Historical Exposure to Air Pollution and COVID-19 Mortality in the US

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Background

• COVID-19 is an unmatched public health emergency
• Sudden and global scope
• Important to identify environmental factors (such as air pollution) that impact the severity of COVID-19 and might explain racial differences in COVID-19 mortality rates
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%.
• COVID-19 can cause severe inflammation to the heart and circulatory system.
• Majority of deaths in individuals 60+.
• Certain comorbidities lead to an increase in mortality (especially hypertension, diabetes, cardiovascular disease, cerebrovascular disease).
What is fine particulate air pollution (PM$_{2.5}$) 

- Particle pollution, also known as particulate matter or PM, is a general term for a mixture of solid and liquid droplets suspended in the air.
- Fine particles can come from various sources. They include power plants, motor vehicles, airplanes, residential wood burning, forest fires, agricultural burning, volcanic eruptions and dust storms.
- These smaller particles generally pass through the nose and throat and enter the lungs.
Health Effects of long-term exposure to PM$_{2.5}$

- Strong evidence of an association between long-term exposure to PM$_{2.5}$ and heart and lung disease, brain diseases, irregular heartbeats, aggravated asthma, decreased lung function
Why investigate effects of PM$_{2.5}$ on COVID-19 deaths?

• Although the epidemiology of COVID-19 is evolving, we have determined that there is a large overlap between causes of death of COVID-19 patients and the diseases that are affected by long-term exposure to fine particulate matter (PM$_{2.5}$)

• We hypothesize that because long-term exposure to PM$_{2.5}$ adversely affects the respiratory and cardiovascular system; it can also exacerbate the severity of the COVID-19 infection symptoms and may increase the risk of death in COVID-19 patients.
LEVERAGING AN EXISTING 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° grid
Power plants
EPA AMPD daily emissions, 1995-2015
Coal mines
MSHA location and producing pits, 1970-2015

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

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 250m² grid
Factories and industrial sites
Geocoded locations of businesses
# Additional data to account for systematic differences between counties

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
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<tbody>
<tr>
<td>COVID-19 Deaths and Cases</td>
<td>Johns Hopkins University CSSE Coronavirus Resource Center</td>
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<tr>
<td>Long-Term Average PM$_{2.5}$ Concentrations (2000-2016)</td>
<td>Atmospheric Composition Analysis Group, Dalhousie University</td>
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<tr>
<td># of Hospital Beds</td>
<td>Homeland Infrastructure Foundation</td>
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<tr>
<td>Temperature, Relative Humidity</td>
<td>GRIDMET via Google Earth Engine</td>
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<tr>
<td>Time of issuances of public policy interventions</td>
<td>COVID-19 United States state policy database</td>
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<tr>
<td>Time since first reported COVID-19 case</td>
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We found that a 1-unit increase in long-term average exposure to PM$_{2.5}$ is associated with an 8% 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 PM$_{2.5}$ than County B.
- We found that people that have lived in County A will have 8% higher risk of dying from COVID-19 than the people that live in County B.

![Graph showing mortality rate ratios for different scenarios.](image)
Is air pollution making the coronavirus pandemic even more deadly?

Dirty air is well known to worsen the heart and lung risk factors for Covid-19 - early research is cause for concern

Decades of research have shown air pollution damages lungs. Illustration: Guardian Design
Public Health Implications

• Prioritize counties that are more polluted
• Stress importance of continued regulation of PM$_{2.5}$ and air pollution
• People of color and poor people disproportionately affected by air pollution, further exacerbating health disparities
COVID-19 PM2.5
A national study on long-term exposure to air pollution and COVID-19 mortality in the United States

All Code and data used available on GitHub:
https://github.com/wxwx1993/PM_COVID
Our website: https://projects.iq.harvard.edu/covid-pm