

AIR POLLUTION ACCOUNTABILITY STUDIES: LESSONS LEARNED AND FUTURE OPPORTUNITIES

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Chain of Accountability

What is the relationship between exposure to pollution and health outcomes?

Academic



What is the relationship between a regulatory intervention and health?

Policy
Maker



Exposure
and Dose

Human Health
Response



Reviews of Accountability Studies



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REVIEW PAPER

Interventions to reduce ambient air pollution and their effects on health: An abridged Cochrane systematic review

J. Burns^{a,b,*}, H. Boogaard^c, S. Polus^{a,b}, L.M. Pfadenhauer^{a,b}, A.C. Rohwer^d, A.M. van Erp^c, R. Turley^e, E.A. Rehfuess^{a,b}

Evaluating the effectiveness of air quality regulations: A review of accountability studies and frameworks

Lucas R.F. Henneman^a, Cong Liu^b, James A. Mulholland^a, and Armistead G. Russell^a

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Review article



Using natural experimental studies to guide public health action: turning the evidence-based medicine paradigm on its head

David Ogilvie^a, Jean Adams¹, Adrian Bauman², Edward W. Gregg³, Jenna Panter¹, Karen R. Siegel⁴, Nicholas J. Wareham¹, Martin White¹

Curr Envir Health Rpt (2017)
DOI 10.1007/s40572-017-017-0

AIR POLLUTION AND HEALTH

Accountability studies of air pollution and health effects: lessons learned and recommendations for future natural experiment opportunities

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Accountability Studies on Air Pollution and Health: the HEI Experience

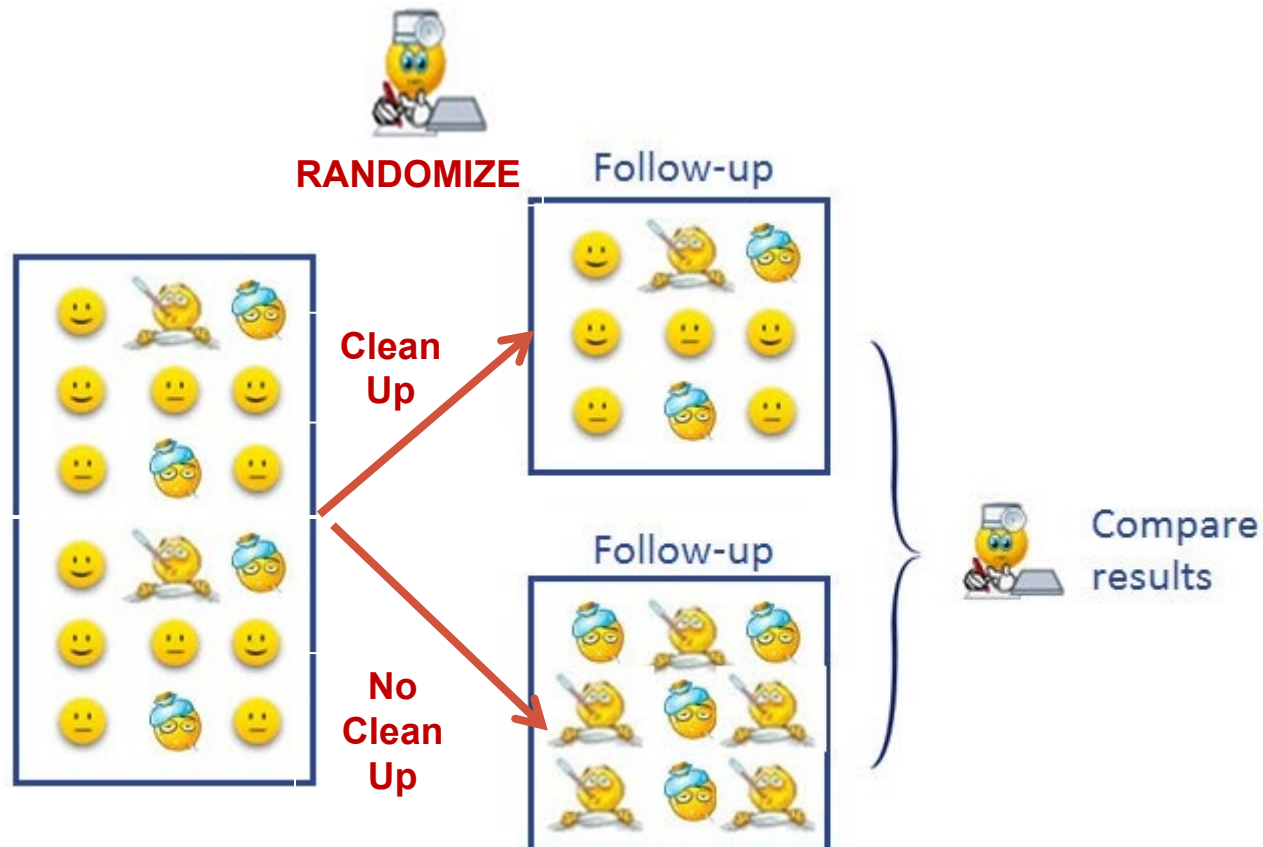
Hanna Boogaard¹ • Annemoon M. van Erp¹ • Katherine D. Walker¹ • Rashid Shaikh¹

Epidemiol Community Health

Accountability - Empirical Designs

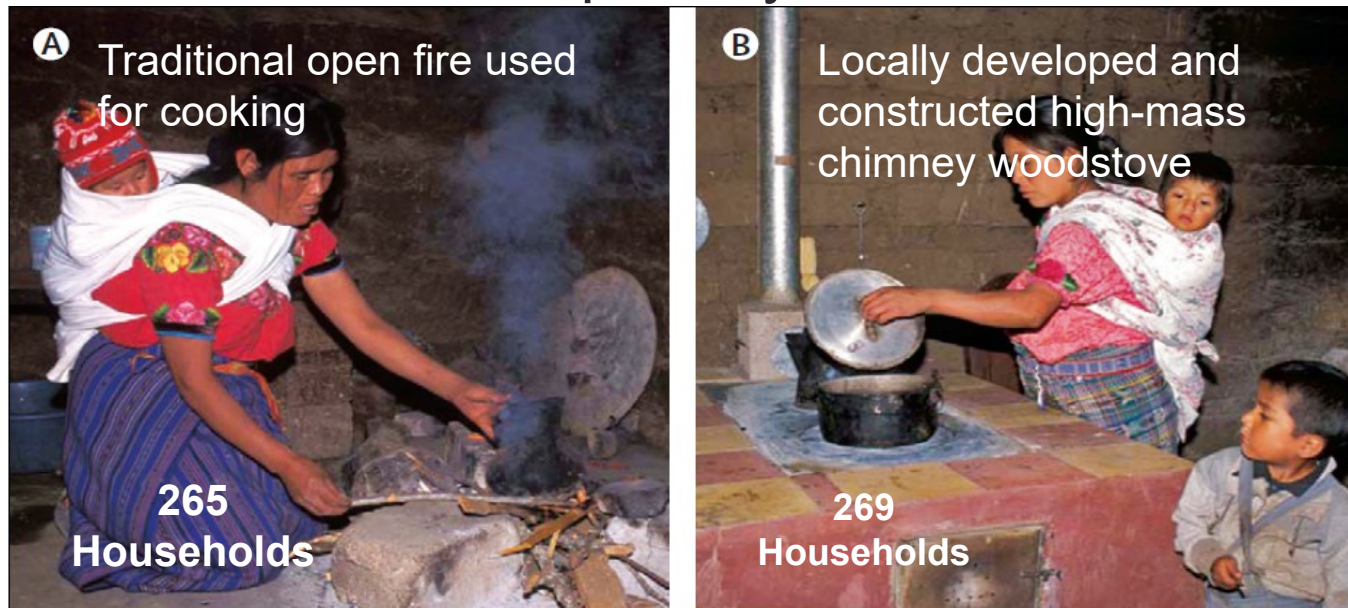
- **Randomized Controlled Trials**
 - Gold standard for casual associations in observational studies
- **Quasi-Experimental Studies**
 - Natural experiments
- **Policy Evaluation**
 - Post-hoc analyses
- **“Randomization” of Observational Studies**
 - Matching using big data

Randomized Controlled Trials



Generally not feasible and ethical for environmental exposures

RESPIRE: Randomized Exposure Study of Pollution Indoors and Respiratory Effects



	Control	Intervention	% Reduction
PM _{2.5} (µg/m ³)	821	32	96%
Physician-Diagnosed Pneumonia (Cases/100 child-yr)	62.6	49.7	21%

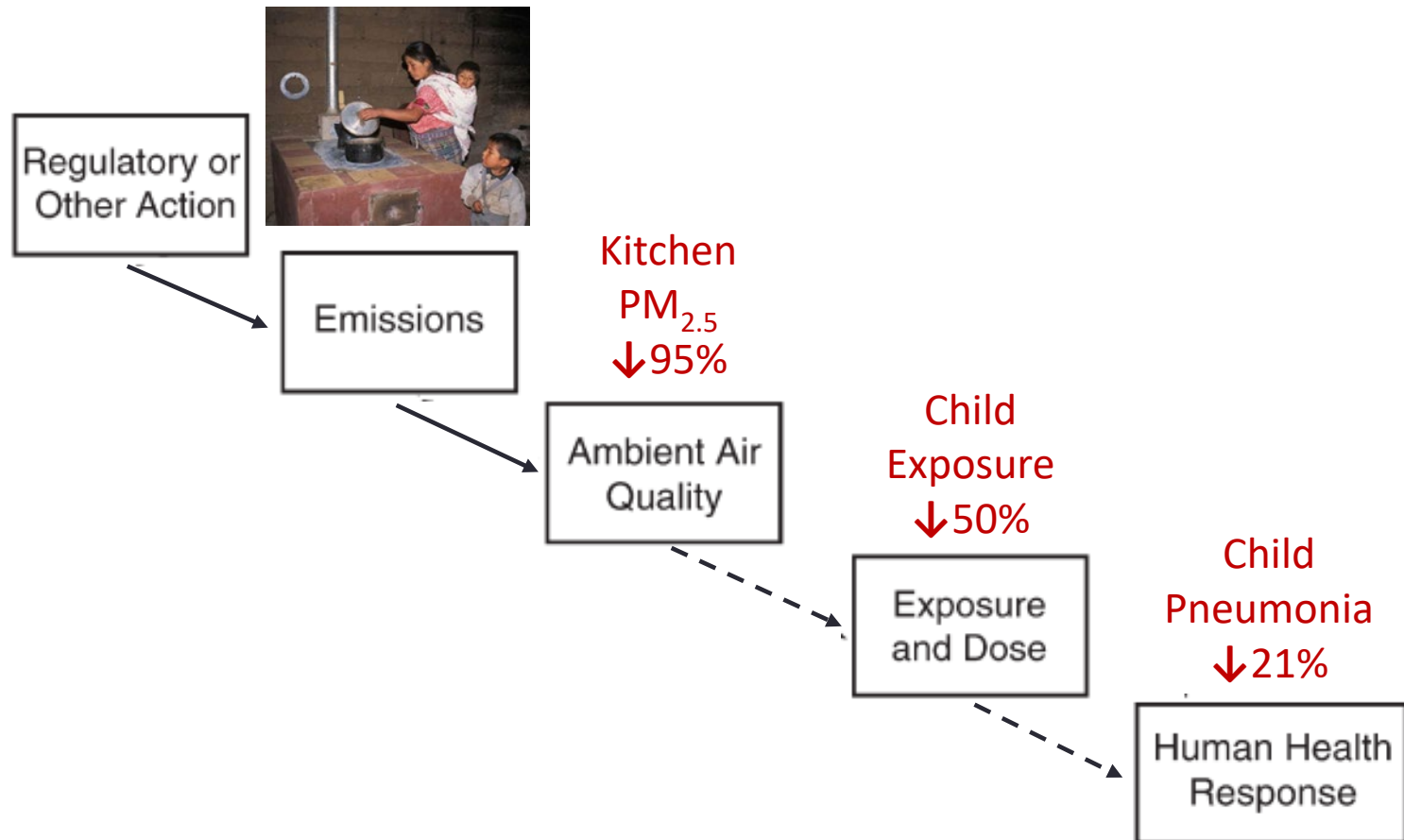
Exposures: Kitchen PM_{2.5} concentrations down by 20 fold,
but children exposure down by only 2 fold

Time-activity: kids do not spend their entire day in the kitchen

“Neighborhood” pollution: chimney does not reduce smoke, but
just shifts it outside, where the difference between intervention
and control households was less

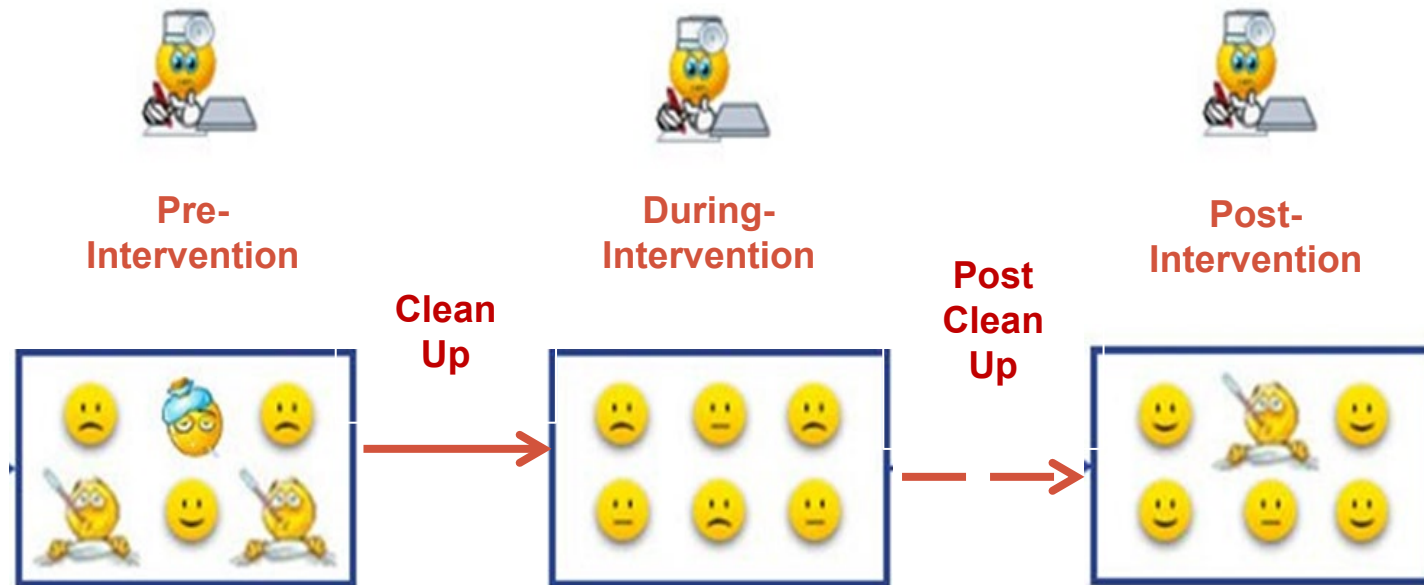


RESPIRE: Randomized Exposure Study of Pollution Indoors and Respiratory Effects



Quasi-Experiments

“Natural Experiments”

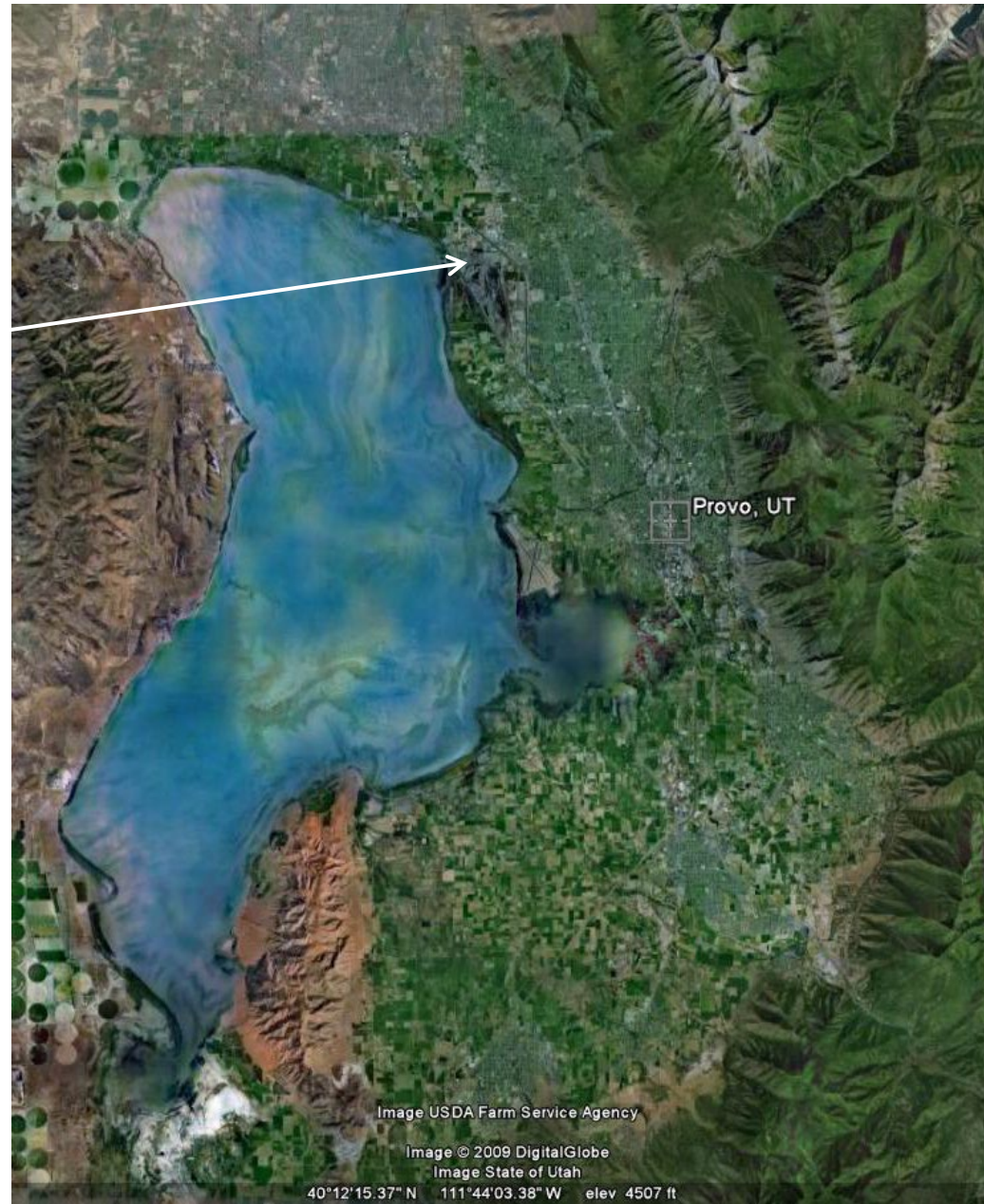


Utah Valley, 1980s

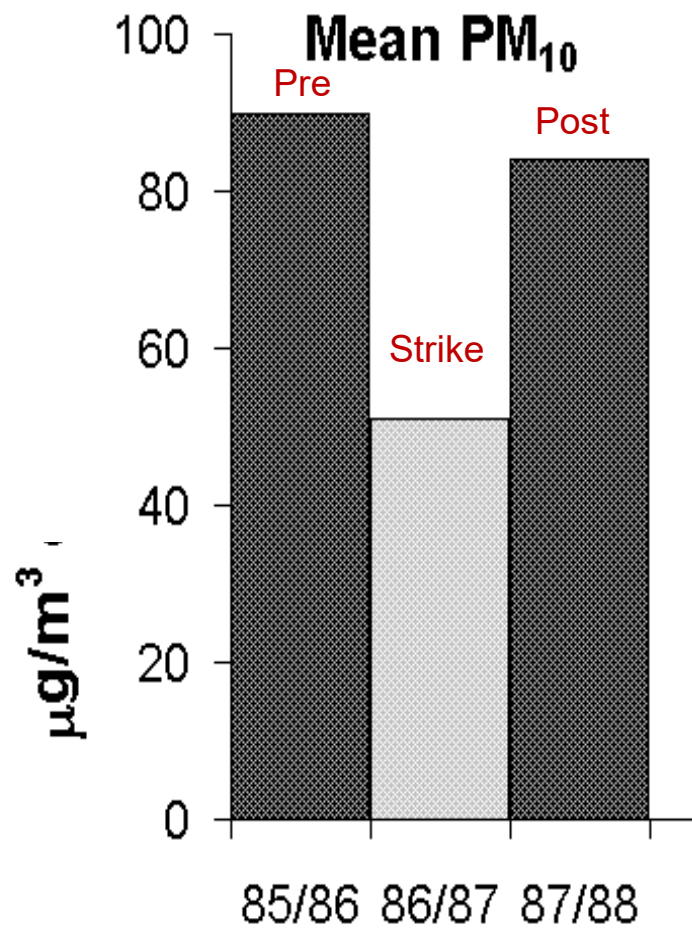
- Winter **inversions** trap local pollution



- Local Steel mill contributed ~50% $PM_{2.5}$
- Strike July 1986-August 1987



PM₁₀ and Hospital Admissions – Children 0-17 yrs

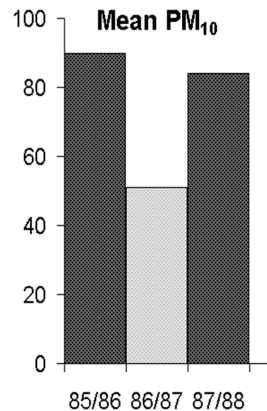


Respiratory Disease Associated with Community Air Pollution and a Steel Mill, Utah Valley



Regulatory or
Other Action

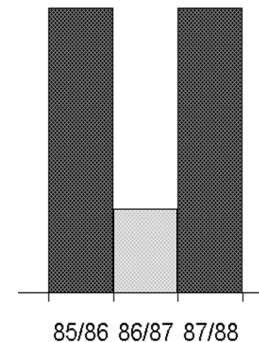
Emissions



Ambient Air
Quality

Exposure
and Dose

Bronchitis
& Asthma



Economic Downturn,
Loss of Medical Insurance,
Lost population, ...

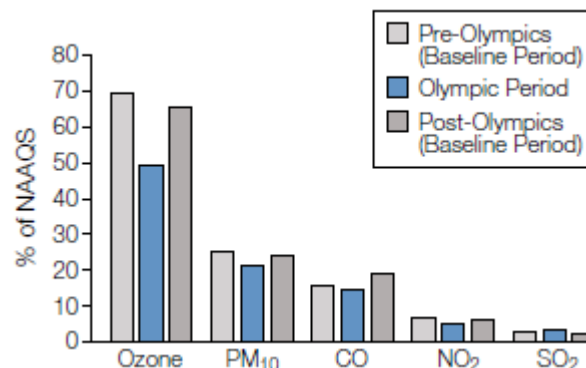
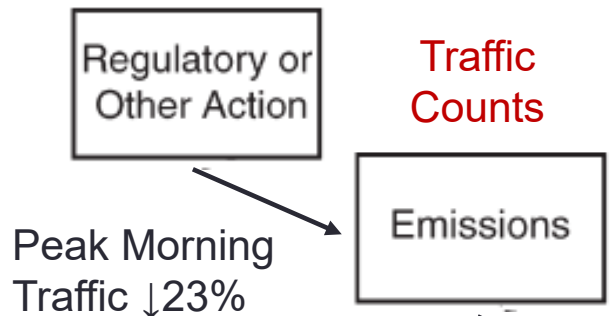
Human Health
Response

Counter-Factual

Traffic, Air Quality, and Childhood Asthma During 1996 Atlanta Olympic Games

MS Freidman, KE Powell, L Hutwagner, LM Graham, and WG Teague

Traffic Intervention During Olympics



Data Source	Asthma Events / day		Crude RR	Adjusted RR(95% CI)
	Baseline	Olympics		
Georgia Medicare Claims File	4.23	2.47	58%	0.48 (0.44, 0.86)
Health Maintenance Organization	1.36	0.76	56%	0.58 (0.32, 1.06)
Pediatric Emergency Department	4.77	2.47	52%	0.93 (0.71, 1.22)
Georgia Hospital Discharges	2.04	1.65	81%	0.71 (0.46, 1.11)

Ambient Air Quality

Exposure and Dose

Asthma Emergency Department Visits and Admissions

Human Health Response

Impact of Improved Air Quality During the 1996 Summer Olympic Games in Atlanta on Multiple Cardiovascular and Respiratory Outcomes

Jennifer L. Peel, Mitchell Klein, W. Dana Flanders,
James A. Mulholland, and Paige E. Tolbert

Traffic Intervention During Olympics

Regulatory or
Other Action

Traffic
Counts

Emissions

O_3 , PM_{10} ,
 NO_2 , CO ,
 SO_2

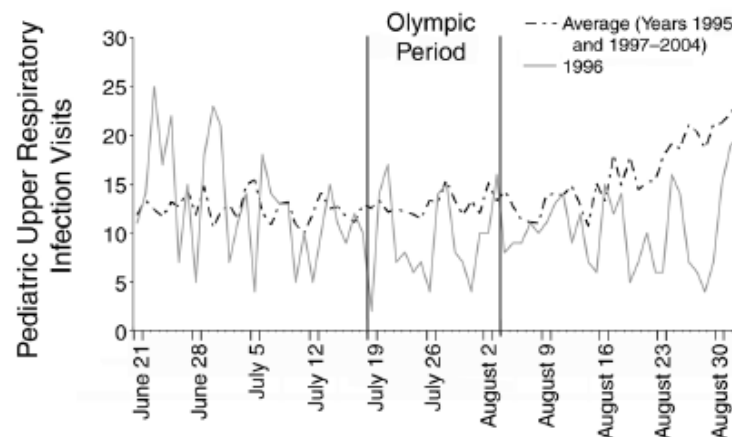
Ambient Air
Quality

Exposure
and Dose

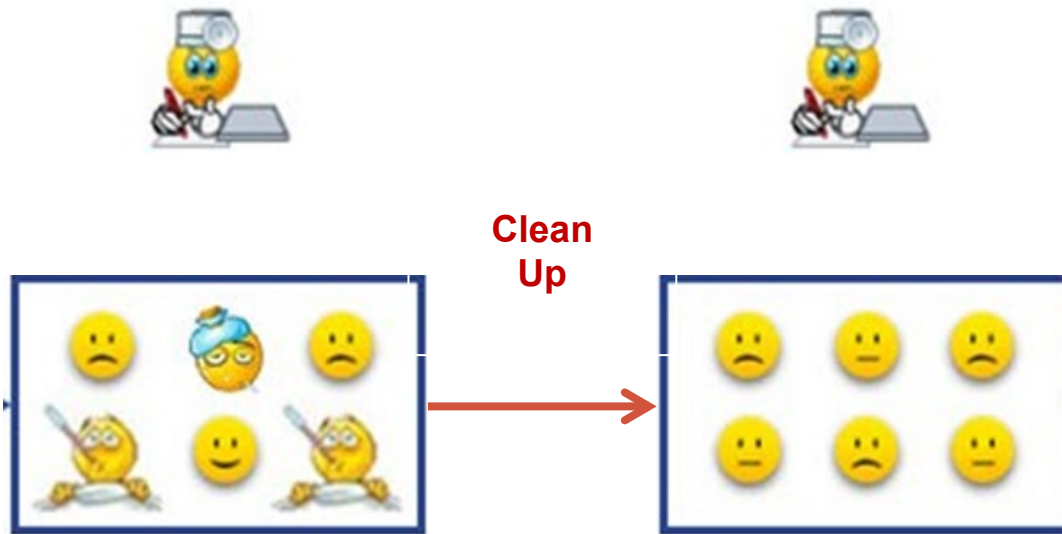
CVD and
Respiratory
Emergency
Department
Visits

Human Health
Response

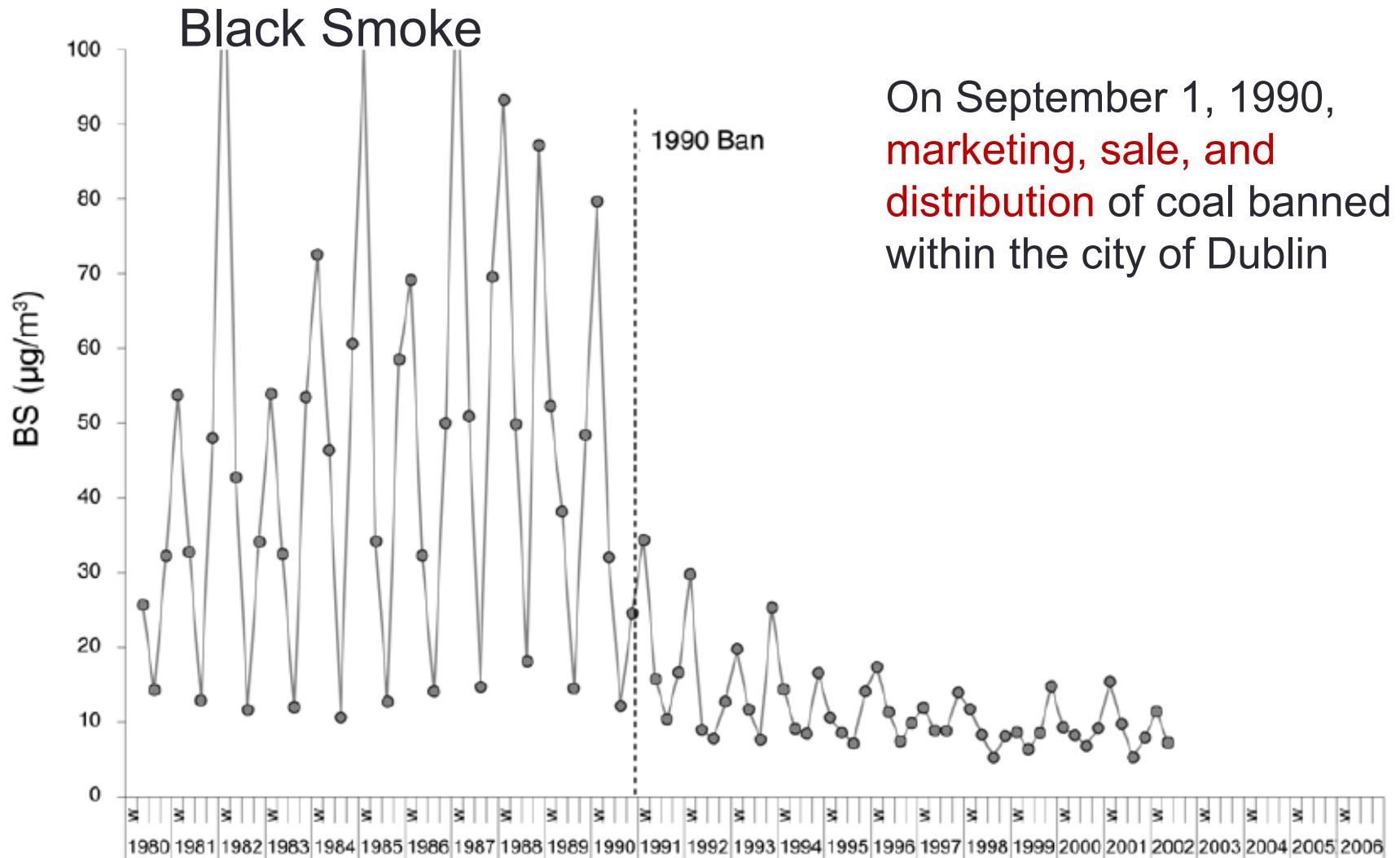
City	Mean 8-Hr Ozone (ppb)		
	Before	During	After
Atlanta	69	46	69
Augusta	63	51	53
Columbus	59	44	57
Savannah	50	36	45



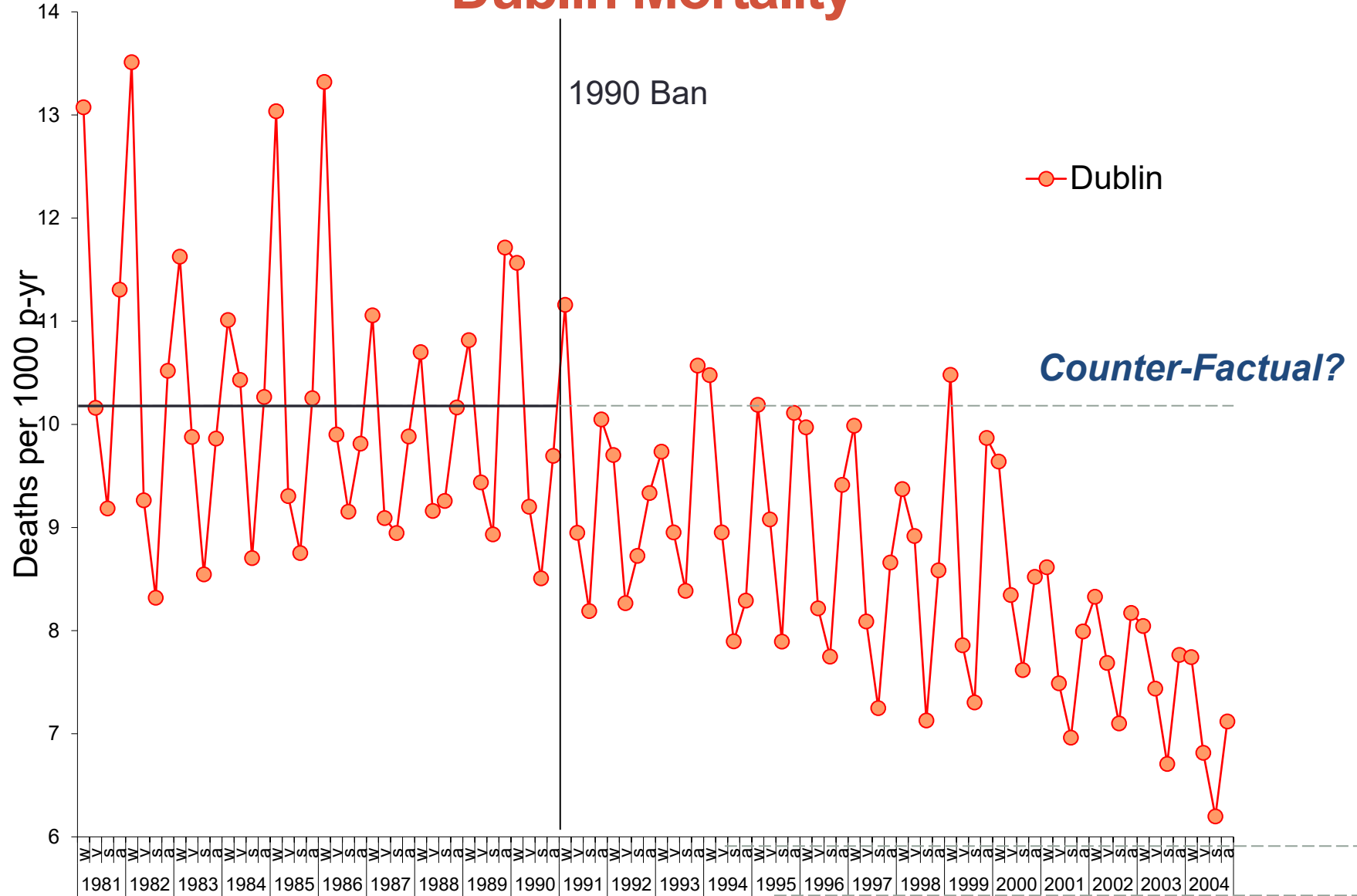
Policy Evaluation



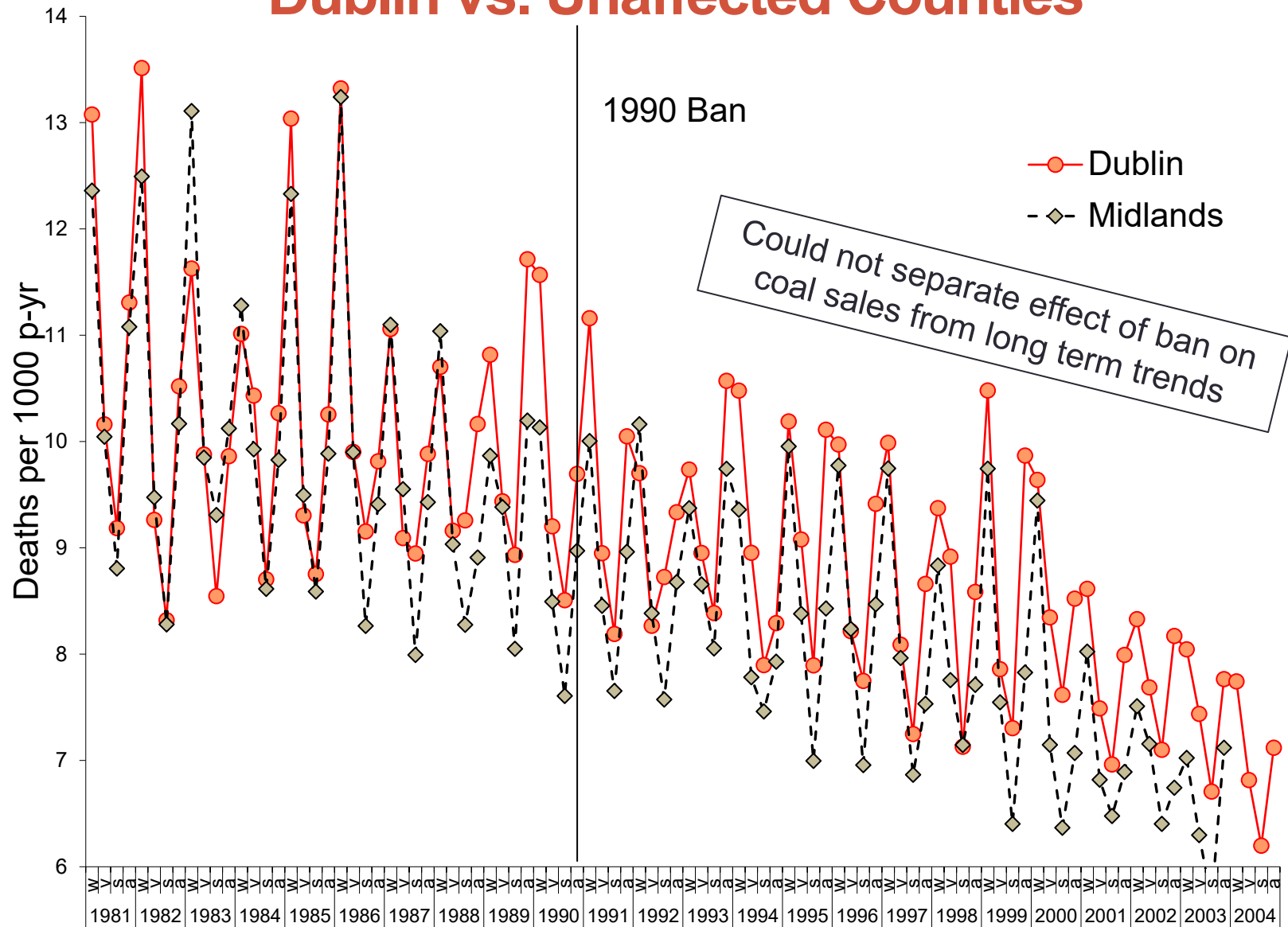
Effect of Dublin 1990 Ban on Coal Sales 1980-2004



Dublin Mortality



Dublin vs. Unaffected Counties

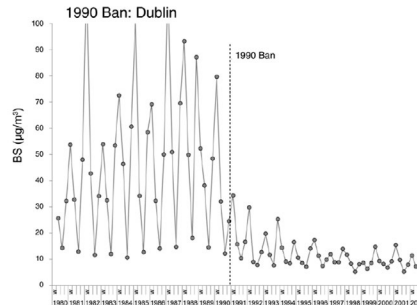


Effect of Air Pollution Control on Mortality and Hospital Admissions in Ireland

Coal Sales

Regulatory or
Other Action

Emissions



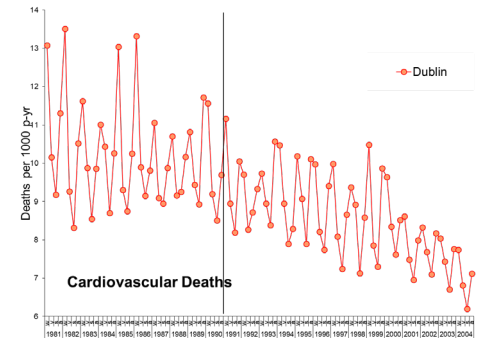
Ambient Air
Quality

Exposure
and Dose

Counter-Factual

Demographic Trends,
Health Care,
Behavioral Factors, ...

Meteorology,
Seasonal Infections



Human Health
Response

HEALTH EFFECTS INSTITUTE

Impacts of Regulations on Air Quality and Emergency Department Visits in the Atlanta Metropolitan Area, 1999–2013

Power Plant and Mobile
Sources Controls

Regulatory or
Other Action

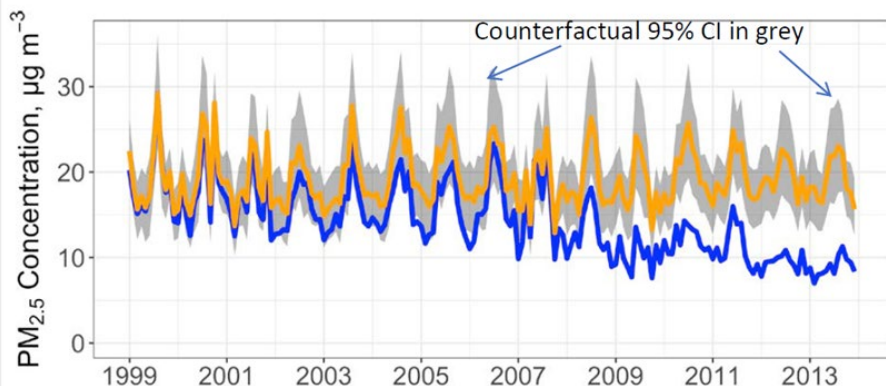
Emissions

*Estimated daily
AP from
emissions,
meteorology,
chemical
transport model
regressions*

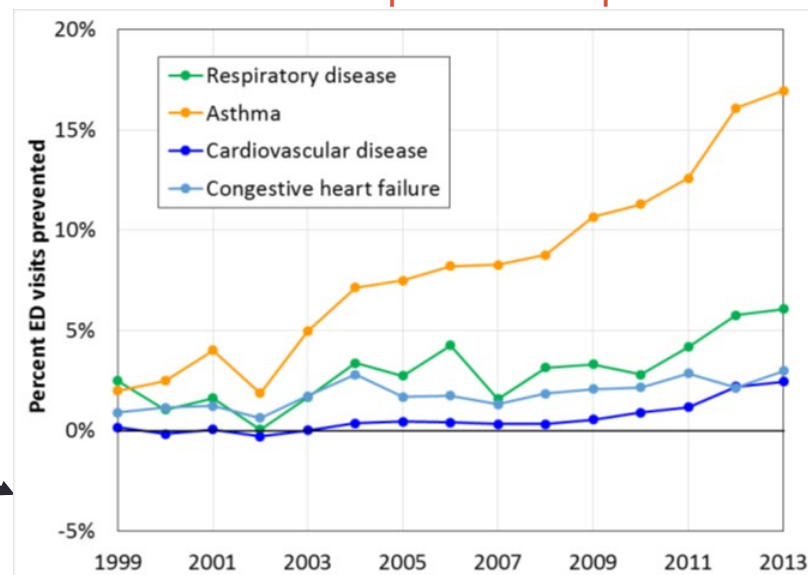
Ambient Air
Quality

*Estimated emission
reductions based on
actual emission and
implementation
patterns*

■ Observed ■ Counterfactual



Observed Resp & CV
ED visits compared to expected



Human Health
Response

*Estimated daily
ER visits based
on time series
applied to
counter-factual AP*

Policy Evaluation



Clean
Up



Intervention
Community



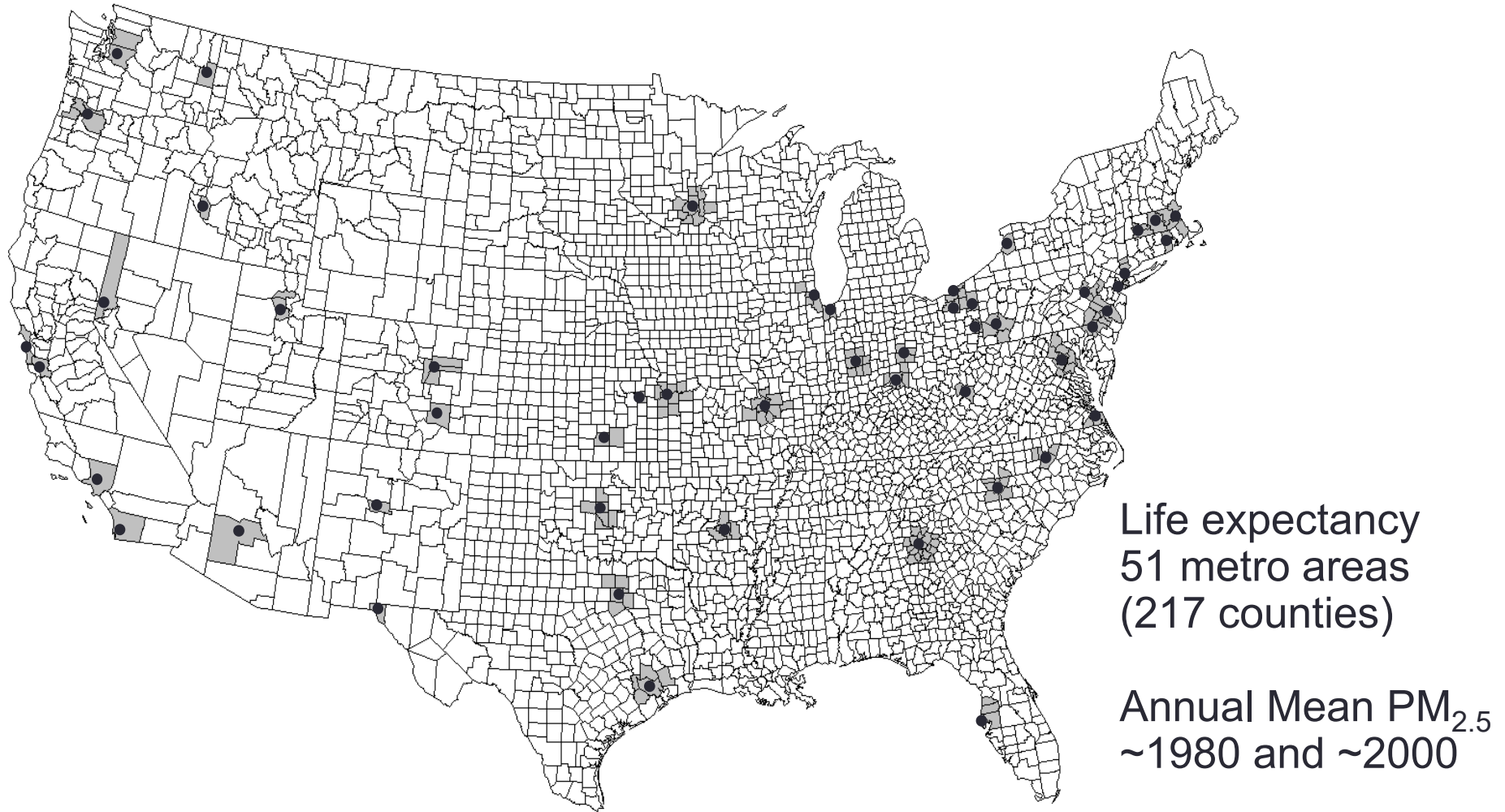
NO
Clean
Up



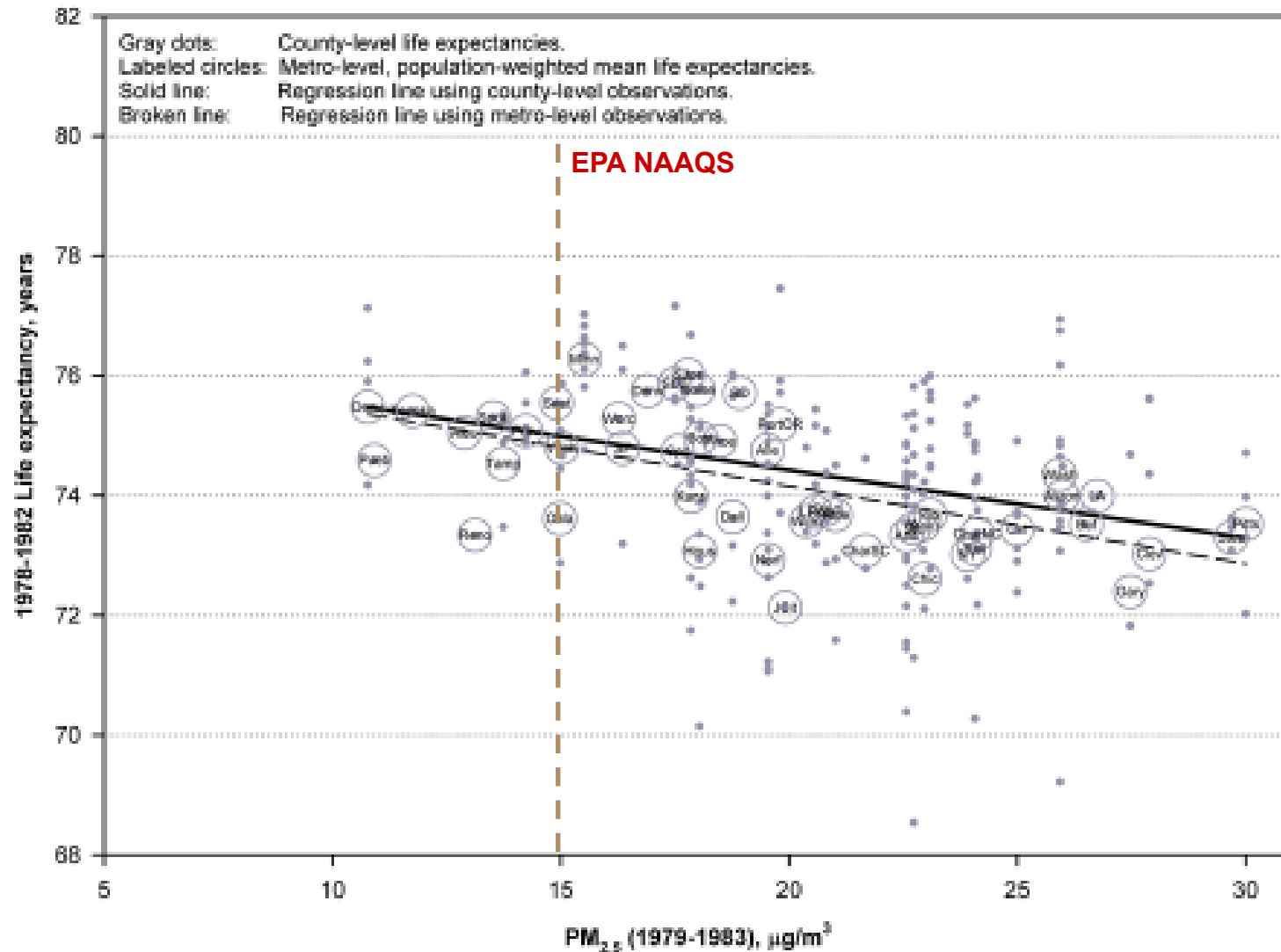
Comparison
No Intervention
Community

Fine Particulate Air Pollution & US County Life Expectancies

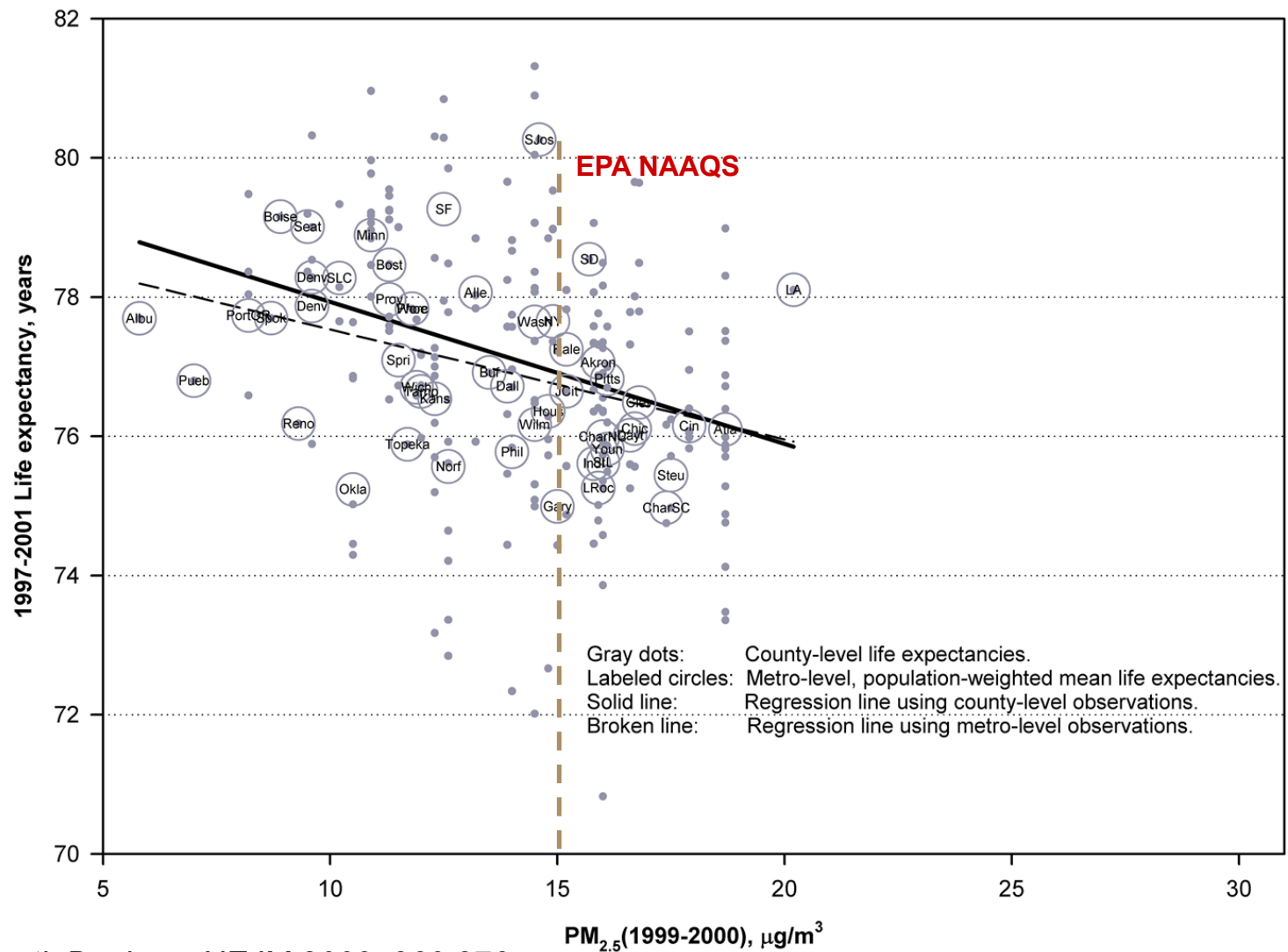
Pope, Ezzati, Dockery (NEJM 2009)



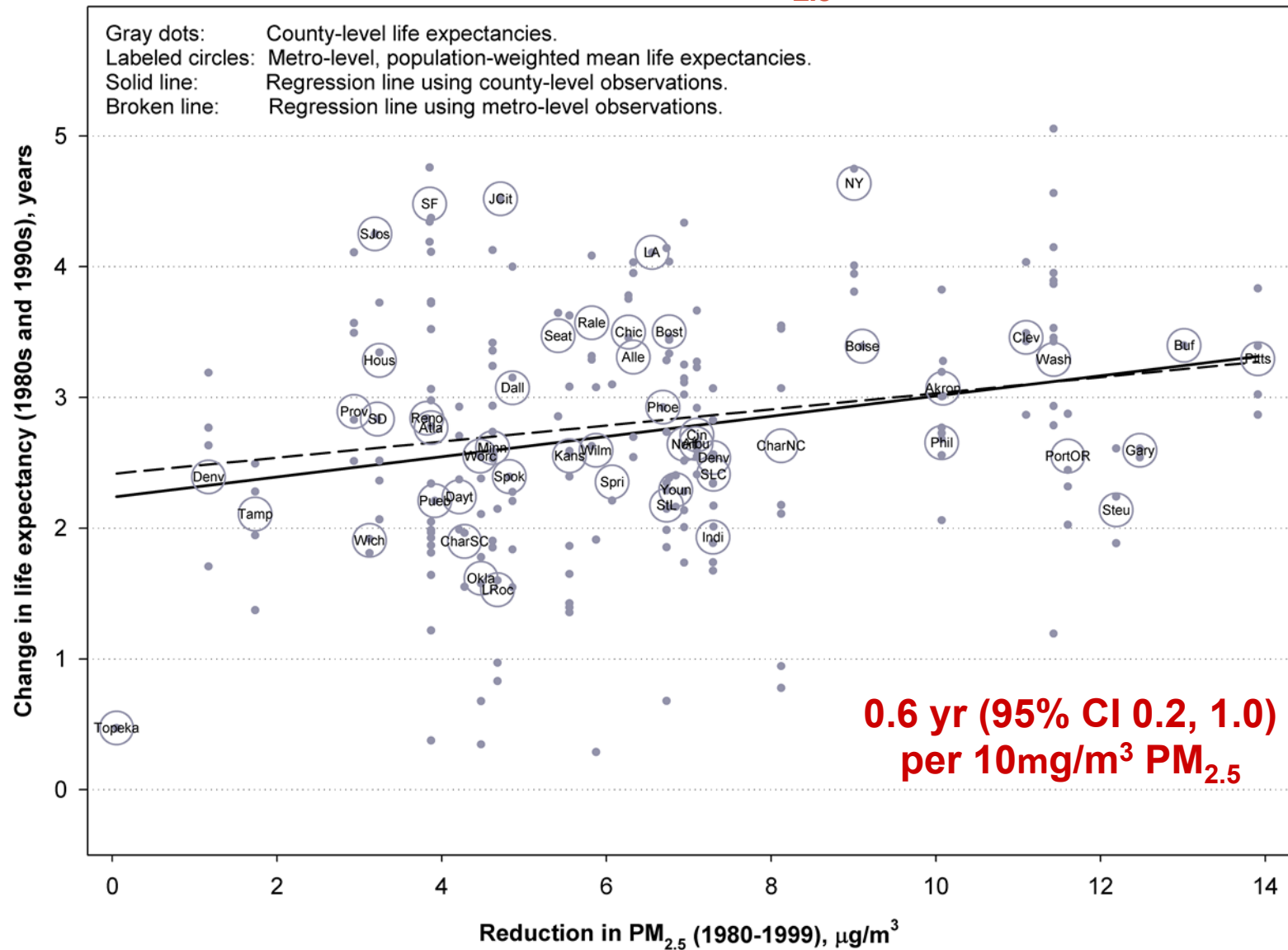
Life Expectancy vs PM_{2.5} 1979-83



Life Expectancy vs PM_{2.5} 1999-2000

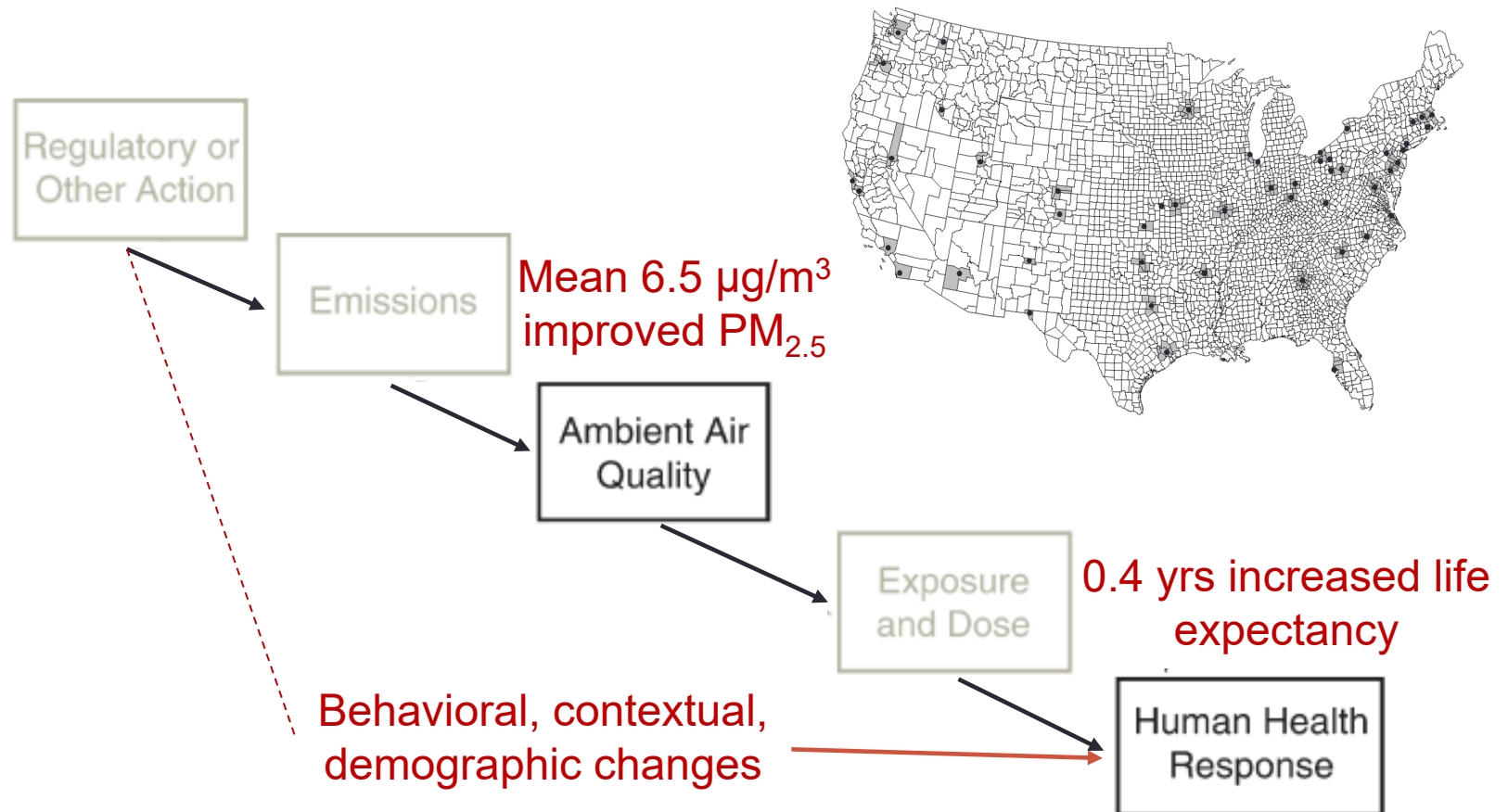


Δ Life Expectancy vs Δ PM_{2.5} 1980-1999



Fine Particulate Air Pollution & US County Life Expectancies

Pope, Ezzati, Dockery (NEJM 2009)



Randomizing Observational Studies



**Matching on
Covariates**

With enough people, possible to match
people with intervention to someone with
no intervention

Intervention



**No
Intervention**



Follow-up



Follow-up

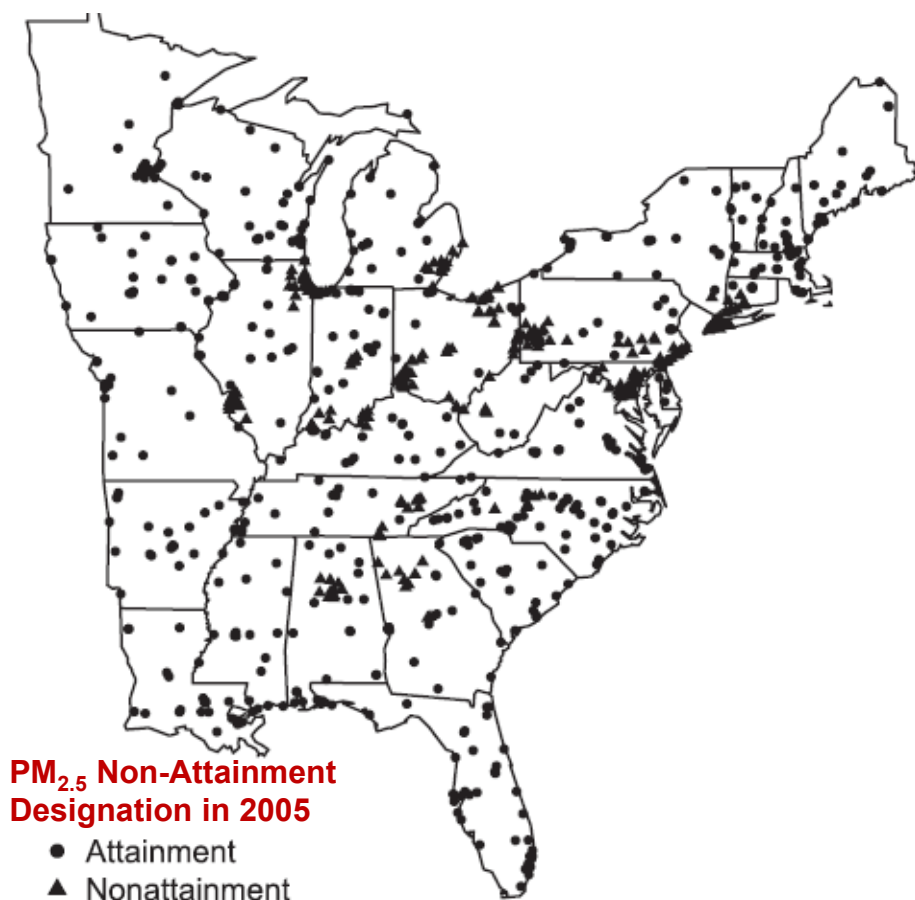


**Compare
results**

Analogue of Randomized Trial

Impact of National Ambient Air Quality Standards Nonattainment Designations on Particulate Pollution and Health

CM Zigler, C Choirat, and F Dominici



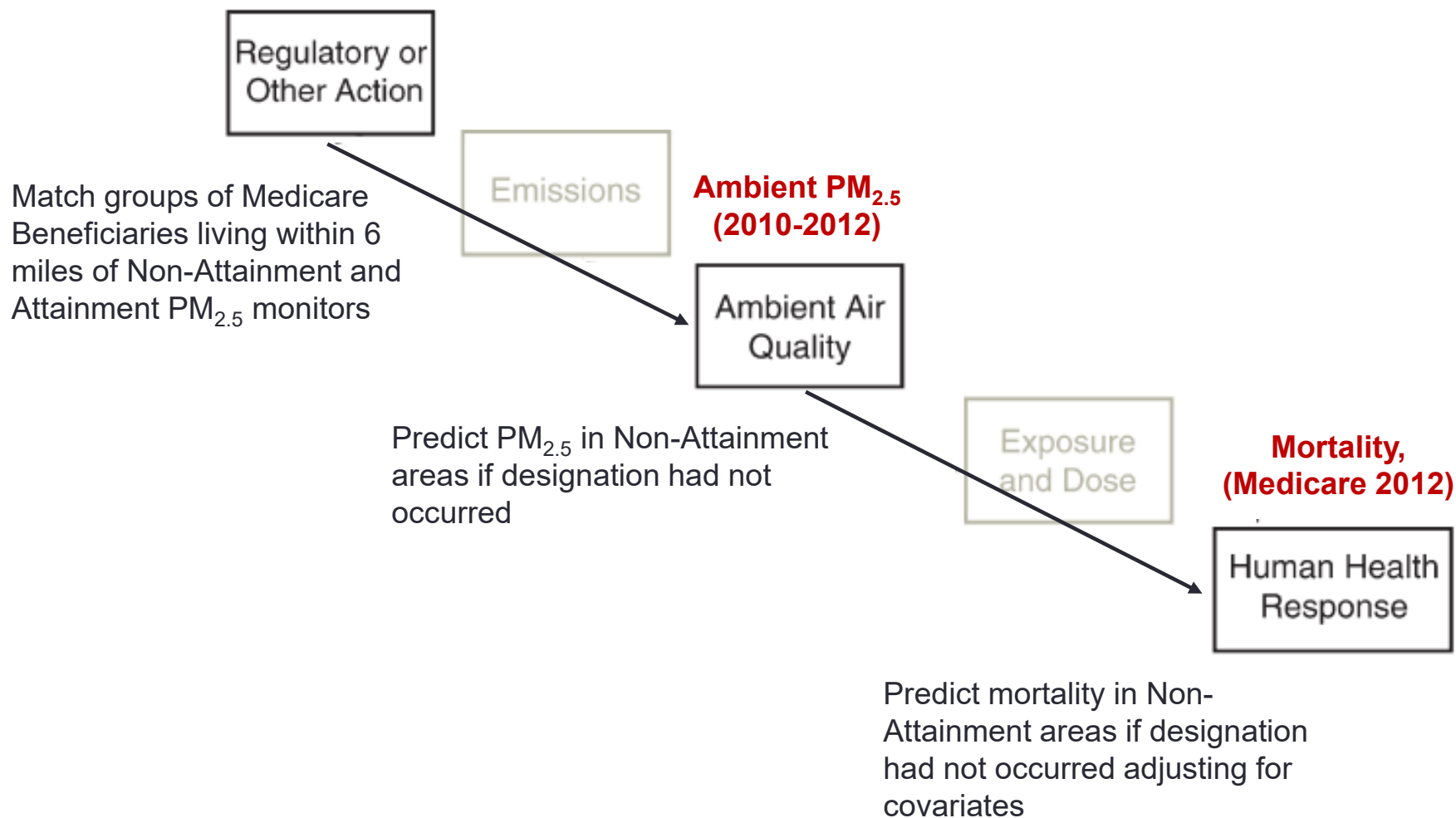
892 PM_{2.5} monitors

- 292 Non-Attainment
- 600 Attainment

10.5 million Medicare beneficiaries living within 6 miles of PM_{2.5} monitor

Impact of National Ambient Air Quality Standards Nonattainment Designations on Particulate Pollution and Health

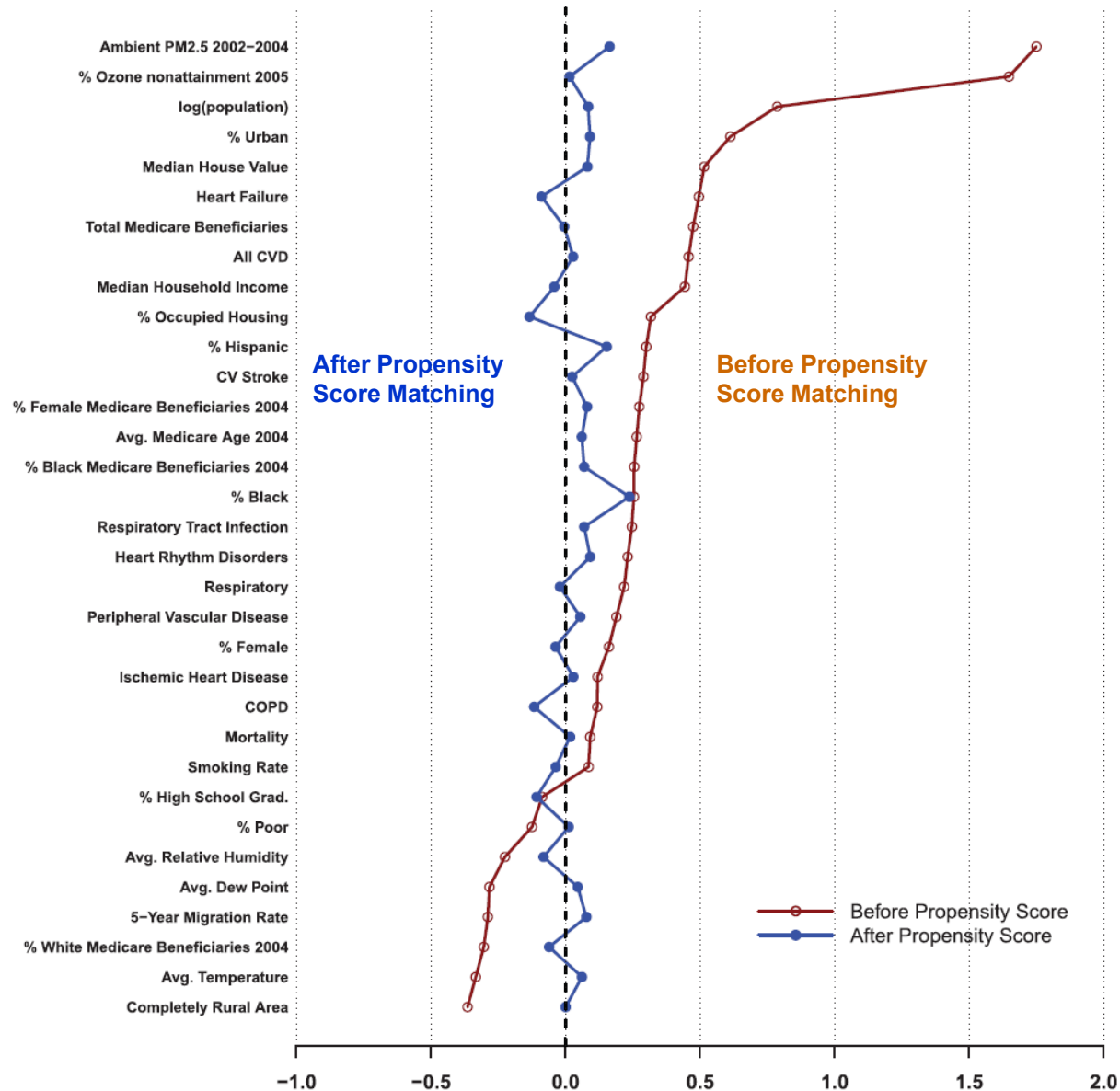
PM_{2.5} Non-Attainment Designation (2005)



- 10.5 million Medicare beneficiaries living within 6 miles of 600 Attainment & 292 Non-attainment monitors
- Clear differences between these areas
- **Propensity Score** – aggregate measure of probability of being in non-attainment area
- **Match** based on propensity scores
- **Prune** area without matches

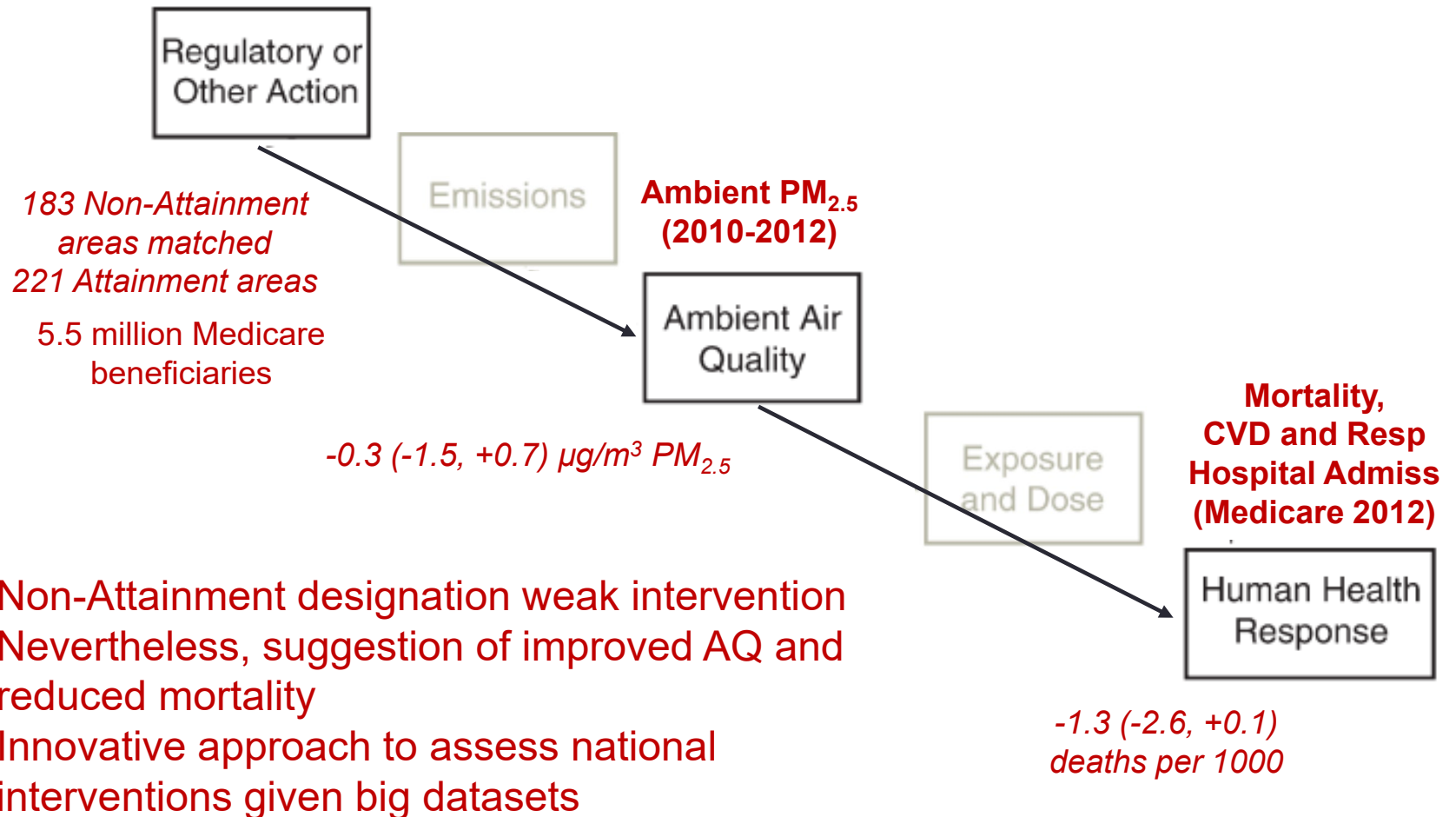
	Attainment (N=537)	NonAttainment (N=292)
Pollution Monitoring Data		
PM _{2.5} 2002–2004 (µg/m ³)	11.6	14.5
% Ozone nonattainment 2005	31%	92%
Population Demographics (year2000)		
Log(population)	11.42	12.59
Completely rural area	8%	1%
% Urban	77%	91%
% Black	17%	22%
% Hispanic	4%	7%
Median HH Inc.(\$1000)	\$37.34	\$42.60
% HS Grad.	31%	31%
% Poor	14%	14%
% Female	51%	52%
% occupied housing	91%	92%
5-year migration rate	49%	0%
Median house value(\$)	\$98.2	\$129.9
Smoking rate	26%	26%
Climate (years2004–2006)		
Avg. dewpoint(F)	46.3	44.6
Avg. temperature(F)	56.1	54.0
Avg. rel. humidity (%)	72.3	71.9
Baseline Medicare Characteristics (year 2004)		
Total beneficiaries (1000)	9.31	15.87
Avg. age (years)	75.2	75.5
% female	59%	60%
% White	87%	81%
% Black	11%	15%
Mortality (per 1000)	52.6	53.4
All CVD (per 1000)	108.7	120.9
Respiratory (per 1000)	31.4	34.4

Average standardized difference between Non-Attainment and Attainment areas



Impact of National Ambient Air Quality Standards Nonattainment Designations on Particulate Pollution and Health

PM_{2.5} Non-Attainment Designation (2005)



Empirical Evidence

- Randomized Controlled Trials
 - Gold standard for casual associations in observational studies
 - Practical limits to application in air pollution
- Quasi-Experimental Studies
 - Natural experiments
 - Short-term effects; dependent on infrequent, unique interventions
- Policy Evaluation
 - Post-hoc analyses
 - Long term, retrospective analyses; counterfactual difficult to define
- “Randomization” of Observational Studies
 - Matching using big data
 - Potential for showing long-term benefits of large scale interventions

Lessons and Opportunities

- These studies ask right question for policy assessment
- Designs can be intuitive, and results accessible
- Modelling and statistics do not compensate for weak study designs
- Defining counterfactuals challenging
- Traditional randomized trials have limited applicability
- Evaluating accountability studies based on criteria for clinical trials not helpful
- Big data offers opportunities
- However, still need creative study designs



The New York Times

Traffic and Pollution Plummet as U.S. Cities Shut Down for Coronavirus

By Brad Plumer and Nadja Popovich March 22, 2020