Air Pollution, Race, COVID-19, and Data Science

Francesca Dominici, PhD

Professor of Biostatistics, Population Health and Data Science

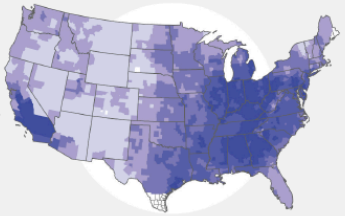
Director Harvard Data Science Initiative

Research Questions

- **Q1**: Is there evidence of a causal link between long term exposure to air pollution and mortality, even at levels below the National Ambient Air Quality Standards? A study of more than 550 million observations
- **Q2:** The air is cleaner today than 20 years ago, but are we making progress in eliminating environmental injustice as well?
- **Q3:** Does long term exposure to air pollution increases COVID19 mortality rate?

RESEARCH DATA PLATFORM

EXPOSURES AND INTERVENTIONS (E OR I)



$PM_{2.5}$ exposure levels by county (average 2000-2012)

DATA SOURCES

Criteria air pollutants
EPA AQS daily average of $PM_{2.5}$, ozone, NO_2, 1995-2015;
Daily 1km x 1km predictions of $PM_{2.5}$, ozone, NO_2, 2000-2014

Methane
1km x 1km predictions at 3-day intervals, 2009-present

Weather
NOAA daily estimates (temperature, precipitation, humidity, ...) on a 0.3^0 grid

Power plants
EPA AMPD daily emissions, 1995-2015

Coal mines
MSHA location and producting pits, 1970-2015

Fracking wells and disposal wells
Drillinginfo database with well location and depth, daily production

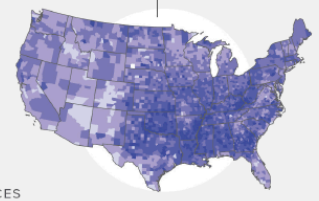
Traffic
Annual traffic counts and density from the Department of Transportation

Residential community green space
NASA vegetation index on a $250m^2$ grid

Factrories and industrial sites
Geocoded locations of businesses

HEALTH OUTCOMES (Y)

Medicare mortality rate by county (average 2000-2012)



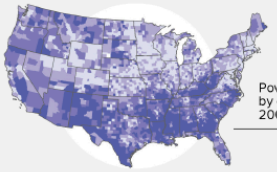
DATA SOURCES

Medicare
28 million per year, 1999-2015

Medicaid
28 million per year, low income, 2010-2011

Aetna
40 million, all ages, above-average income, 2008-2016

CONFOUNDERS (X)



Poverty prevalence by county (average 2000 and 2010)

DATA SOURCES

Individual demographics
Age, sex, race, ZIP code of residence

Individual medical history
Previous diagnoses, medications prescribed

ZIP code level variables
Income, education, demographics, employment, household size

County-level variables
Crime, smoking, BMI

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 29, 2017 VOL. 376 NO. 26

Air Pollution and Mortality in the Medicare Population

Qian Di, M.S., Yan Wang, M.S., Antonella Zanobetti, Ph.D., Yun Wang, Ph.D., Petros Koutrakis, Ph.D., Christine Choirat, Ph.D., Francesca Dominici, Ph.D., and Joel D. Schwartz, Ph.D.

- A 10 units increase in PM2.5 is associated with a 7.3% increase in all cause mortality among 60 million older American (evidence of a link is even stronger at levels of PM2.5 below the NAAQS)
- African American have a risk of death from PM 2.5 exposure that is three times higher than the national average

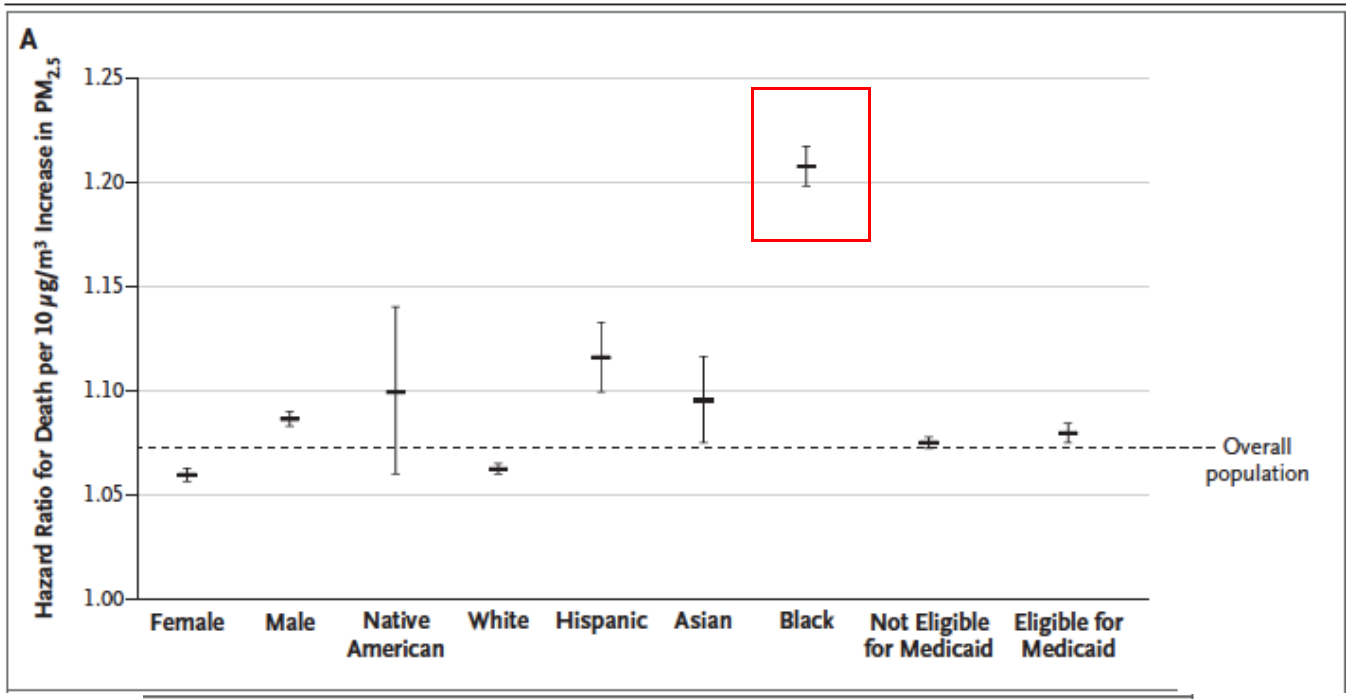


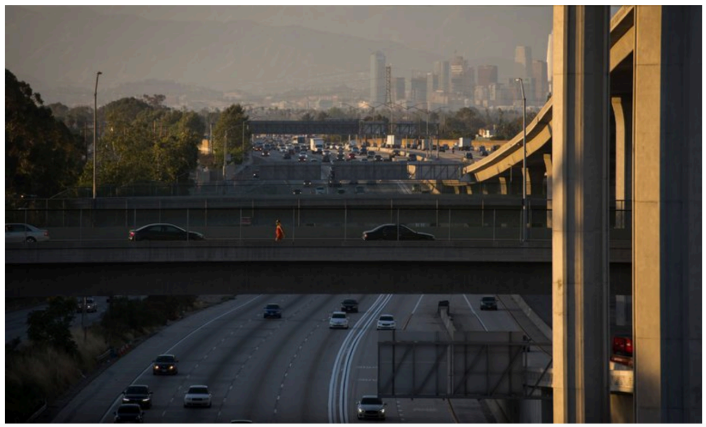
Figure 2. Risk of Death Associated with an Increase of 10 μg per Cubic Meter in $PM_{2.5}$ Concentrations and an Increase of 10 ppb in Ozone Exposure, According to Study Subgroups.

Hazard ratios and 95% confidence intervals are shown for an increase of 10 μg per cubic meter in $PM_{2.5}$ and an increase of 10 parts per billion (ppb) in ozone. Subgroup analyses were conducted by first restricting the population (e.g., considering only male enrollees). The same two-pollutant analysis (the main analysis) was then applied to each subgroup. Numeric results are presented in Tables S3 and S4 in the Supplementary Appendix. Dashed lines indicate the estimated hazard ratio for the overall population.

Even ‘Safe’ Pollution Levels Can Be Deadly

Leer en español

By **NICHOLAS BAKALAR** JUNE 28, 2017



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PUBLIC HEALTH

U.S. Air Pollution Still Kills Thousands Every Year, Study Concludes

June 28, 2017 · 5:01 PM ET

Heard on All Things Considered

ROB STEIN

A comprehensive study of air pollution in the U.S. finds it still kills thousands a year, and disproportionately affects poor people

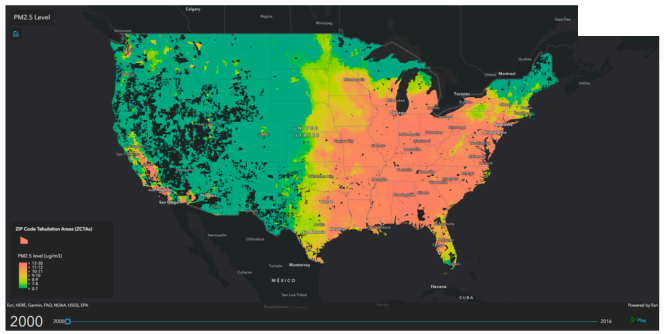
Senator Cory Booker talking about the NEJM study at a hearing on the nominations of Kathleen Hartnett White to be a Member of the Council on Environmental Quality.

Black Americans are suffering disproportionately from air pollution and the coronavirus deaths.

Racial and income inequalities in air pollution exposure are increasing in the United States

Abdulrahman Jbaily[a], Xiaodan Zhou[b], Jie Liu[b], Ting-Hwan Lee[b], Stéphane Verguet[a], Francesca Dominici[1]

[a]*Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, MA, USA*
[b]*Environmental Systems Research Institute, Redlands, CA, USA*

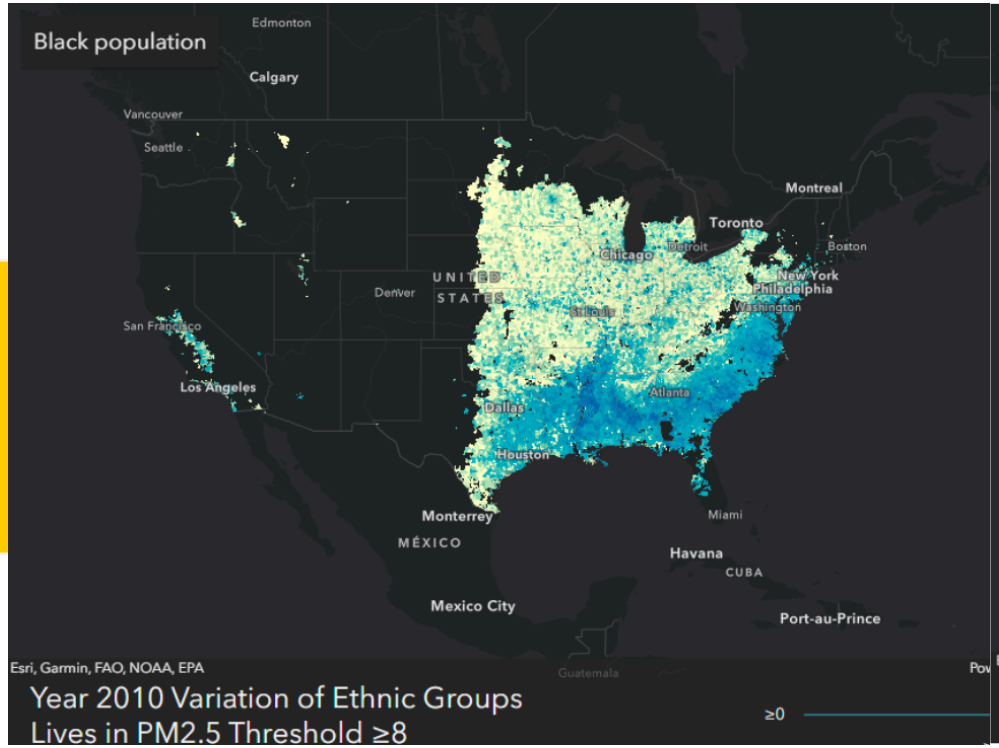


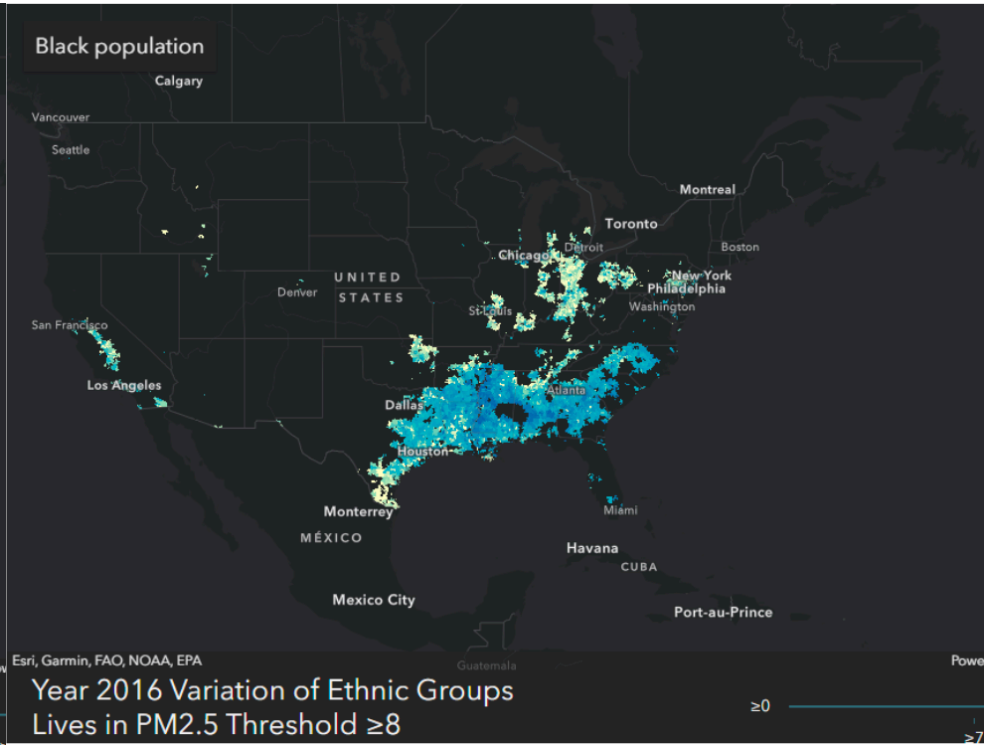
(a)

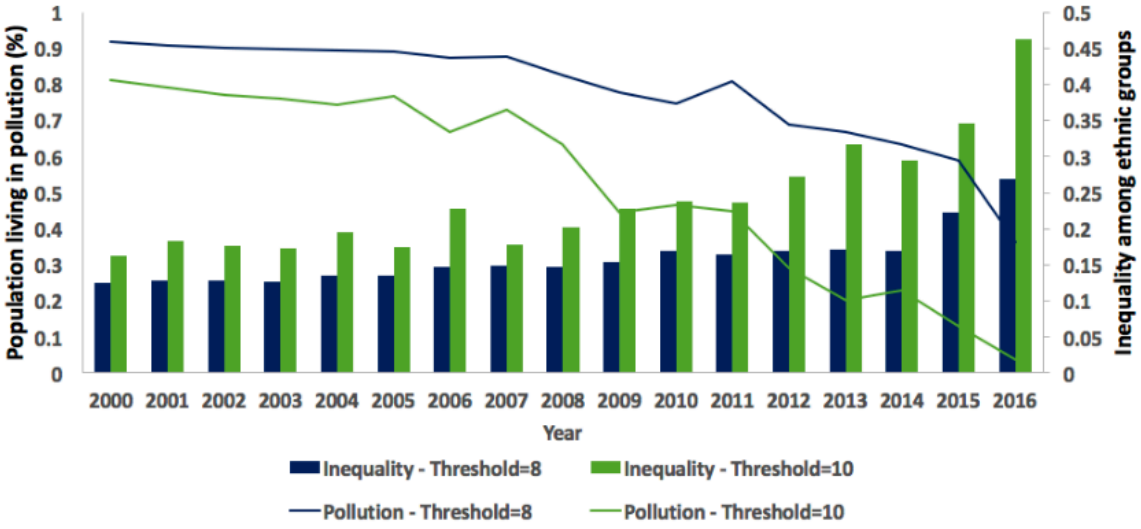
(b)

Air pollution has decreased drastically from 2000 to 2016, where the population-weighted average of PM2.5 has decreased by 43% from the year 2000 to 2016

Blue dots indicate areas with highest ratio of **Black** population to total population – only zip codes with PM>8 are shown



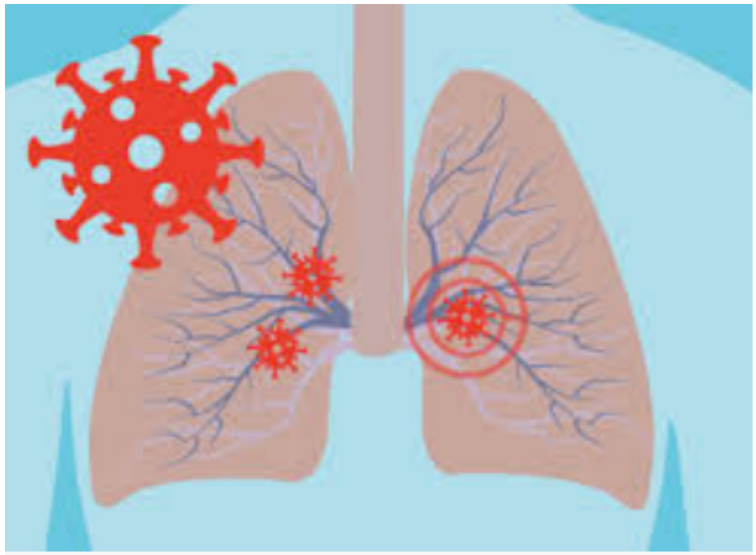




From 2010 to 2016 inequalities in the exposure to PM2.5 levels above 8µg/m3 across racial/ethnic, and income groups increased by factors of 1.58

Health Effects of COVID-19

- COVID-19 can cause viral pneumonia and acute respiratory distress syndrome (ARDS) which has a mortality rate of 27% to 45%.



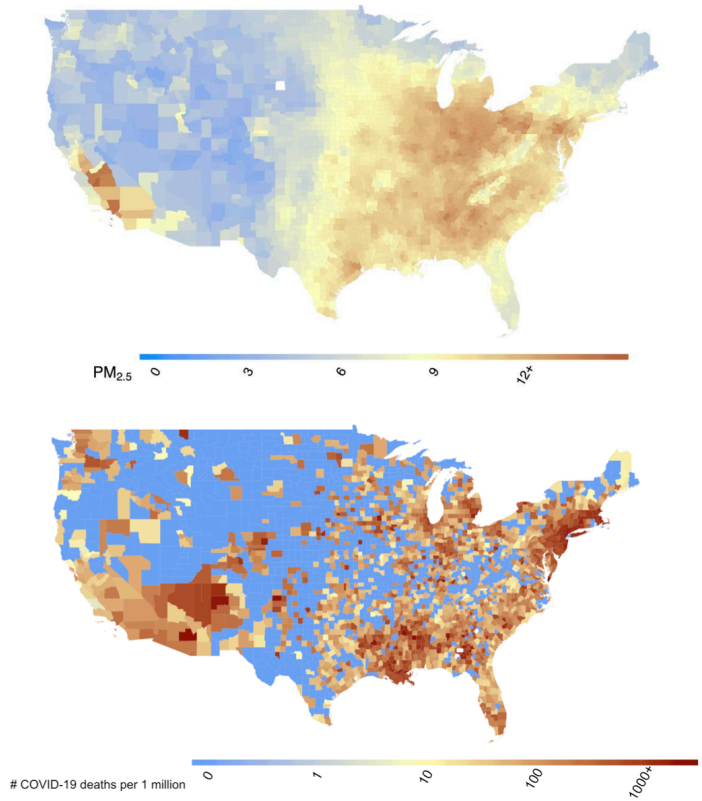
CHEST
Volume 156, Issue 1, July 2019, Pages 71-79

Original Research: Critical Care

Impact of Long-Term Exposures to Ambient $PM_{2.5}$ and Ozone on ARDS Risk for Older Adults in the United States

Jongeun Rhee ScD [a], Francesca Dominici PhD [a], Antonella Zanobetti PhD [a], Joel Schwartz PhD [a], Yun Wang PhD [a], Qian Di ScD [a], John Balmes MD [b, c], David C. Christiani MD, MPH [a]

Fig. 1. Maps show (a) county-level 17-year long-term average of $PM_{2.5}$ concentrations (2000–2016) in the United States in $\mu g/m^3$, and (b) county-level number of COVID-19 deaths per 1 million population in the United States up to and including June 18, 2020.



Data	Source
COVID-19 Deaths and Cases	Johns Hopkins University CSSE Coronavirus Resource Center
Long-Term Average PM2.5 Concentrations (2000-2016)	Atmospheric Composition Analysis Group, Dalhousie University
# of Hospital Beds	Homeland Infrastructure Foundation Level Data
Population, Population Density, Age Demographics, Racial Demographics, Education, Income, Wealth, Poverty, and Home Ownership	US Census + American Community Survey
Ever Smoked Population, Mean BMI in a county	CDC Behavioral Risk Factor Surveillance System
Temperature, Relative Humidity	GRIDMET via Google Earth Engine

New Research Links Air Pollution to Higher Coronavirus Death Rates

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

Coronavirus patients in areas that had high levels of air pollution before the pandemic are more likely to die from the infection than patients in cleaner parts of the country, according to a new nationwide study that offers the first clear link between long-term exposure to pollution and Covid-19 death rates.

We found that a 1 unit increase in long-term average exposure to PM2.5 is associated with a 11% increase in COVID-19 mortality rate

- For instance, consider a hypothetical County A and County B that are next to one another and very similar in most ways (i.e., similar population density, SES, smoking rates, temperature, and demographics).
- However County A has a slightly higher level of long-term exposure to PM2.5 than County B.
- We found that people that have lived in County A will have 11% higher risk of dying from COVID-19 than the people that live in Co

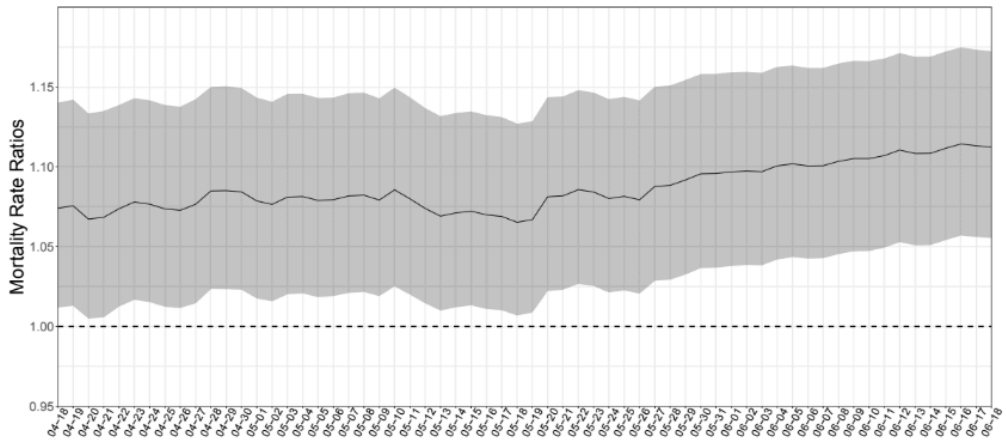


Figure S3: Daily COVID-19 mortality rate ratios (MRR) per 1 $\mu g/m^3$ increase in $PM_{2.5}$ and 95% CI. We conduct our main analysis using daily cumulative COVID-19 death counts from April 18, 2020 to June 18, 2020.

Table 1: Mortality rate ratios (MRR), 95% confidence intervals (CI), and P-values f
variables in the main analysis. Details of the statistical models are available in Secti

	MRR	95% CI	P-value
$PM_{2.5}$	1.11	(1.06, 1.17)	0.00
Population density (Q2)	0.91	(0.71, 1.15)	0.42
Population density (Q3)	0.91	(0.71, 1.16)	0.45
Population density (Q4)	0.74	(0.57, 0.95)	0.02
Population density (Q5)	0.92	(0.69, 1.23)	0.56
% In poverty	1.04	(0.96, 1.12)	0.31
log(Median house value)	1.13	(0.99, 1.29)	0.07
log(Median household income)	1.19	(1.04, 1.35)	0.01
% Owner-occupied housing	1.12	(1.04, 1.20)	0.00
% Less than high school education	1.20	(1.10, 1.32)	0.00
% Black	1.49	(1.38, 1.61)	0.00
% Hispanic	1.06	(0.97, 1.16)	0.23
% 65 years of age	1.04	(0.93, 1.17)	0.46
% 45-64 years of age	0.77	(0.67, 0.90)	0.00
% 15-44 years of age	0.76	(0.68, 0.85)	0.00

We also found a 49% (38%, 61%) increase in COVID- 19 mortality rate associated with a 1-standard deviation (per 14.1%) increase in percent Black residents of the county.

Regional and global contributions of air pollution to risk of death from COVID-19

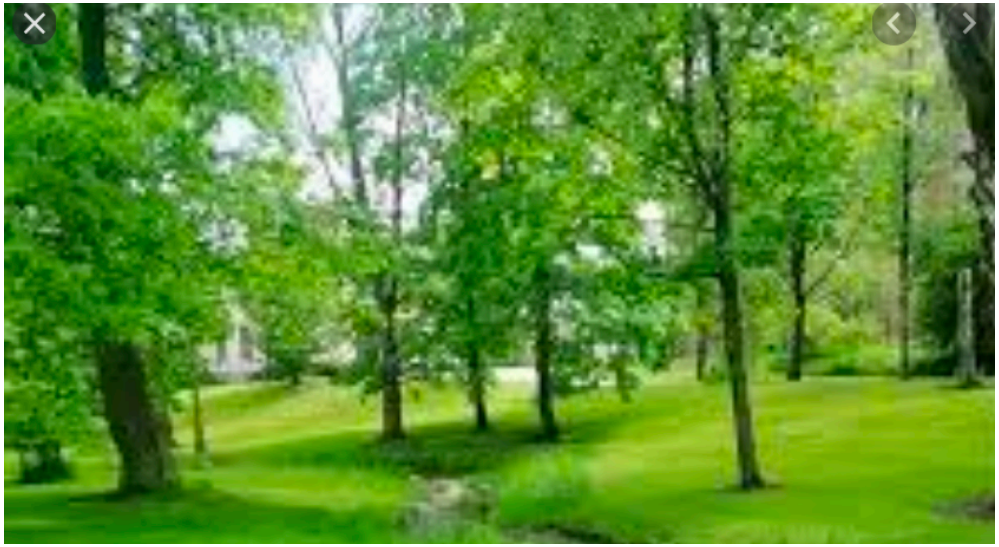
Andrea Pozzer [1,2], Francesca Dominici[3], Andy Haines[4], Christian Witt [5], Thomas Münzel [6,7]*, and Jos Lelieveld [2,8]*

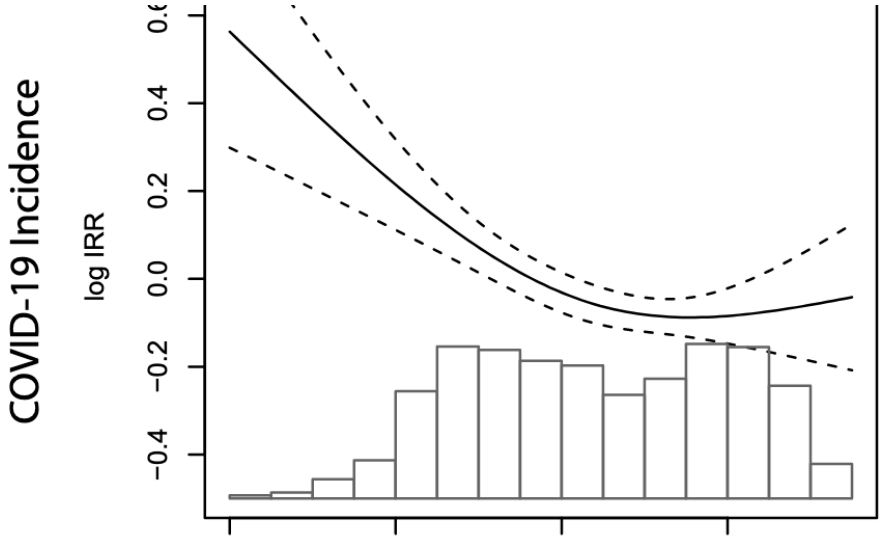
[1]International Center for Theoretical Physics, Trieste, Italy; [2]Max Planck Institute for Chemistry, Atmospheric Chemistry Department, Mainz, Germany; [3]Harvard T.H. Chan School of Public Health, Department of Biostatistics, Boston, MA, USA; [4]Centre for Climate Change and Planetary Health, London School of Hygiene and Tropical Medicine, London, UK; [5]Charité University Medicine, Pneumological Oncology and Transplantology, Berlin, Germany; [6]University Medical Center of the Johannes Gutenberg University, Mainz, Germany; [7]German Center for Cardiovascular Research, Mainz, Germany; and [8]The Cyprus Institute, Climate and Atmosphere Research Center, Nicosia, Cyprus

Table 1 Regional percentages of COVID-19 mortality attributed to fossil fuel-related and all anthropogenic sources of air pollution

Region	Population (million)	COVID-19 mortality fraction attributed to air pollution (%)	
		Fossil fuel-related emissions	All anthropogenic emissions
Europe	628	13 (6–33)	19 (8–41)
Africa	1345	2 (1–19)	7 (3–25)
West Asia	627	6 (3–25)	8 (4–27)
South Asia	2565	7 (3–22)	15 (8–31)
East Asia	1685	15 (8–32)	27 (13–46)
North America	525	14 (6–36)	17 (6–39)
South America	547	3 (1–23)	9 (4–30)
Oceania	28	1 (0–20)	3 (1–23)
World	7950	8 (4–25)	15 (7–33)

The 95% confidence levels are given in parentheses.





1 **County-level exposures to greenness and associations with COVID-19 incidence and**
2 **mortality in the United States**
3
4 Jochem O Klompmaker [a], Jaime E Hart [a, b], Isabel Holland [b], M Benjamin Sabath [c], Xiao Wu [c],
5 Francine Laden [a, b, d], Francesca Dominici [c], Peter James [a, e]
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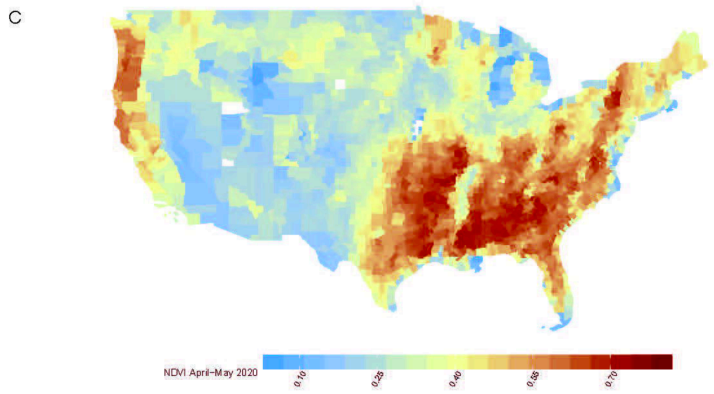

A collaboration among college, master, PhD students and post docs (**email fdominic@hsph.harvard.edu**)