

Evidence from the US:
Air pollution and mortality in the Medicare population

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MAILMAN SCHOOL
of PUBLIC HEALTH

ENVIRONMENTAL HEALTH SCIENCES

Brussels
21.01.2020

Scientific Questions:

- 1 Is exposure to $PM_{2.5}$ below the current national standards associated with increased mortality risk?
 - o Annual standard: $12 \mu\text{g}/\text{m}^3$
 - o Daily standard: $35 \mu\text{g}/\text{m}^3$
- 2 Are some populations at higher risk than others?

Team



**Francesca
Dominici**



Joel Schwartz



Joey Antonelli



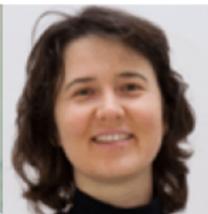
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Iste Zahn



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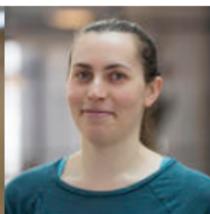
Kwonsang Lee



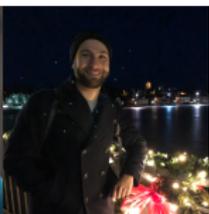
Qiao Wu



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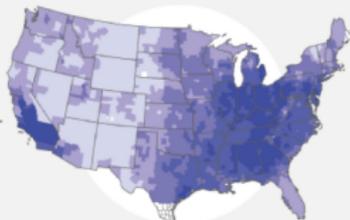
Emma Thomas

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, NO₂, 1995-2015;

Daily 1km x 1km predictions of PM_{2.5}, ozone, NO₂, 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

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



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

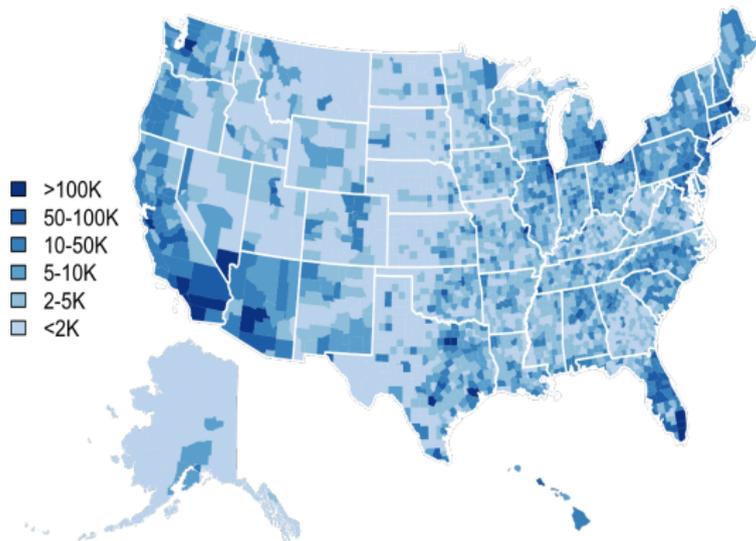
ZIP code level variables

Income, education, demographics, employment, household size

County-level variables

Crime, smoking, BMI

Medicare Cohort

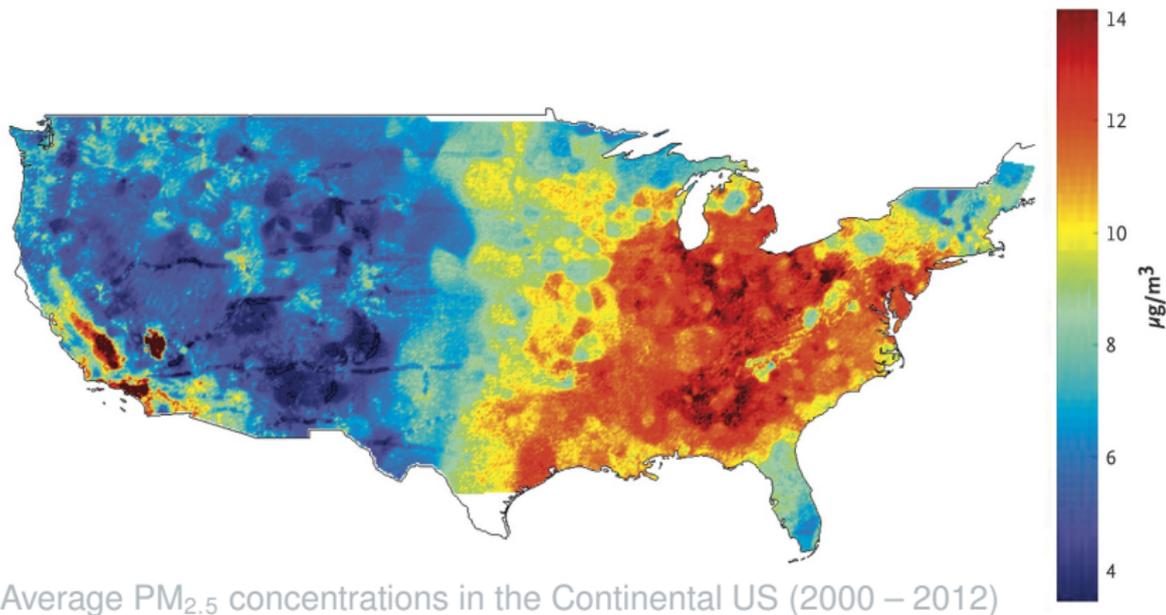


Medicare Enrollment by County (2010)

- Open Cohort (2000 – 2012)
- > 60M enrollees
- > 460M person-years

PM_{2.5} predictions

- Well-validated model with excellent predictive accuracy
- High spatio-temporal resolution: daily 1 × 1 km² grids



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.

Table 1. Cohort Characteristics and Ecologic and Meteorologic Variables.

Characteristic or Variable	Entire Cohort	Ozone Concentration		PM _{2.5} Concentration	
		≥50 ppb*	<50 ppb	≥12 μg/m ³	<12 μg/m ³
Population					
Persons (no.)	60,925,443	14,405,094	46,520,349	28,145,493	32,779,950
Deaths (no.)	22,567,924	5,097,796	17,470,128	10,659,036	11,908,888
Total person-yr†	460,310,521	106,478,685	353,831,836	212,628,154	247,682,367
Median yr of follow-up	7	7	7	7	7
Average air-pollutant concentrations‡					
Ozone (ppb)	46.3	52.8	44.4	48.0	45.3
PM _{2.5} (μg/m ³)	11.0	10.9	11.0	13.3	9.6

Results (cont'd)

Table 2. Risk of Death Associated with an Increase of 10 μg per Cubic Meter in $\text{PM}_{2.5}$ or an Increase of 10 ppb in Ozone Concentration.*

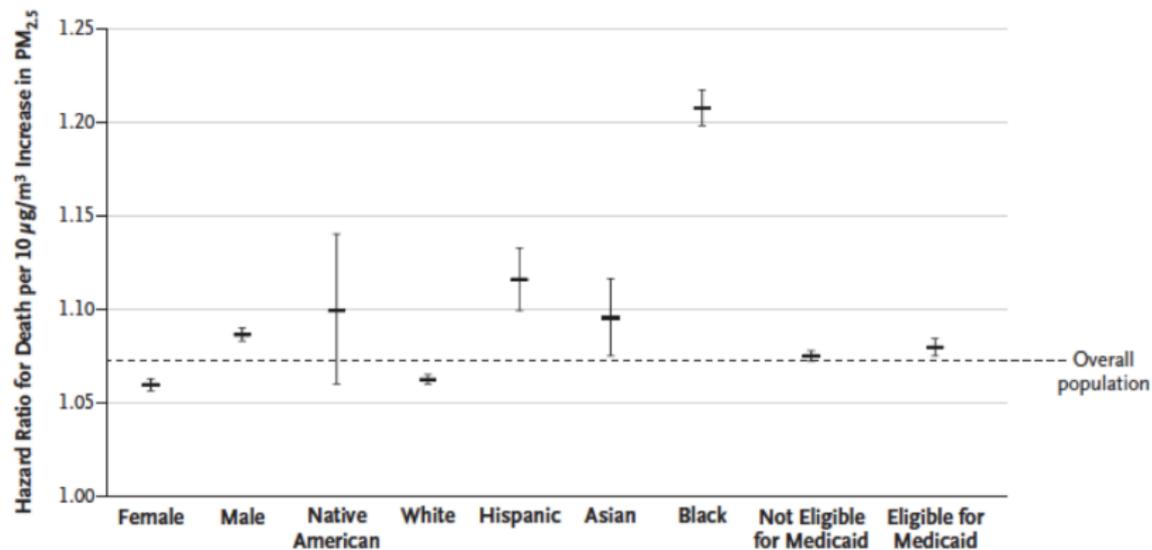
Model	$\text{PM}_{2.5}$	Ozone
	<i>hazard ratio (95% CI)</i>	
Two-pollutant analysis		
Main analysis	1.073 (1.071–1.075)	1.011 (1.010–1.012)
Low-exposure analysis	1.136 (1.131–1.141)	1.010 (1.009–1.011)
Analysis based on data from nearest monitoring site (nearest-monitor analysis)†	1.061 (1.059–1.063)	1.001 (1.000–1.002)
Single-pollutant analysis‡	1.084 (1.081–1.086)	1.023 (1.022–1.024)

Results (cont'd)

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Results (cont'd)



JAMA | **Original Investigation**

Association of Short-term Exposure to Air Pollution With Mortality in Older Adults

Qian Di, MS; Lingzhen Dai, ScD; Yun Wang, PhD; Antonella Zanobetti, PhD; Christine Choirat, PhD; Joel D. Schwartz, PhD; Francesca Dominici, PhD

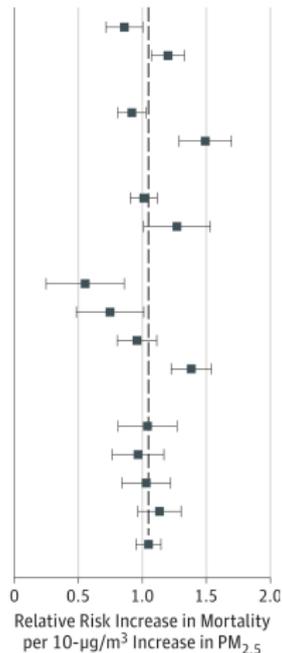
Air Pollutant Analysis	Relative Risk Increase, % (95% CI)	
	PM _{2.5}	Ozone ^b
Main analysis ^c	1.05 (0.95-1.15)	0.51 (0.41-0.61)
Low-exposure analysis ^d	1.61 (1.48-1.74)	0.58 (0.46-0.70)
Single-pollutant analysis ^e	1.18 (1.09-1.28)	0.55 (0.48-0.62)
Nearest monitors analysis ^f	0.83 (0.73-0.93)	0.35 (0.28-0.41)

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Results (cont'd)

Model	Relative Risk Increase in Mortality per 10- $\mu\text{g}/\text{m}^3$ Increase in $\text{PM}_{2.5}$, % (95% CI)	P Value for Effect Modification
Sex		
Male	0.86 (0.72-1.00)	[Reference]
Female	1.20 (1.07-1.33)	<.001 ^a
Medicaid eligibility		
Noneligible	0.92 (0.81-1.03)	[Reference]
Eligible	1.49 (1.29-1.70)	<.001 ^a
Race/ethnicity		
White	1.01 (0.91-1.12)	[Reference]
Nonwhite	1.27 (1.01-1.53)	.07
Age, y		
≤69	0.55 (0.25-0.86)	[Reference]
70-74	0.75 (0.48-1.01)	.35
75-84	0.96 (0.80-1.11)	.02 ^a
≥85	1.38 (1.23-1.54)	<.001 ^a
Population density		
Low	1.04 (0.81-1.27)	[Reference]
Medium low	0.97 (0.76-1.17)	.64
Medium high	1.03 (0.84-1.22)	.95
High	1.13 (0.97-1.30)	.52
Overall	1.05 (0.95-1.15)	



Conclusions

- Significantly harmful PM_{2.5} effect estimates in the US elderly both for long- and short-term exposures
 - No evidence of threshold:
- Significant estimated effects even at levels **below the current standards**

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- No evidence of threshold:
- Significant estimated effects even at levels **below the current standards**
- Next steps: comparison of effects estimated by traditional approaches vs. causal inference modeling
 - Preliminary analyses indicate the results are robust

Acknowledgments



This study was supported by HEI (4953-RFA14-3/16-4), NIEHS (R01 ES024332, P30 ES000002, R21 ES024012, R01 ES026217, P30 ES009089) and the USEPA (RD-83587201 and RD-83479801).

The contents are solely the responsibility of the grantees and do not necessarily represent the official views of the funding agencies.

Thank you!

Questions?

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