



# ONGOING NEEDS FOR AIR QUALITY MONITORING IN HEALTH EFFECTS RESEARCH

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# OVERVIEW

- Who is the Health Effects Institute?
- Progress in Air Quality
- Major research questions that we still get asked
  - Some research projects we've hoped might help answer them
- Are we there yet?
  - Some reflections on the ongoing need for AQ monitoring

# WHO IS THE HEALTH EFFECTS INSTITUTE?

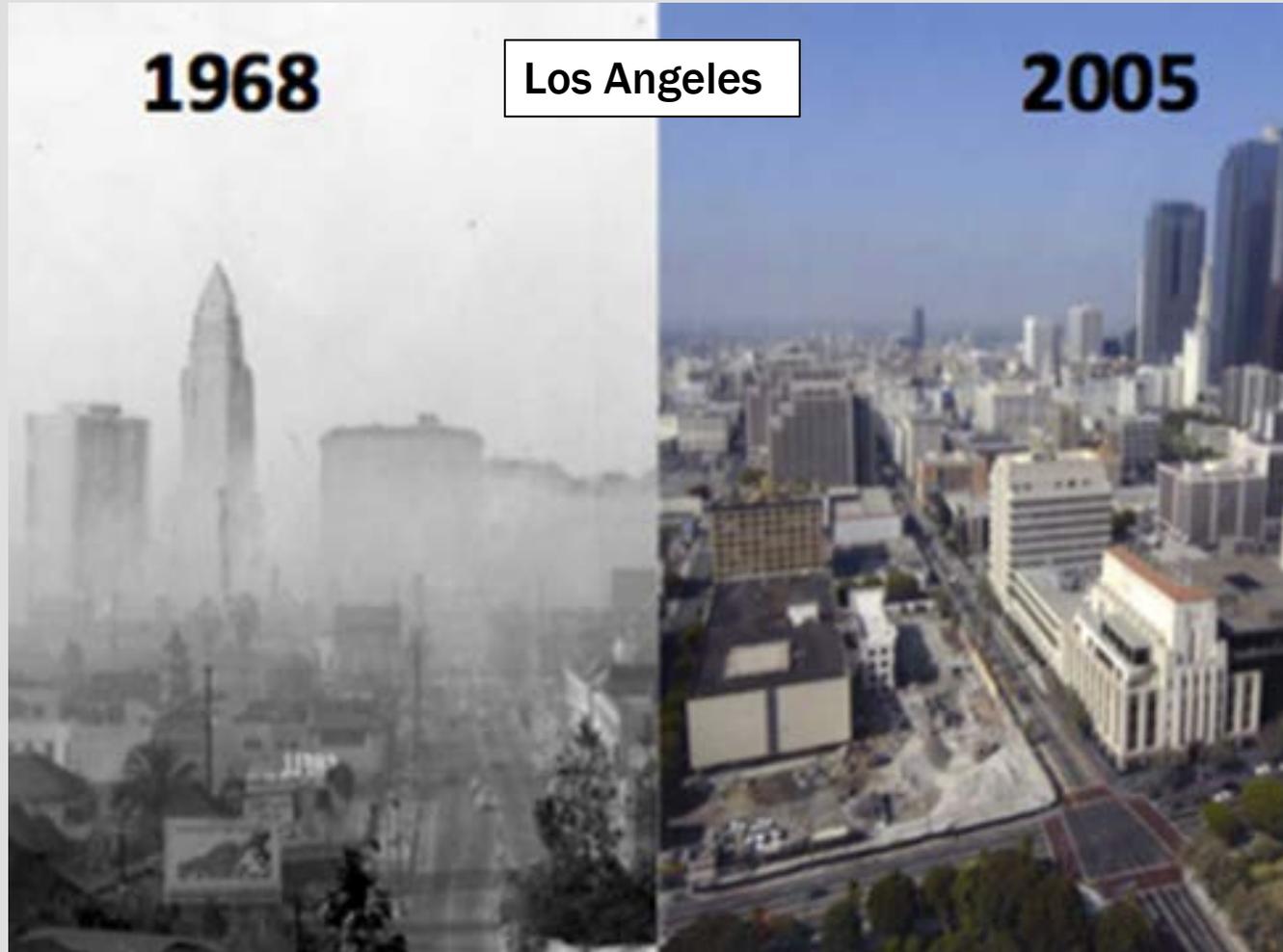
- An independent, nonprofit corporation chartered in 1980 with balanced funding from USEPA and the worldwide motor vehicle industry
- Commissioned to provide high-quality, impartial, and relevant science on the health effects of air pollutants

*HEI's goal is "simply to gain acceptance by all parties of the data that may be necessary for future regulation."*

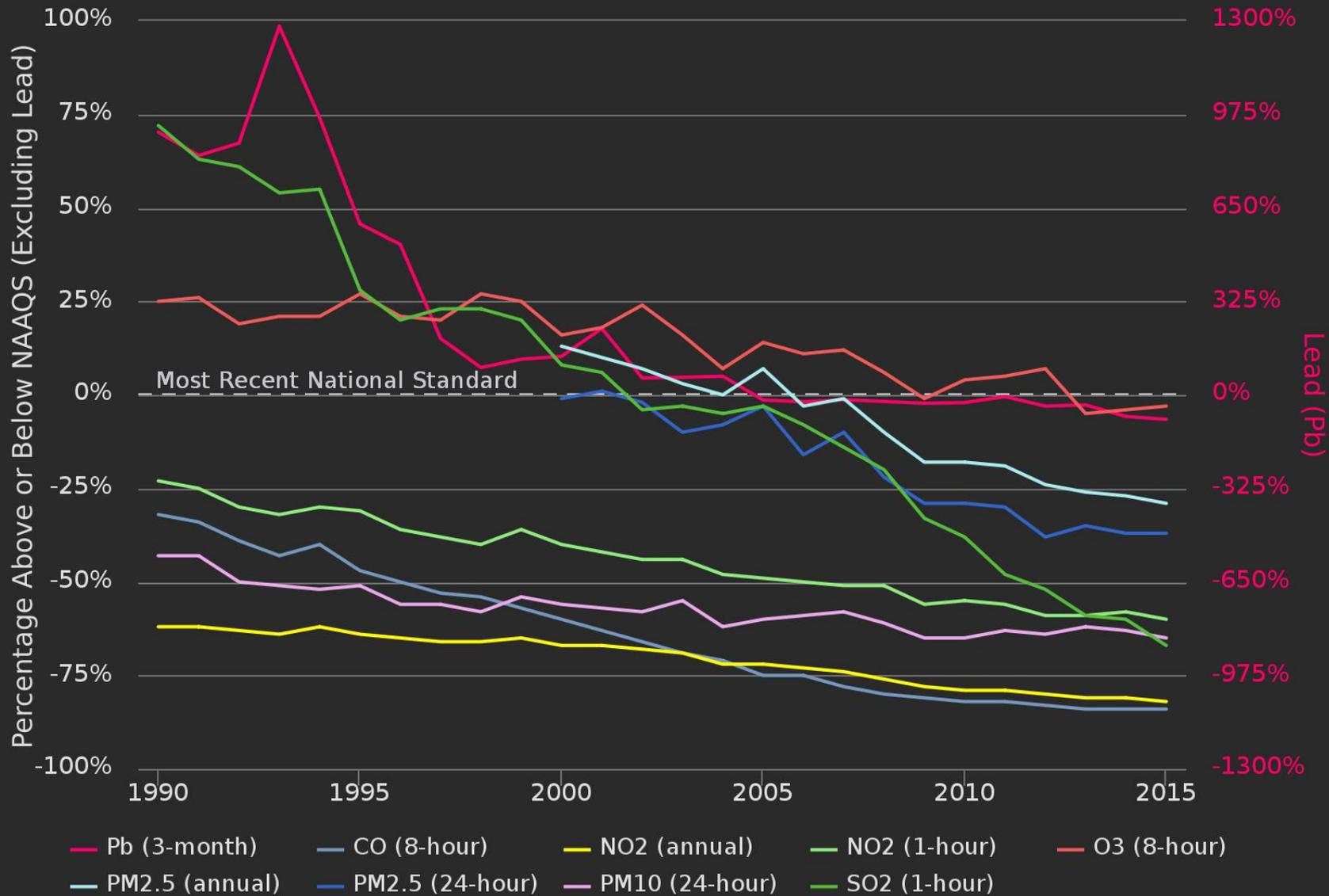
*Willam Ruckleshaus, Former EPA Administrator*



# We've come a long way...

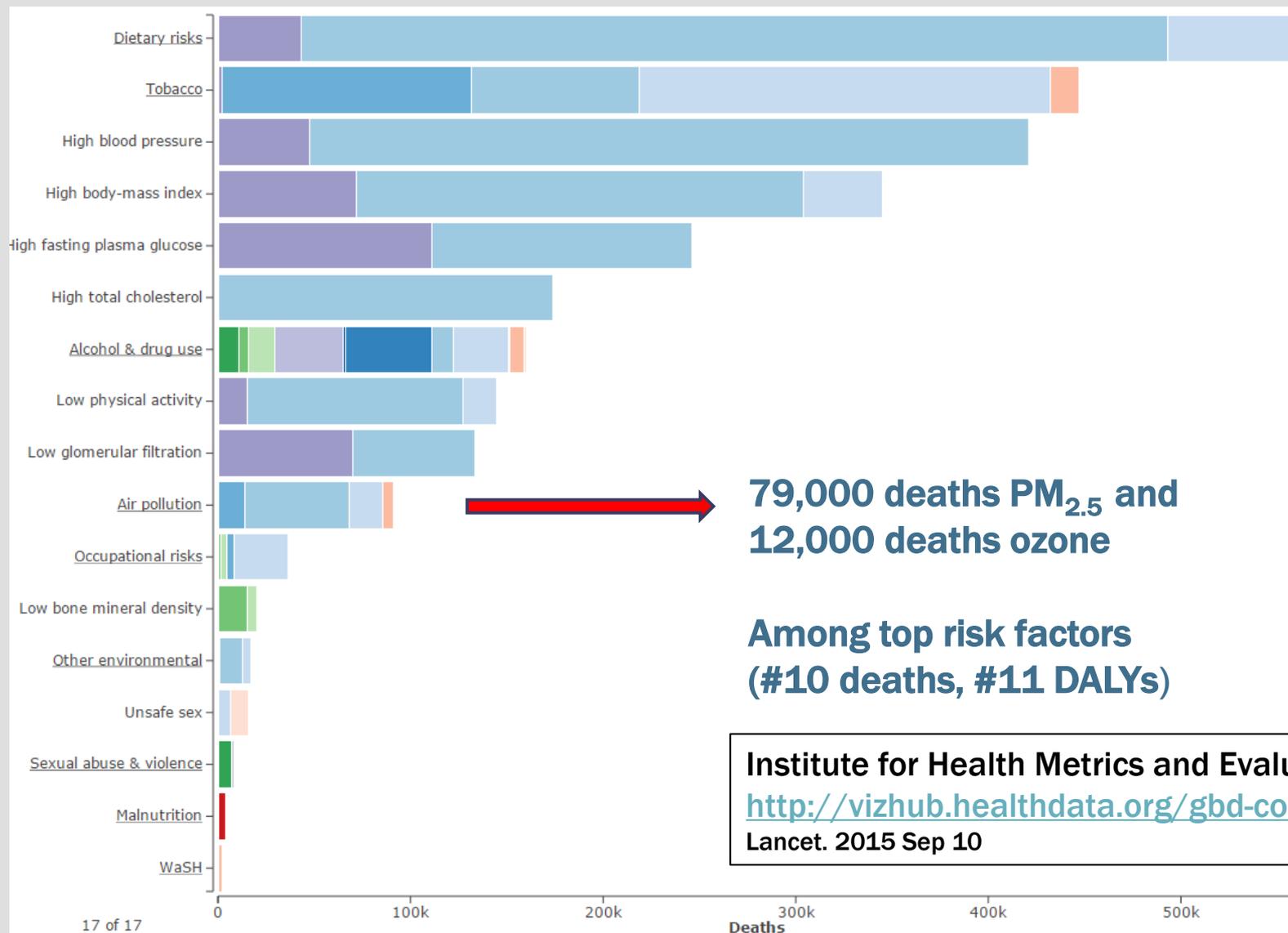


# NATIONAL AIR QUALITY CONCENTRATION AVERAGES



# US Burden of Disease 2013:

## Air pollution ranked 10<sup>th</sup> among risk factors

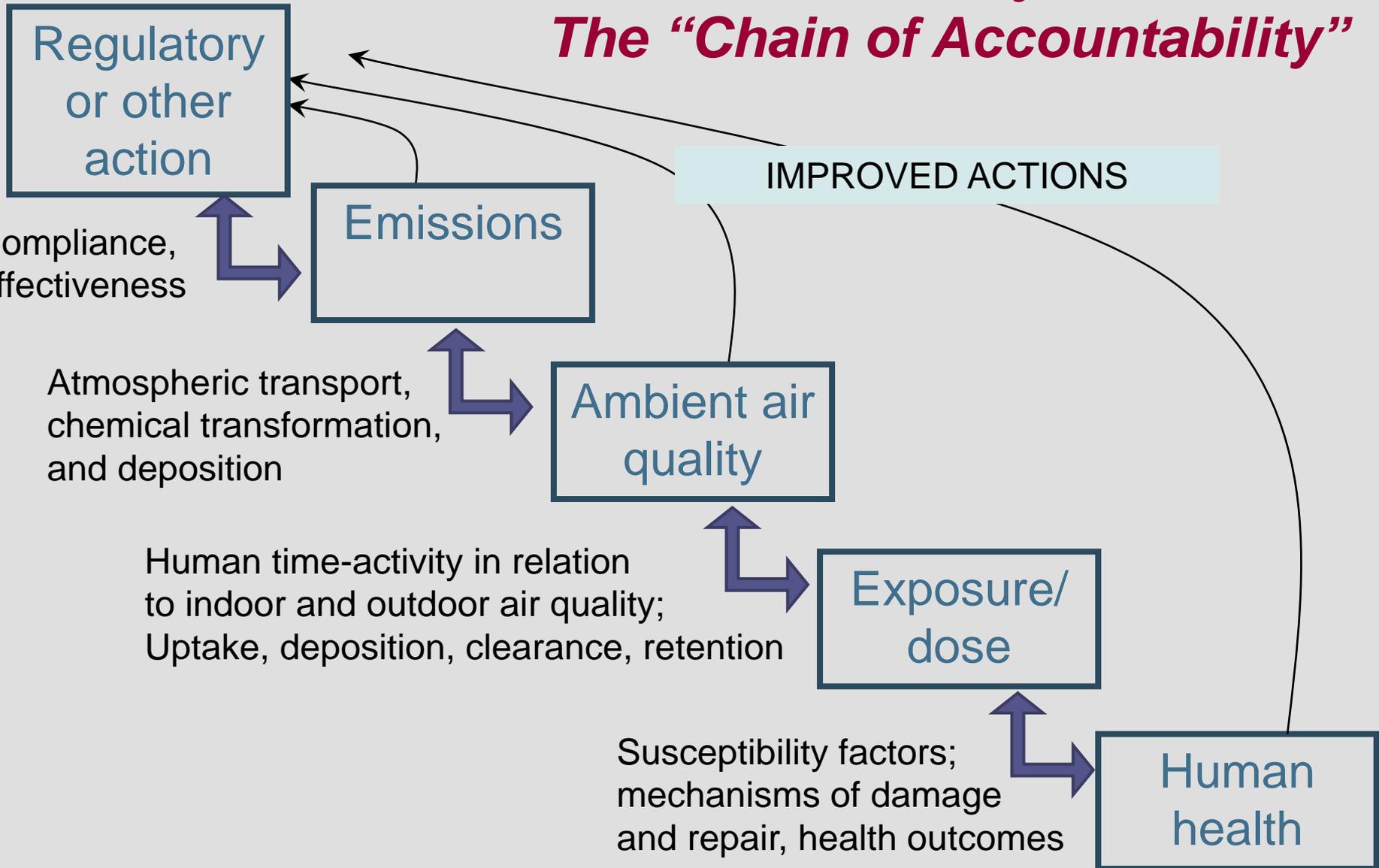


# ARE WE THERE YET?

## SOME QUESTIONS WE HAVE BEEN ASKED...

- What health benefits have regulations actually achieved?
  - Do changes in air pollution actually cause changes in health?
- Are the expected health benefits of reducing air pollution likely to be the same at the low concentrations observed today as they were when levels were higher?
  - i.e. what's the real shape of the concentration response at low concentrations?

# HEI Accountability Research: The “Chain of Accountability”



# HEI'S U.S. ACCOUNTABILITY RESEARCH

## WHAT HAPPENS WHEN THERE'S...

- Traffic diversions during the 1996 Summer Olympics in Atlanta, Georgia?
  - Peel et al. 2010
- A small town in Montana that replaces all old wood stoves?
  - Noonan et al. 2011
- Title IV of the 1990 Clean Air Act Amendments?
  - Morgenstern et al. 2012
- Policy driven air quality improvements in California?
  - Gilliland et al. 2016
- 2006 CARB Regulations on Goods movements around Port of Los Angeles?
  - Meng et al. ongoing
- Control programs imposed on major stationary sources (e.g., CAIR) and mobile sources (e.g., Tier II, Heavy Duty Diesel/Low Sulfur)?
  - Russell et al. ongoing



EPA  
AQS



State  
site



EPA  
AQS



Local &  
regional  
networks



Local &  
regional  
networks



SEARCH  
network



EPA  
AQS



EPA  
Supersite

# LATEST ACCOUNTABILITY RESEARCH

## RESEARCH REPORT

### **Causal Inference Methods for Estimating Long-Term Health Effects of Air Quality Regulations**

Corwin Matthew Zigler, Chanmin Kim, Christine Choirat, John Barrett Hansen, Yun Wang, Lauren Hund, Jonathan Samet, Gary King, and Francesca Dominici

#### **Case study 1:**

What was the effect of PM<sub>10</sub> nonattainment designation on ambient AQ and Health?

#### **Case study 2:**

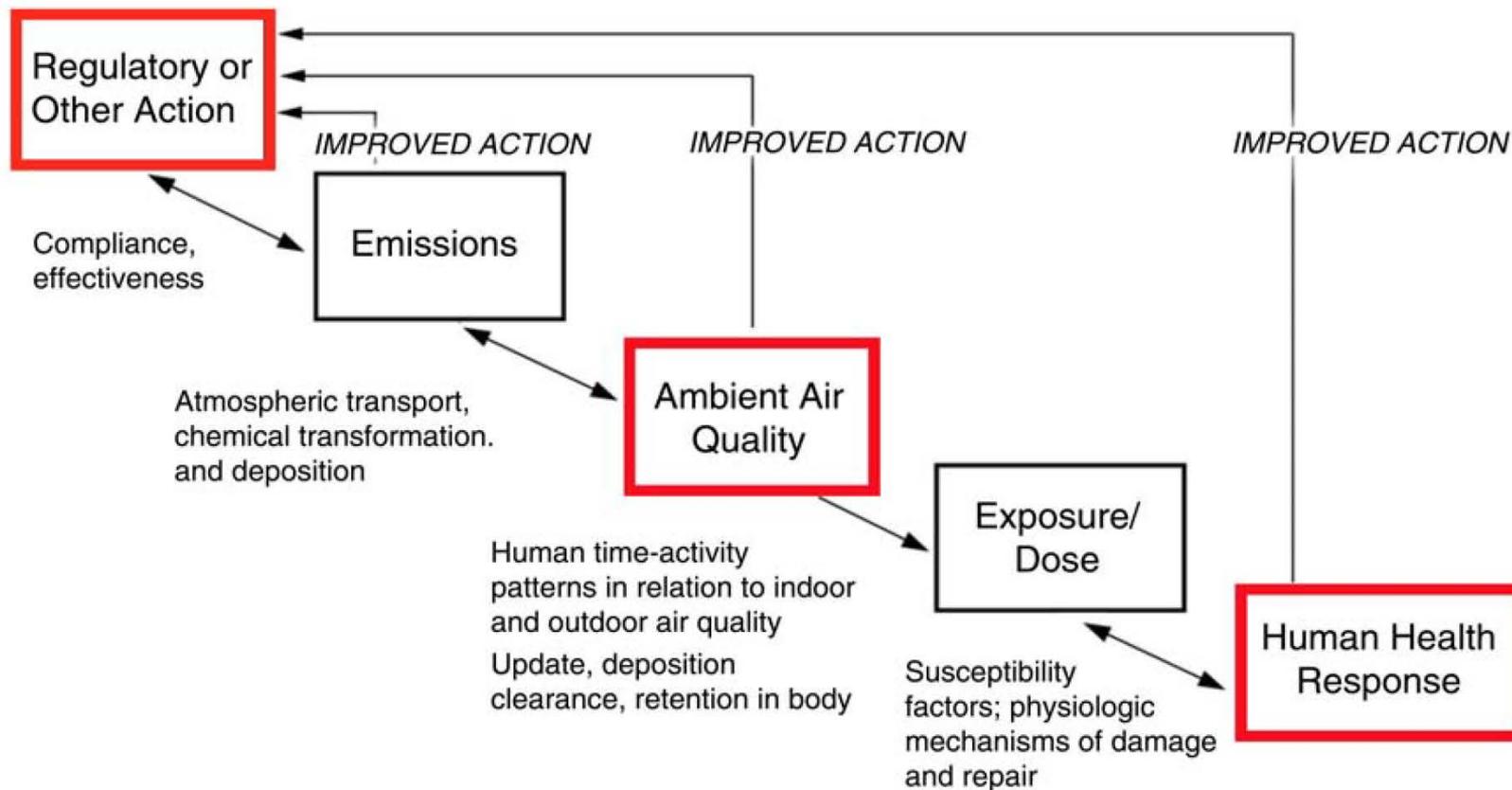
What was the impact of installing SO<sub>2</sub> scrubbers on emissions and ambient PM<sub>2.5</sub> concentrations?

# NEW STATISTICAL APPROACHES: CAUSAL INFERENCE METHODS, BAYESIAN ESTIMATION

Causal Inference Methods	Case Study 1:	Case Study 2:
Potential outcomes framework (Framing as a randomized experiment)	X	X
Propensity scores (confounding)	X	
Principal stratification	X	X (multipollutant)
Causal mediation analysis		X (multipollutant)

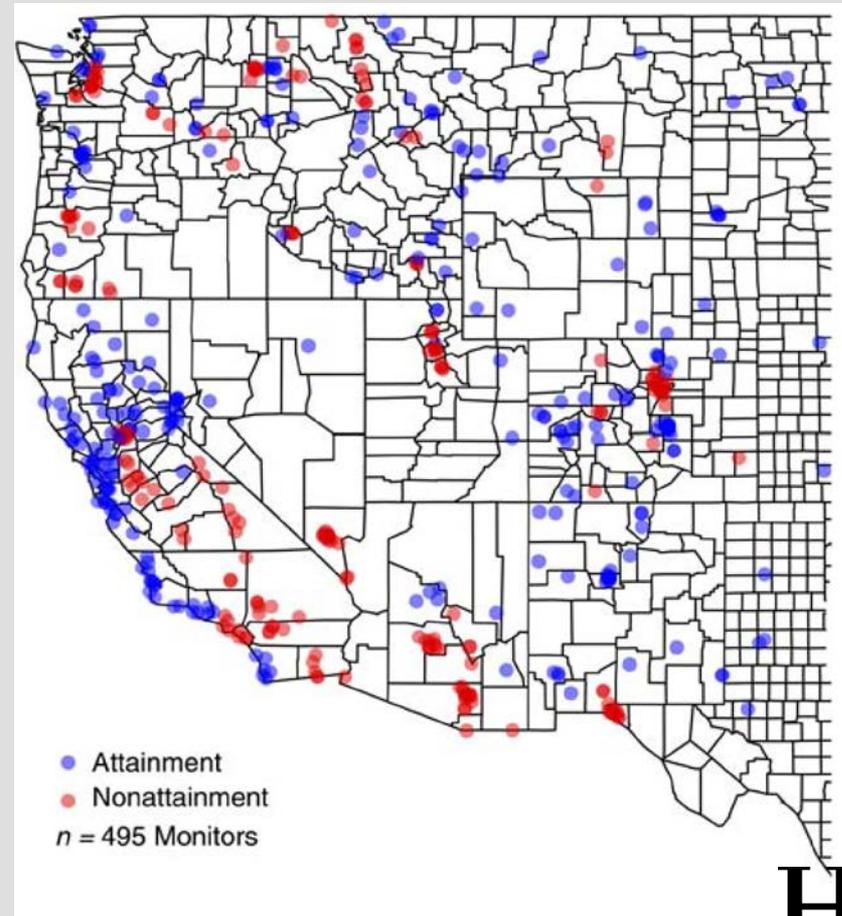
# CASE STUDY 1:

## LINKS IN THE CHAIN OF ACCOUNTABILITY



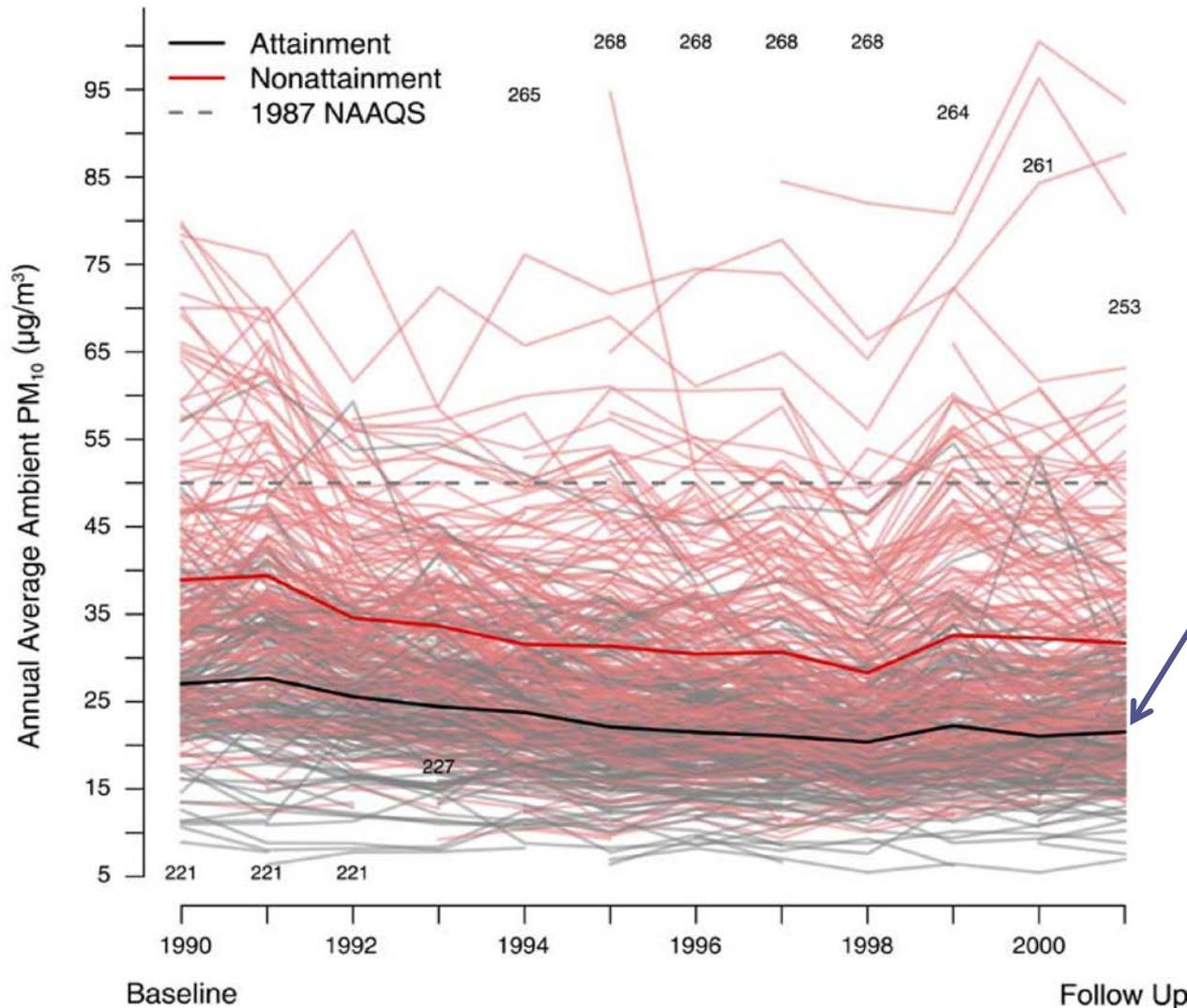
# CASE STUDY 1: PM<sub>10</sub> NONATTAINMENT DESIGNATIONS IN THE WESTERN U.S.

- U.S EPA – AQS data
  - Daily and annual measurements:
    - PM<sub>10</sub>
    - Ozone
  - Monitoring stations that were operating between 1990 and 2001
  - Annual PM<sub>10</sub> assumed **“Missing”** if **<67% valid measurements**
  - Linked to Medicare beneficiaries living within 6 miles of a monitoring location in 2001



# CASE STUDY 1:

## AIR MONITORING DATA ARE NOISY



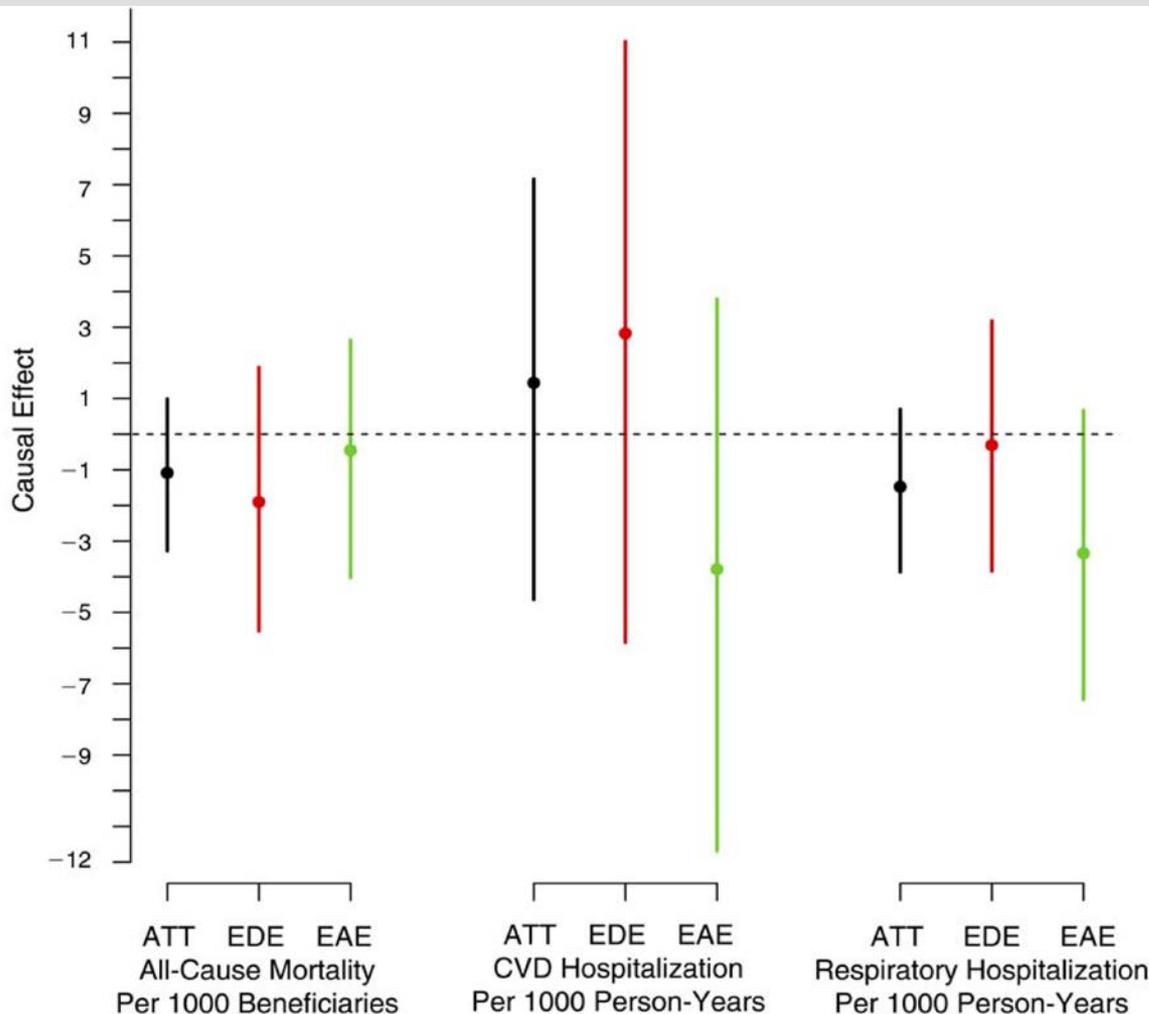
...But on average, PM<sub>10</sub> levels were lower in attainment areas

Zigler et al. 2016



# CASE STUDY 1:

## CAUSAL EFFECTS OF NONATTAINMENT DESIGNATION ARE CHALLENGING TO SEE



Posterior means (95% CI)

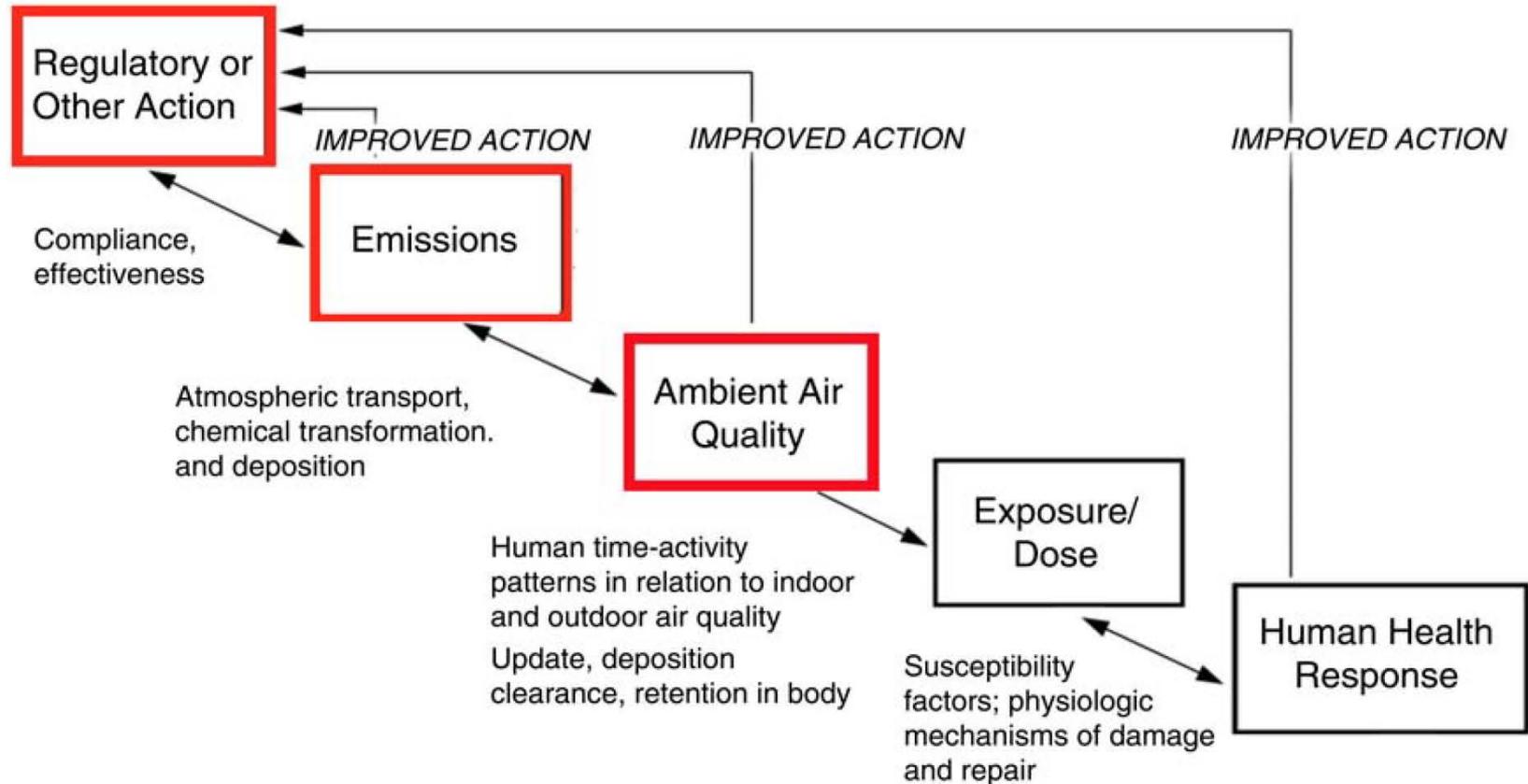
- ATT - Average treatment effect
- EDE - expected dissociative effect
- EAE - expected associative effect

### Interpretations:

Decreases in mortality and respiratory, but not CVD hospitalizations.

Not always associated with nonattainment designation

# CASE STUDY 2: LINKS IN THE CHAIN OF ACCOUNTABILITY



## CASE STUDY 2:

# WHAT WAS THE IMPACT OF INSTALLING SO<sub>2</sub> SCRUBBERS ON EMISSIONS AND AMBIENT PM<sub>2.5</sub> CONCENTRATIONS?

### ■ U.S EPA – AQS data

- Average ambient PM<sub>2.5</sub> in 2005

- Monitors (●) located within 150-km radius of each power plant

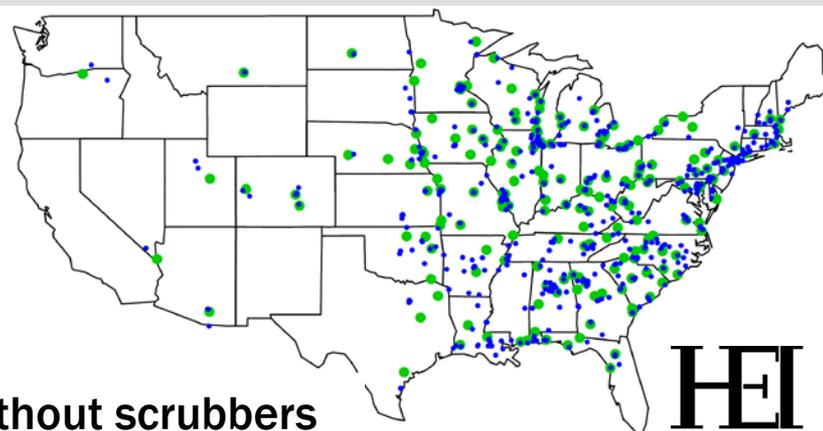
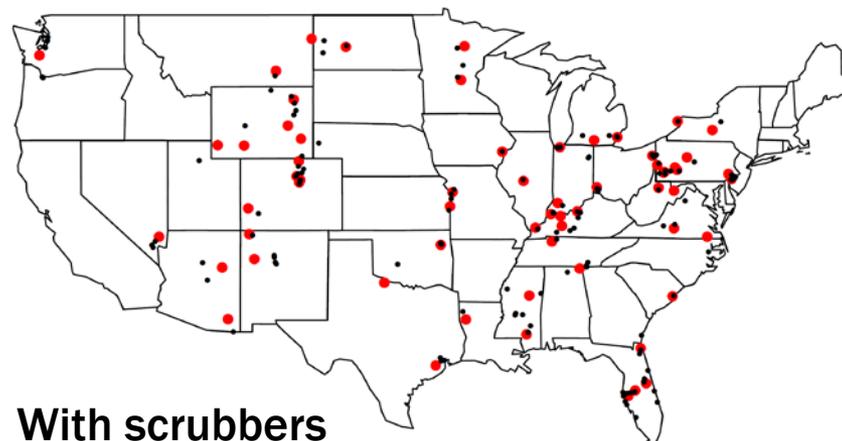
  - 63 with scrubbers ●

  - 195 without scrubbers ●

### ■ Other data:

- SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub> emissions

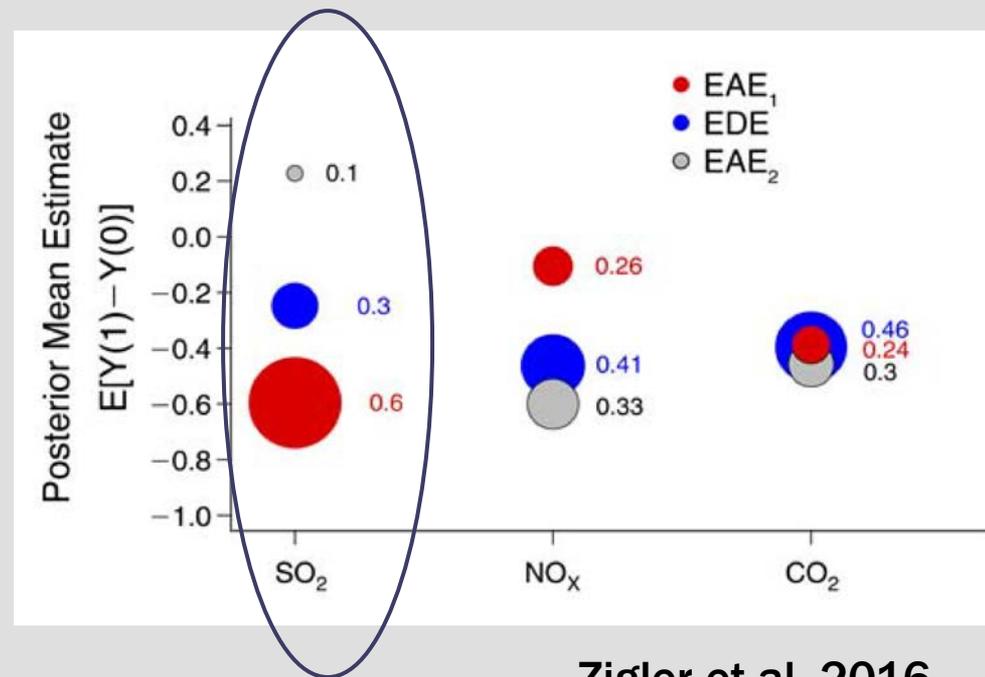
- Scrubber unit characteristics



HEI

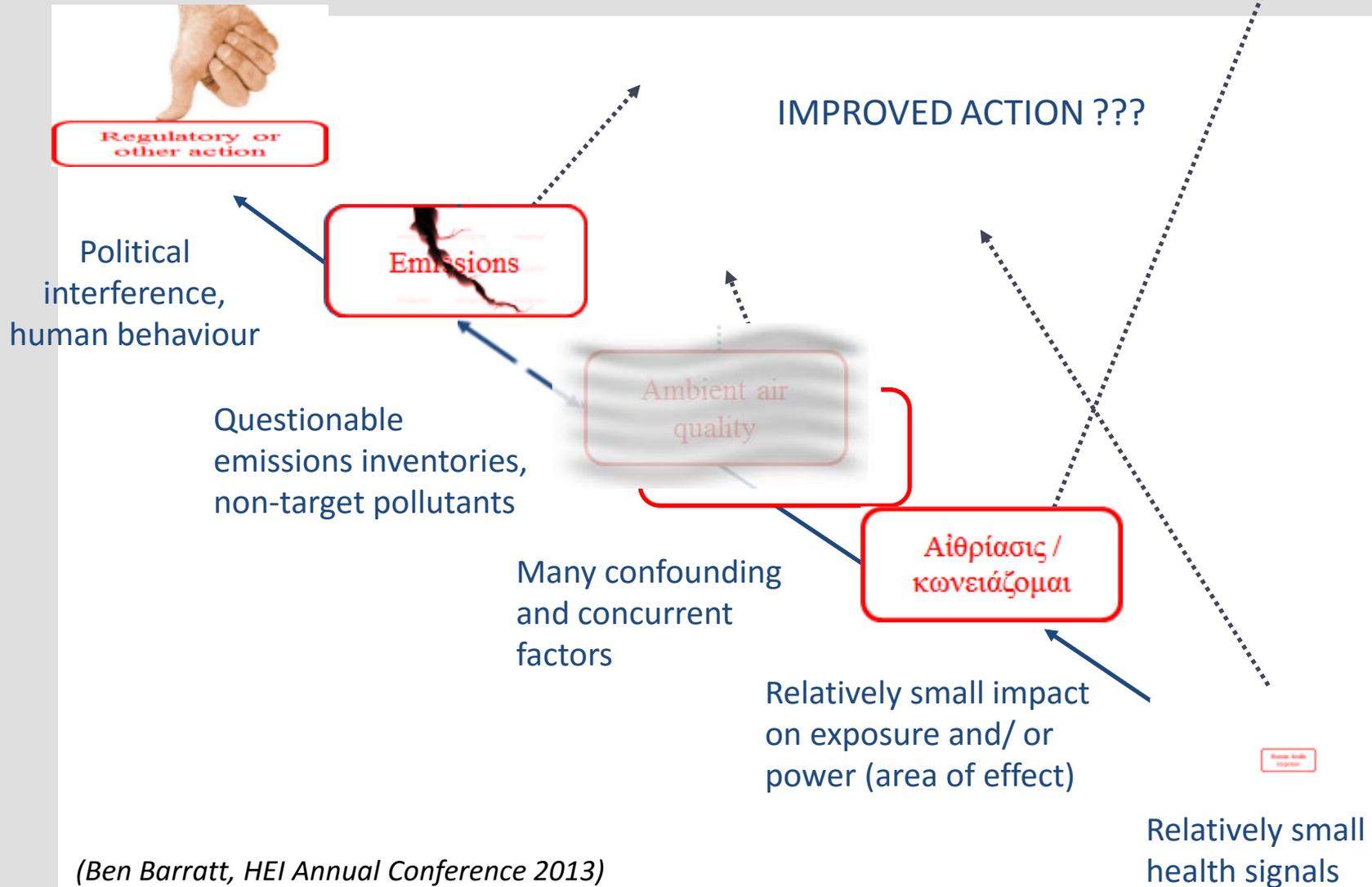
# CASE STUDY 2 RESULTS: SHOW STRONGEST EFFECT OF SCRUBBERS ON AMBIENT PM<sub>2.5</sub> MEDIATED BY SO<sub>2</sub>

- Average causal reduction in ambient PM<sub>2.5</sub> of 0.6 μg/m<sup>3</sup> in 60% of plants installed with scrubbers ( ● )
- Little or no effect in 30% of plants with scrubbers ( ● )
- Causal increase in PM<sub>2.5</sub> in 10% of plants! ( ● )
- Overall, results highly uncertain



Zigler et al. 2016

# *Real* The chain of accountability

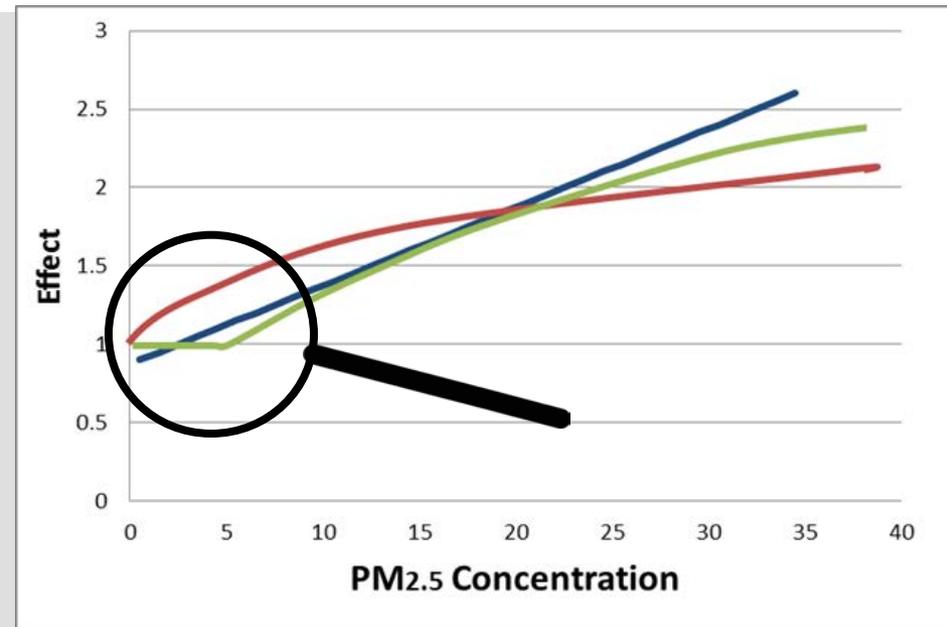


(Ben Barratt, HEI Annual Conference 2013)

# ARE WE THERE YET?

## WHAT ARE THE HEALTH EFFECTS ASSOCIATED WITH LOW AIR POLLUTION CONCENTRATIONS?

- US Regulatory Impact Assessments (RIAs) assume:
  - Linear concentration-response relationship extending through zero
- A science policy decision, based on the best evidence (Krewski et al. 2009 reanalysis of the ACS cohort)
- Evidence constrained by study size and power
- HEI has launched a new research program with 3 large studies in the US, Canada, and Europe



What will we see?

- **Threshold below some level?**
- **Steeper at low concentrations? (as in Global Burden of Disease model)**
- **Protective at lowest levels?**

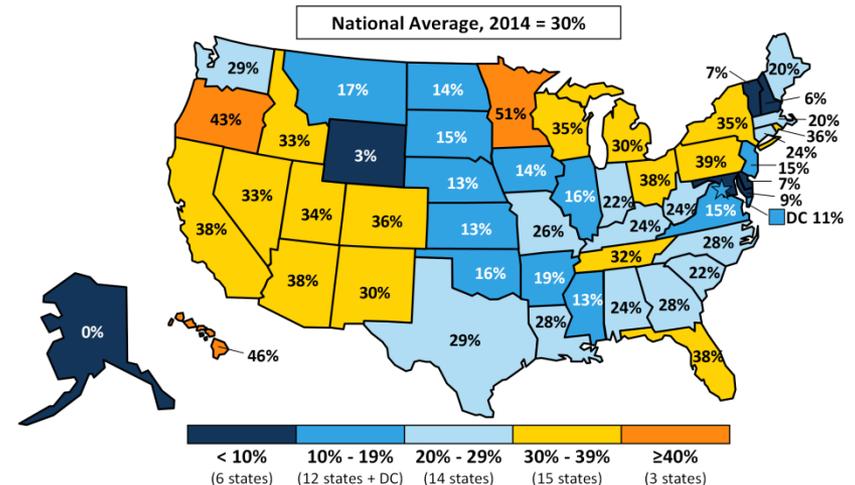
# ASSESSING THE LONG-TERM EFFECTS OF LOW LEVELS OF AMBIENT POLLUTION

DOMINICI ET AL./HARVARD TH CHAN SCHOOL OF PUBLIC HEALTH

- Hybrid exposure strategies:
  - USEPA ACS data, including IMPROVE and STN
  - NASA satellite data at 1km x 1km grid
  - Chemical transport models
  - Land use data
  - Cross-validation
- Zip-code level PM<sub>2.5</sub>, selected PM species, ozone, and NO<sub>2</sub>
- Evaluation of exposure measurement error
- Causal inference methods

- US Medicare and Medicaid enrollees
- ~28 million each
- 2000-2014

Share of Medicare Beneficiaries Enrolled in Medicare Advantage Plans, by State, 2014

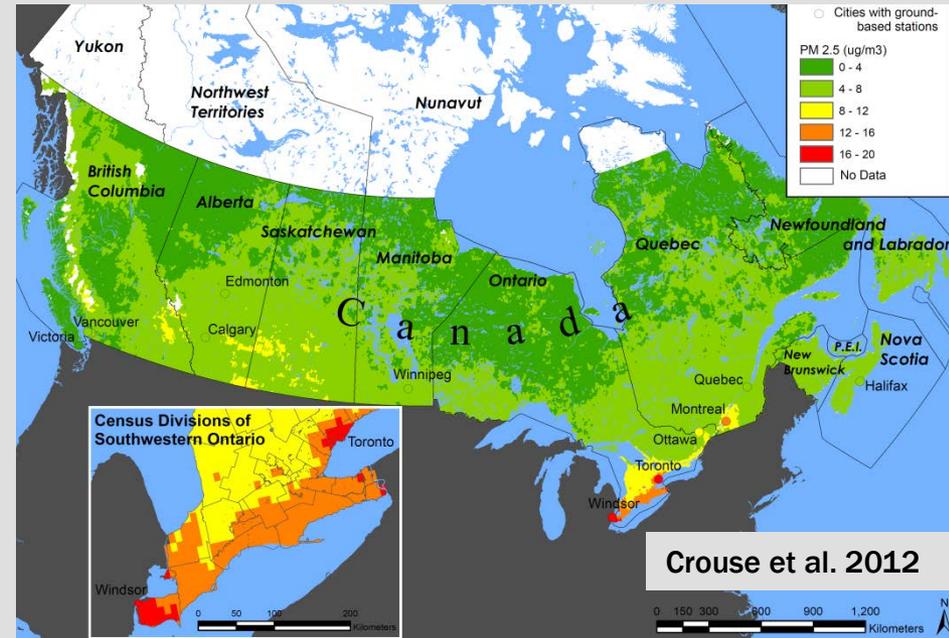


# IDENTIFYING THE SHAPE OF THE ASSOCIATION BETWEEN LONG-TERM EXPOSURE TO LOW LEVELS OF AMBIENT AIR POLLUTION AND THE RISK OF MORTALITY

BRAUER ET AL. / UNIVERSITY OF BRITISH COLUMBIA

- Hybrid exposure strategies:
  - Satellite data (1km x 1km)
  - Validation of satellite predictions with co-located monitors in both US & Canada and
  - Chemical transport models
- Longitudinal address-level exposures to PM<sub>2.5</sub> (1981-2011)
- Sensitivity of concentration response to ozone and NO<sub>2</sub>

- 3 Canadian census datasets
- ~3-4 million people
- 1991 to 2011



# ARE WE THERE YET?

- ▶ Not yet. We're still answering some of these questions:
  - ▶ What health benefits have regulations actually achieved? Do changes in air pollution actually cause changes in health?
  - ▶ Are the expected impacts of reducing air pollution likely to be the same at low concentrations observed today?
- And there are more questions to be answered:
  - What's the impact of changing technologies and fuels on exposures to:
    - PM<sub>2.5</sub> ?
    - PM composition?
    - NO<sub>2</sub> ?
    - ultrafine particles?
    - Components of brake and tire wear?
  - And their impact on human health?
  - What's the value of denser monitoring networks of low cost monitors to improved individual-level exposure and health assessment?

# SO... ARE WE THERE YET?

## ■ Not yet!

- Our existing monitoring system form the core of many health effects research studies:
  - AQS
  - MOVES
  - Speciation network
  - Near-road monitoring netwrok
- There's an increasing demand for very large data sets so an ongoing need for long-term, high quality, complete data from as many existing monitors as possible.
- It may not be enough. We need more systematic evaluation of the information added by higher density, low cost monitors.
- We need your continued expertise and involvement in epidemiologic and other studies to make sure the data are appropriately used and interpreted.

# ACKNOWLEDGEMENTS

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- Kathryn Liziewski, Research Assistant
- Hilary Polk, Managing Editor
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