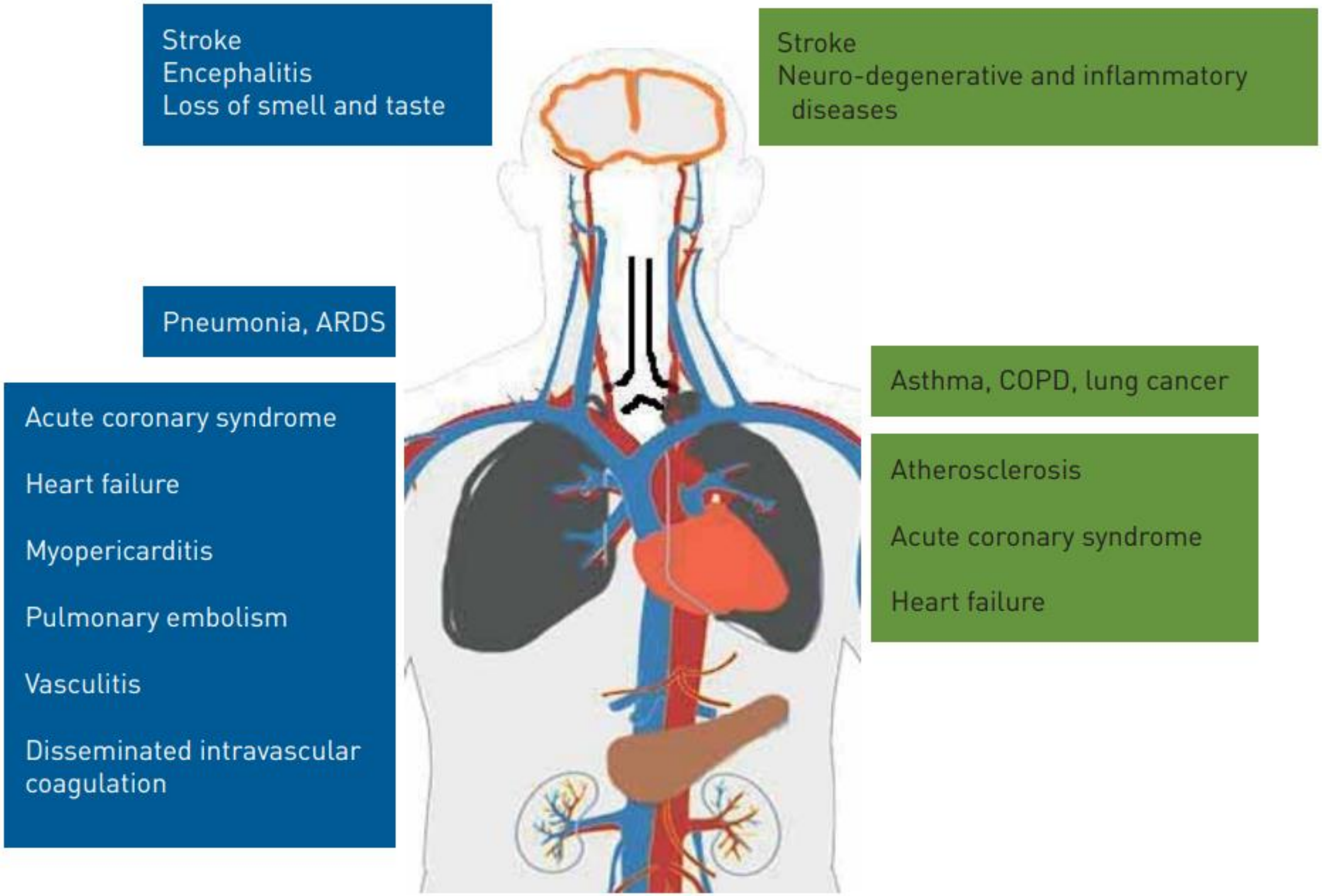
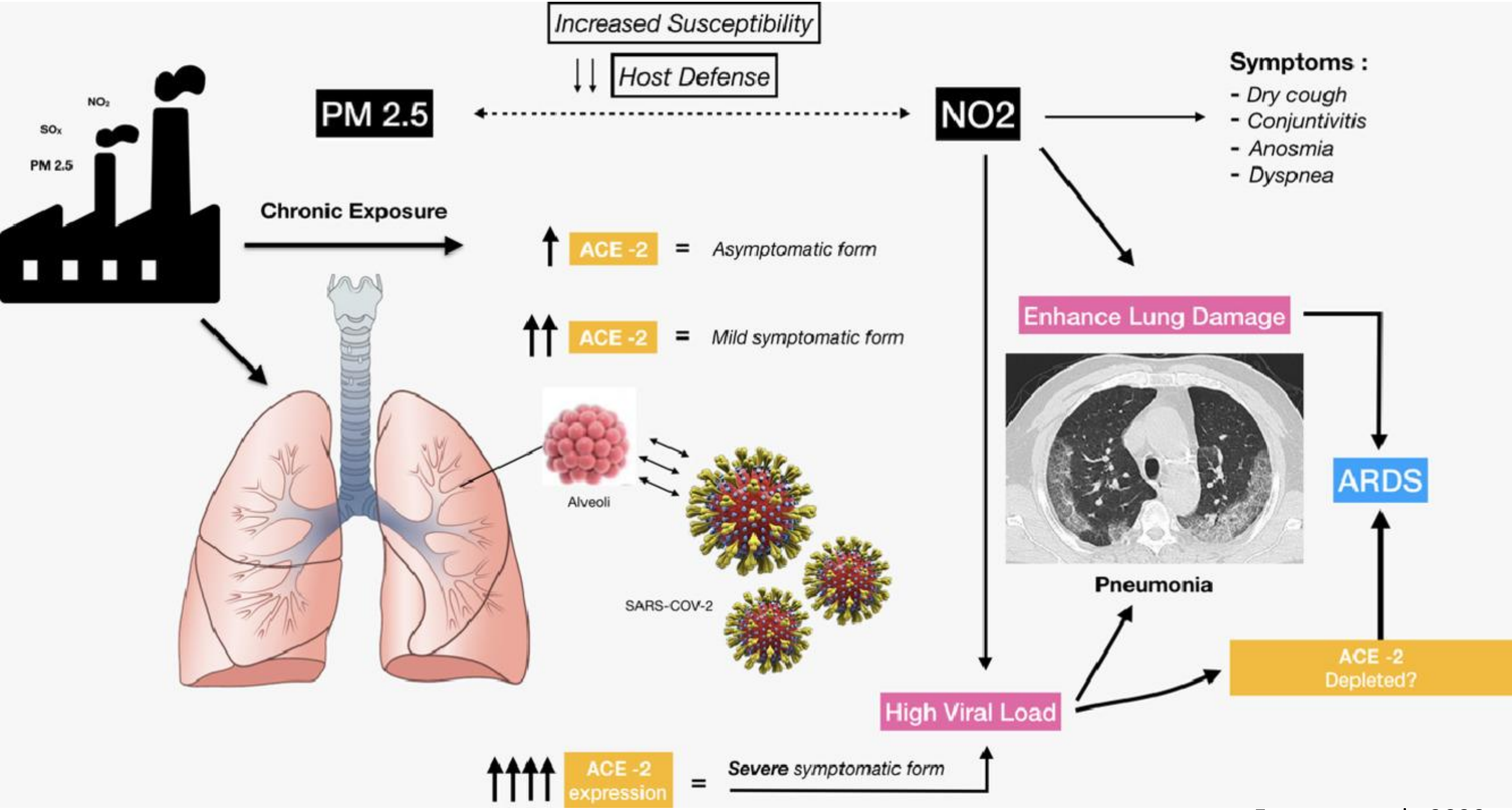


FIGURE 1 Target organs and the main diseases that coronavirus disease 2019 (blue) and air pollution (green) share. ARDS: acute respiratory distress syndrome.

Bourdrel et al., 2021



Frontera et al., 2020

Summary

- Positive associations between outdoor air pollution and the incidence and severity of COVID-19
- Significant reduction in pollution emissions and air pollutant levels due to the lockdown measures in the early pandemic
- Actions needed to protect vulnerable populations and disadvantaged communities
- Transition towards a green economy with clean, renewable energy sources

Acknowledgement

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