Air pollution and Covid-19 risk

TOM BECKER, NORTHWEST PORTLAND AREA INDIAN HEALTH BOARD

Game plan

- Examine recent articles on air pollution and its potential risk for Covid-19 incidence and mortality

- Focus will be primarily on outdoor air pollution

Objectives

- Recite key findings from an ecologic study we will review on air pollution and Covid-19 fatality:case ratio and mortality

- Summarize key findings from a few other studies of pollution and Covid-19 outcomes

- Recognize shortcomings of published research and suggest alternative study designs to better unravel the exposure-disease relationships

Take home messages

- A very small increase (only 1 microgram/cubic meter) in small particulate matter (PM 2.5) in air resulted in a 8% increase in Covid-19 mortality in this nationwide ecological study

- Other associations with increased Covid-19 mortality on a county-by-county basis included : population density, days since first case diagnosis, % of hospital beds occupied, income, low education, and Black/African American race

- Other studies have shown associations with SARS-CoV-2 infection or Covid-19 deaths with different pollutant gases, PM, and other components of polluted air (in dozens of studies)

Introduction

- Anything that causes dysregulation of the immune system predisposes people to Covid, and air pollution is one of those factors… especially chronic exposures to multiple components of polluted air

- Minority communities, including tribal communities, are often more likely to have poor air quality environments (particularly true for inner city African Americans in 'redline communities')

- Obesity, asthma, htn, DM, heart disease often more common in high pollution environments (and areas of high Covid-19)…true for some tribal peoples

Intro, cntd

▶ Poor air quality pre-Corona may have been very important re: infection acquisition in highly polluted environments such as N. Italy, Wuhan, New York City and New Jersey, Madrid (? Influence of pollution-induced overexpression of ACE 2 receptors)

▶ Satellite studies from Wittenberg are tracking pollution and correlating with Covid-19 reports …with strong correlations between satellite images and disease (they can focus their studies on NO2 from the usual sources…cars, planes, industry).

▶ The satellite and other data show stronger correlations with Covid deaths, rather than acquisition

Intro, continued

▶ In NM reservations, wood-burning fires for heat indoors were common (resulting in outdoor air pollution), and outdoor fires were also commonplace

▶ In Pueblos, people ran their cars and trucks (some with diesel) for electricity for the insides of their houses…resulting in high levels of pollutants in outside air

▶ Shoshone-Bannock fertilizer plant and poor air

▶ Many young AI men work on firefighting crews, resulting in both acute and chronic wildfire smoke exposures

Air pollution components (not comprehensive)

- PM 2.5 (combustion particles, organic compounds, metals)
- PM 10 (dust, pollen, mold)
- NO2
- O3
- CO
- SO2
- NO
- HCHO
- NH3
- (Diesel particulate matter)

PM 2.5, in higher concentrations, is associated with

- Multiple respiratory infections (acute)
- Chronic respiratory diseases
- Neurocognitive diseases
- Cardiovascular disease
- Poor pregnancy outcomes

Air pollution and other epidemics

▶ For areas with high pollution indices, we observed increases in SARS fatality

▶ For PM 2.5, increase in pneumonia and influenza

▶ For PM 2.5, increase in H1N1 mortality in 2009

▶ Heavy coal pollution and influenza mortality in 1918 Spanish Flu

Some of the effects of chronic air pollution

- Dysregulation of the immune system and altered regulation of key genes that affect T-cells

- Induces oxidative stress and inflammation

- Damages lung ciliary function

- Considered by WHO as a human carcinogen

- In addition to cancer links, associated with stroke, diabetes, COPD

- Small particulates (PM 2.5) can travel to alveoli and enter bloodstream, potentially causing multiple sequelae

Complex biological relationships

▶ The relation between/among infectious agents, mediators of inflammatory response, and acute infection added to chronic inflammation from air pollutants…is very complex and the understanding of the many components is evolving rapidly for Covid-19 and its causal agent.

Reminder about ecological studies and causal inference

▶ Population-based or geographic measures of some exposure (sunlight, air pollution, cigarette sales in each state)

▶ Population-level information about some outcome (lung cancer rates in the US by state, Covid-19 cases by county)

▶ We do NOT have individual-level information on exposures, or on outcomes (so we cannot tell if a Covid-19 decedent experienced substantial air pollutants even if the county-level measures were high

▶ Good for hypothesis generation, leading to other study designs

# Methods for Wu et al, Exposure to air pollution and Covid-19 mortality

- Nationwide, US, county-level data

- Death counts for 3000 counties

- Long term PM 2.5 counts for each county (average)

- Statistical adjustment for 20 potential confounders, including age, sex, race, income, weather, pop density, hospital beds,

- 68 additional sensitivity analyses after main analysis (very thorough!)

Exposures and Outcomes measured (Wu et al)

- Air pollution particulate matter 2.5, averaged for each county
- Other confounders available from multiple sources
- Covid-19 mortality on county level—main outcome

Table 1: Publicly available data sources used in the analysis

	Source	Data
Outcome: COVID-19 Deaths	Johns Hopkins University the Center for Systems Science and Engineering (JHU-CSSE) Coronavirus Resource Center (https://coronavirus.jhu.edu/)	County-level COVID-19 death count up to and including April 22, 2020
Exposure: $PM_{2.5}$ concentrations	Atmospheric Composition Analysis Group (https://sites.wustl.edu/acag/)	$0.01° \times 0.01°$ grid resolution $PM_{2.5}$ prediction, averaged across the period 2000–2016 and averaged across grid cells in each county

PM$_{2.5}$ 0   3   6   9   12+
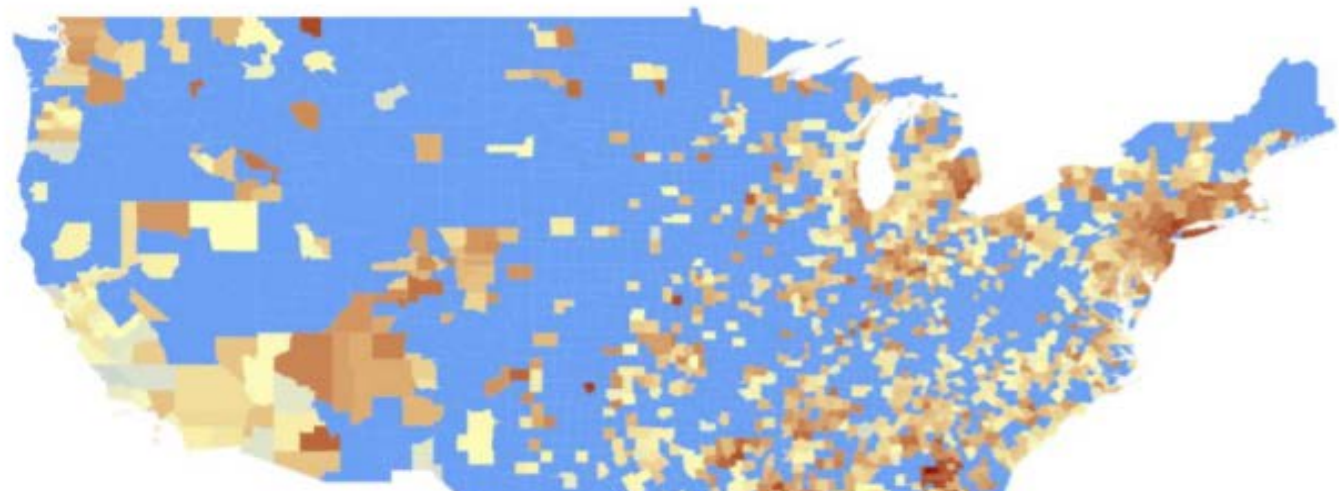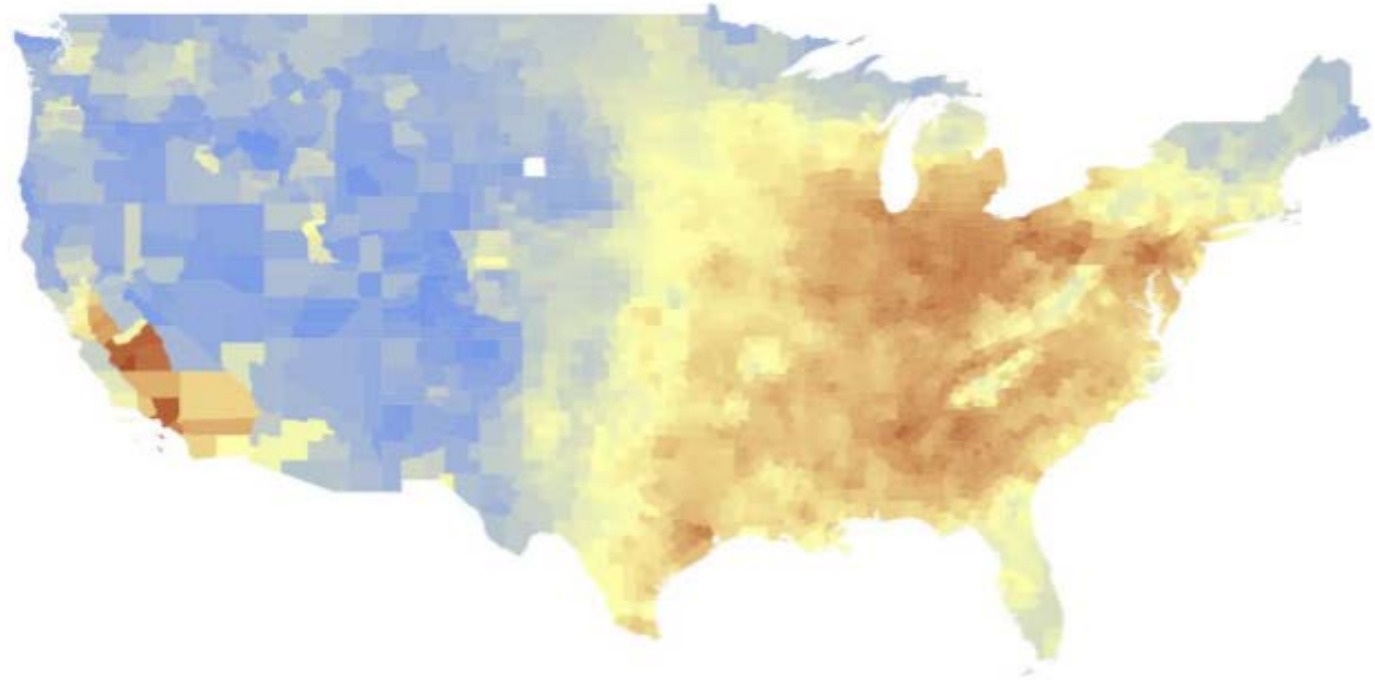
findings from Wu study

▶ A very small increase (only 1 microgram/cubic meter) in small particulate matter (PM 2.5) in air results in a 8% increase in Covid-19 mortality in this nationwide ecological study

▶ Other associations with increased Covid-19 mortality on a county-by-county basis included : population density, days since first case diagnosis, % of hospital beds occupied, income, low education, and Black/African American race

▶ Other studies have shown associations with SARS-CoV-2 infection or Covid-19 deaths associated with different gases and other components of polluted air (in dozens of studies)

Limitations of study

- As for any ecologic or correlational study

Liang et al, Urban air pollution may enhance Covid-19 outcomes in US

- Ecologic study at county level in US

- Exposure measures focused on PM 2.5, NO2, O3

- Control for multiple confounders

- Outcome measures were fatality:case ratios and mortality rates by county for Covid-19

- Key finding: increases in NO2 (but not the other pollutants) were associated with higher fatality:case ratios and mortality rates for Covid-19 (results reported as 'marginal' for PM 2.5)

Basker et al, Air pollution, SARS CoV-2 transmission (2020)

► Review of carefully-selected articles from 9 countries

► Studies included short-term, long-term, and cross-sectional studies of various pollutants and Covid-19 outcomes

► 27/28 studies reported evidence of some pollutant with adverse outcomes from Covid-19

► PM 2.5 most consistently associated with Covid-19 incidence, mortality, and/or fatality:case ratios

Alternative study designs

▶ Case-control study of risk factors for Covid-19, with particular focus on outdoor air pollution in neighborhoods of the patients…and considering other relevant factors related to Covid-19 development

▶ Cohort study on air pollution and Covid-19 incidence and mortality, with clear measures of exposures and medical records to help validate re: outcomes

▶ Occupational studies on firefighters who have remote exposures (retired firefighters), current exposures like in California..including immune signatures for all study participants and tracking them for SARS-CoV-2 acquisition/severity of Covid-19 symptoms and signs

Pragmatic questions;

- Will masks trap PM 2.5 particles in outdoor air?

- Are 'forever chemicals', like PFA's and BPA's from plastics, likely to increase risk for severe Covid-19? They increase IL-6 cytokines levels, also elevated in Covid-19.

- Can SARS-CoV-2 ride on particulates and enter in that manner?

Public health, scientific, and other messages

▶ Air pollution is a critically-important area for Covid-19 research

▶ Although many methods-related challenges characterize most of the published reports so far, the data show consistent findings re: various air pollution components and Covid-19 mortality (in particular)

▶ When given the chance, we in health occupations should lobby for cleaner air and healthier environments…could help with reduction in SARS-CoV-2 transmission and with decreasing Covid-19 disease rates

References

- Podcast, Stanford University, July 17th, 2020, on air pollution and Covid-19

- Xiao Wu, Dominica, et al. Medrv.org/content/10.1101/2020.04.05

- **Liang D, Shi L, Zhao J, et al. Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States. Preprint. *medRxiv*. 2020;2020.05.04.20090746. Published 2020 May 7. doi:10.1101/2020.05.04.20090746**

- Grazie a Grazia Ori…sono smarrito senza lei.