

# EMPIRICAL ASSESSMENTS: TRIALS, QUASI-EXPERIMENTS, AND POLICY EVALUATION

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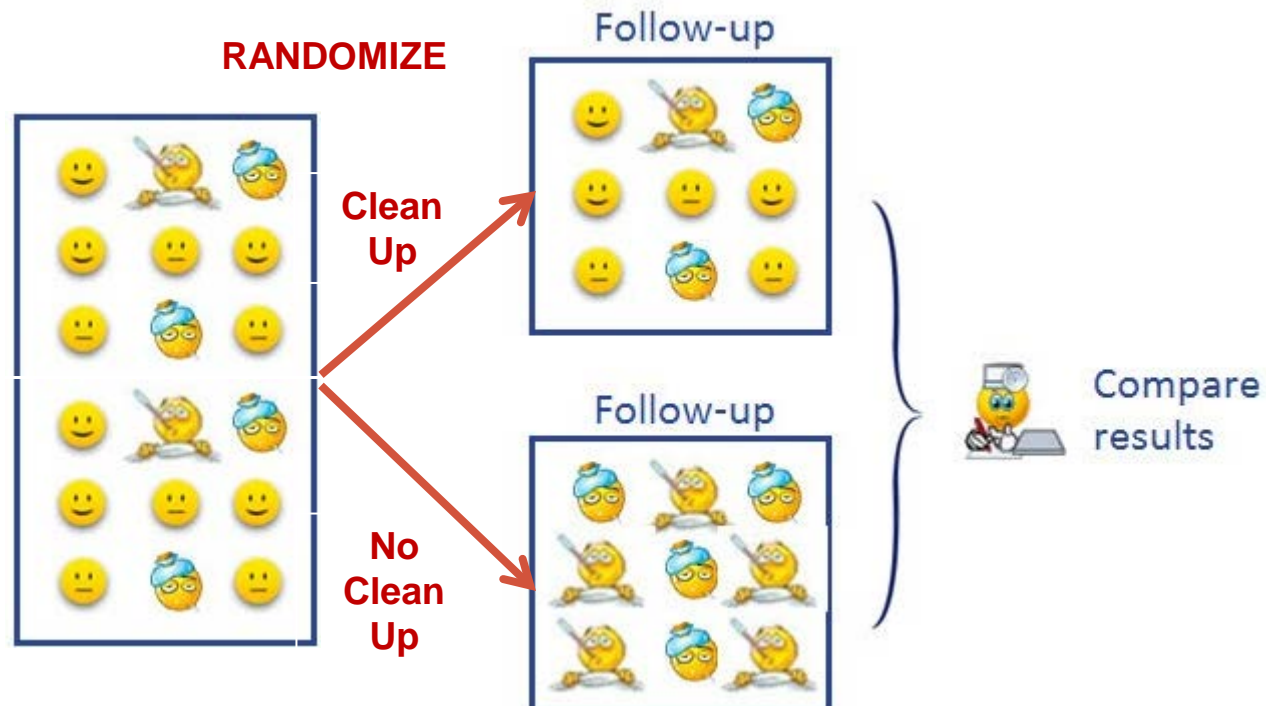
2017 BC Lung Association Air Quality and Health Workshop  
“Policies and Interventions to Improve Air Quality and Health”  
Wednesday March 15, 2017  
Sheraton Wall Centre Hotel, Vancouver

**Douglas W. Dockery**  
*Professor of Environmental Epidemiology*  
Harvard T.H. Chan School of Public Health

# Empirical Evidence

- Randomized Controlled Trials
  - Gold standard for casual associations in observational studies
- Quasi-Experimental Studies
  - Natural experiments
- Policy Evaluation
  - Post-hoc analyses

# Randomized Controlled Trials



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# Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial

*Kirk R Smith, John P McCracken, Martin W Weber, Alan Hubbard, Alisa Jenny, Lisa M Thompson, John Balmes, Anaite Diaz, Byron Arana, Nigel Bruce*

**RESPIRE:** Randomized Exposure Study of Pollution Indoors and Respiratory Effects

**A** Traditional open fire used for cooking



265  
Households

**B** Locally developed and constructed high-mass chimney woodstove



269  
Households

	Control	Intervention	% Reduction
PM <sub>2.5</sub> (µg/m <sup>3</sup> )	821	32	96%
CO (PPM)	11.0	0.5	95%
Physician-Diagnosed Pneumonia (Cases/100 child-yr)	62.6	49.7	21%



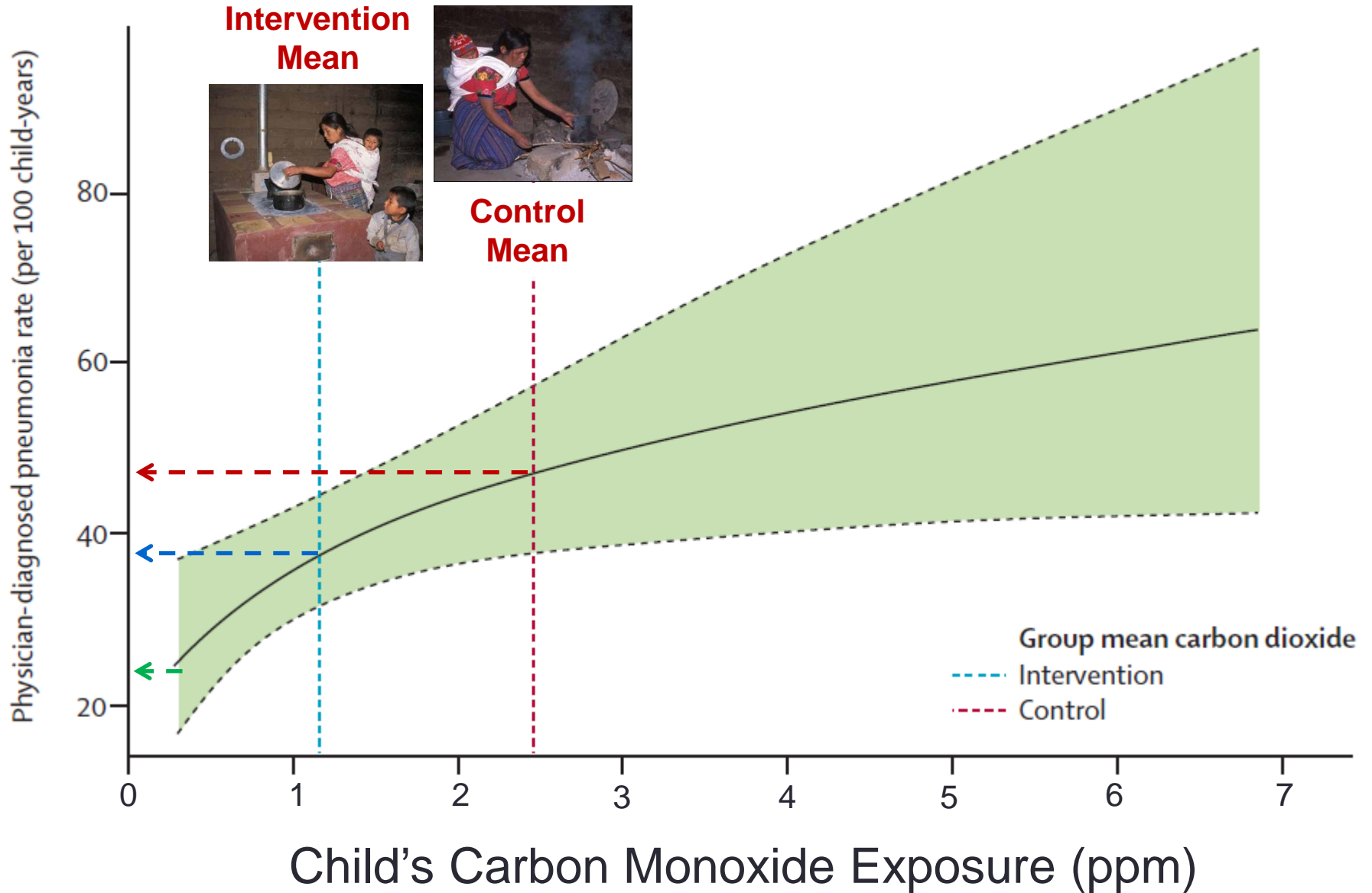
Kitchens down by 20 fold, but children exposure down by only 2 fold

**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

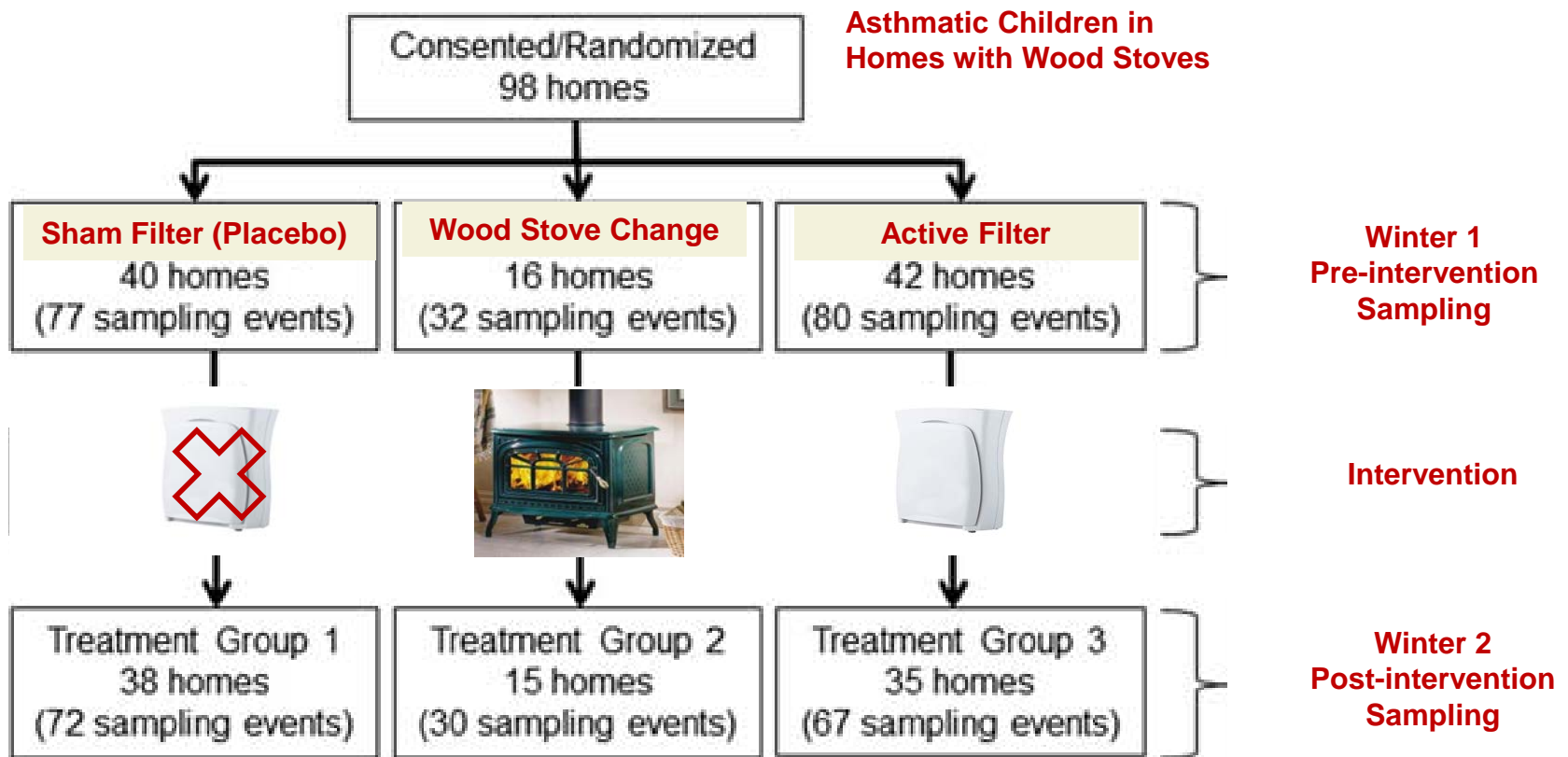


# Physician-Diagnosed Pneumonia



# Asthma randomized trial of indoor wood smoke (ARTIS): Rationale and methods <sup>☆</sup>

Curtis W. Noonan <sup>\*</sup>, Tony J. Ward



Sixteen homes received the wood stove changeout and showed no significant changes in PM<sub>2.5</sub> or particle counts. ... Relative to the wood stove changeout, the filtration unit intervention was more efficacious and less expensive, ...need for the evaluation of additional strategies for improving indoor air quality in homes using wood stoves.

*Journal of Exposure Science and Environmental Epidemiology* (2017) **27**, 64–71



# Are Randomized Trials Necessary to Advance Epidemiologic Research on Household Air Pollution?

Jennifer L. Peel<sup>1</sup> • Jill Baumgartner<sup>2</sup> • Gregory A. Wellenius<sup>3</sup> • Maggie L. Clark<sup>1</sup> • Kirk R. Smith<sup>4</sup>

- Randomization by individuals, households, communities
  - Ethical issues
- Blinding of subjects and investigators impossible
- Efficacy versus effectiveness
  - Adoption and sustained use of intervention
  - Spillover effects
- Not suited for rare chronic or long latency conditions
  - Alternatively measure intermediate marker (e.g. blood pressure)
- Background trends
- Generalizability

# Quasi-Experiments

## SCIENCE AND REGULATION

### Particulate Matter Matters

Francesca Dominici,<sup>1\*</sup> Michael Greenstone,<sup>2,3†</sup> Cass R. Sunstein<sup>4\*</sup>

April 22nd is the 45th Earth Day, which marks the birth of the modern environmental movement that helped lead to the creation of the U.S. Environmental Protection Agency, the Clean Air Act Amendments, and the Clean Water Act. The result has been substantial improvements in environmental quality in the United States. Today, developing countries are contending with levels of pollution that are even higher than those in the United States before the first Earth Day. And in a period of considerable economic difficulty, the United States is trying to strike the right balance between the benefits and costs of further reductions in pollution.

Under federal law, the U.S. Office of Management and Budget (OMB) must report to Congress annually on the benefits and costs of major federal regulations. It is remarkable but true that from 2003 through 2012, reductions of emissions of just one category of pollutant—particulate matter (PM)—have accounted for about one-third to one-half of the total monetized benefits of all significant federal regulations and, by some estimates,



Beijing shrouded in smog.

# Quasi-experimental evidence is needed on the relations between human health and airborne particulate matter.

For example, indeed, the U.S. government itself has drawn attention to the “uncertainty in the reduction of premature deaths associated with reduction in particulate matter” (3).

There is a growing consensus in economics, political science, statistics, and other fields that the associational or regres-

sion approaches, based mostly on exposure, but such studies rely on healthy subjects and focus only on end points of limited value.

An observational study of the health effects of particulates boils down to a comparison of health outcomes across space and/or time among places with differing levels of air pollution. For example, an influential study compared the health outcomes of individuals who lived in six cities with varying levels of air pollution (2). For such studies, one challenge is that the people who live in the more polluted places frequently have differing initial levels of health (e.g., due to

Terences in smoking rates, diet, or socioeconomic status) from the levels of people who live in the less polluted places. Another challenge is that there may be locational determinants of health (e.g., hospital quality or water pollution) that differ across the cities and are correlated with air pollution levels. Further, people may choose to live in different locations on the basis of their (likely unobserved) susceptibility to pollution and other related health problems, and/or they may have more and greater resources on self-protection in more polluted locations in ways that are not measured in available data sets.

Statistical methods, based mostly on regression approaches, aim to “adjust” for observed confounders, by including the available measures of behavioral, socioeconomic, and locational differences as covariates in the regression model. Since many determinants of health are unobserved, these methods that rely on adjustment for observed confounders can lead to biased estimates of the relation between health and particulates.

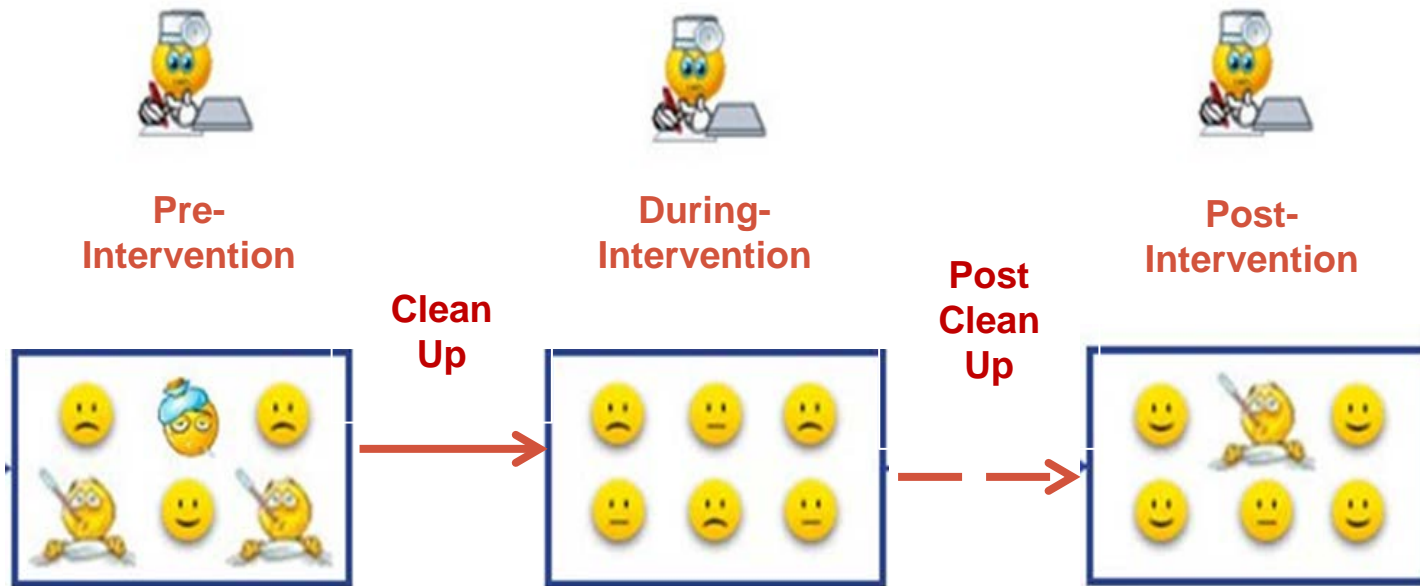
In 2010, the American Heart Association conducted a review of the available observational studies exploring the relation between fine particulate matter [diameter <2.5 μm (PM<sub>2.5</sub>)] exposure and mortality and car-

CREDIT: SHOOTING

<sup>1</sup>Department of Biostatistics, Harvard School of Public Health, Boston, MA 02115, USA. <sup>2</sup>Department of Economics, Massachusetts Institute of Technology, Cambridge, MA 02142, USA. <sup>3</sup>National Bureau of Economic Research, Cambridge, MA 02138, USA. <sup>4</sup>Harvard Law School, Cambridge, MA 02138, USA. \*All authors contributed equally and are listed alphabetically. †Corresponding author. E-mail: mgreenst@mit.edu.

# Quasi-Experiments

“Natural Experiments”



AMERICAN  
JOURNAL  
OF

# Public Health

reprint

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

C. ARDEN POPE III, PhD

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**Abstract:** This study assessed the association between hospital admissions and fine particulate pollution ( $PM_{10}$ ) in Utah Valley during the period April 1985–February 1988. This time period included the closure and reopening of the local steel mill, the primary source of  $PM_{10}$ . An association between elevated  $PM_{10}$  levels and hospital admissions for pneumonia, pleurisy, bronchitis, and asthma was observed. During months when 24-hour  $PM_{10}$  levels exceeded  $150 \mu\text{g}/\text{m}^3$ , average admissions for children nearly tripled; in adults, the increase in admissions was 44 per cent. During months with mean  $PM_{10}$  levels greater than or equal to  $50 \mu\text{g}/\text{m}^3$  average admissions for children and adults increased by 89 and 47 per cent, respectively. During the winter months when the steel mill was open,  $PM_{10}$  levels

were nearly double the levels experienced during the winter months when the mill was closed. This occurred even though relatively stagnant air was experienced during the winter the mill was closed. Children's admissions were two to three times higher during the winters when the mill was open compared to when it was closed. Regression analysis also revealed that  $PM_{10}$  levels were strongly correlated with hospital admissions. They were more strongly correlated with children's admissions than with adult admissions and were more strongly correlated with admissions for bronchitis and asthma than with admissions for pneumonia and pleurisy. (*Am J Public Health* 1989; 79:623–628.)

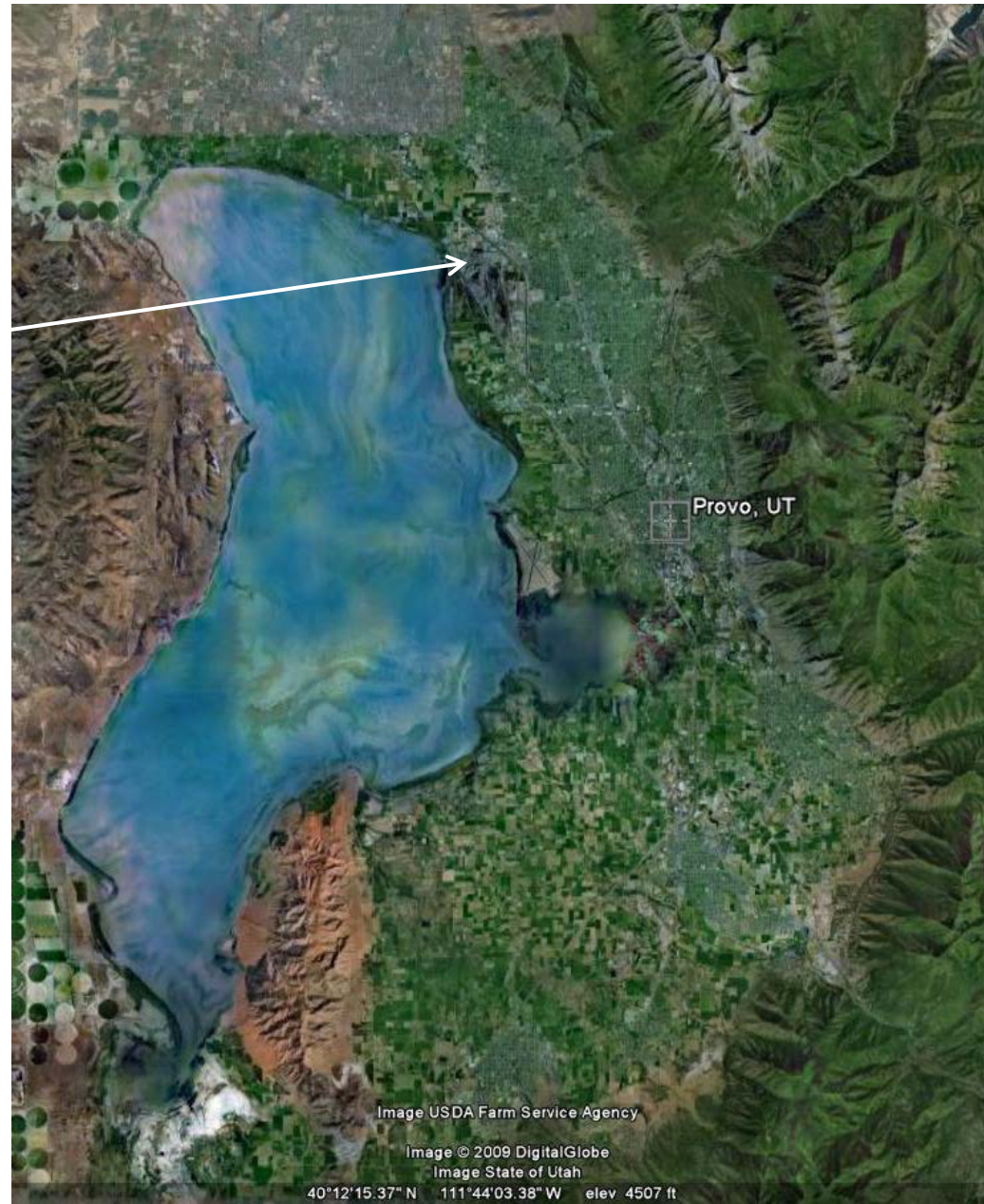


# Utah Valley, 1980s

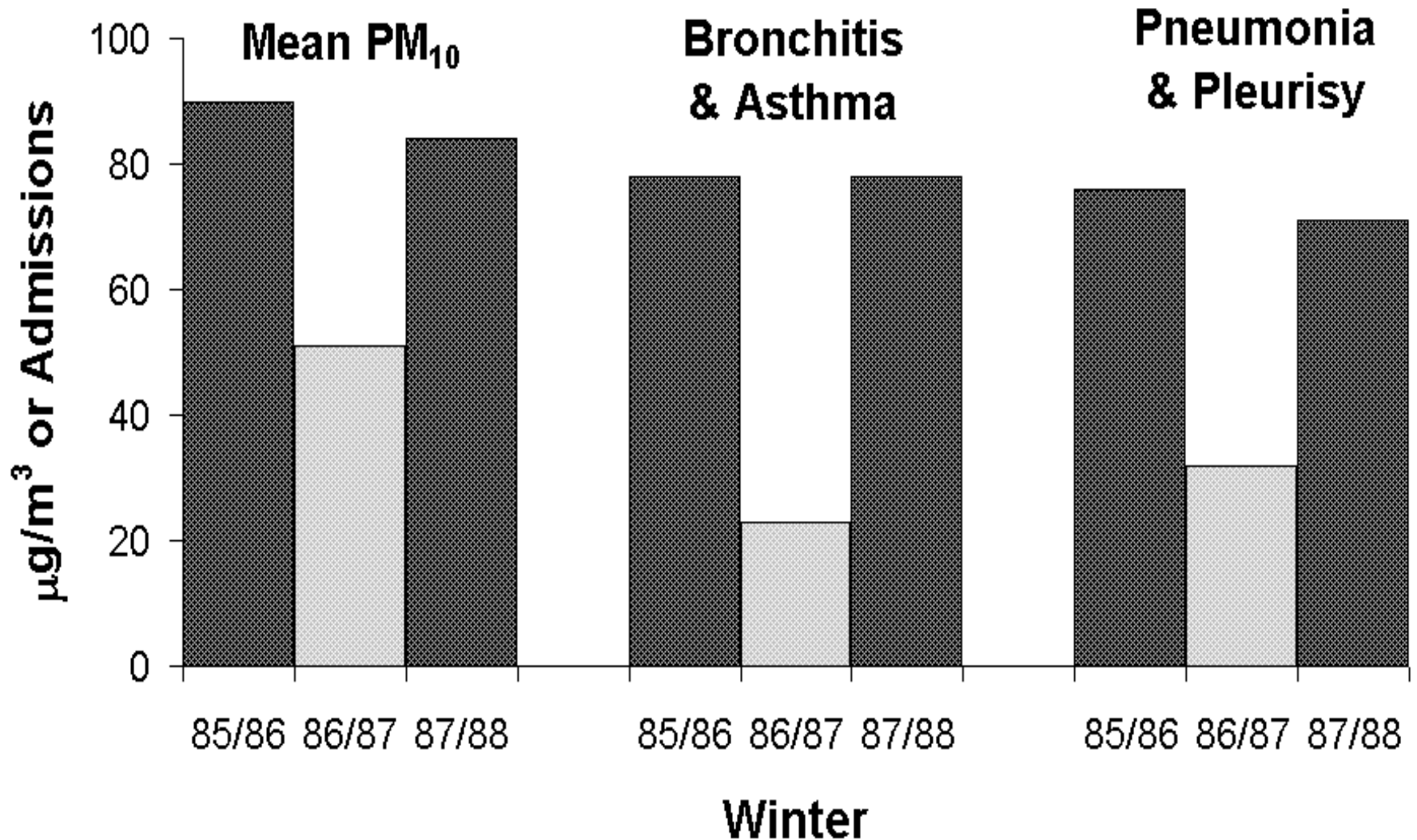
- Winter **inversions** trap local pollution
- Natural test chamber



- Local Steel mill contributed ~50%  $PM_{2.5}$
- Shut down July 1986-August 1987
- Natural Experiment



## Hospital Admissions – Children 0-17 yrs





BODY

# An Olympic Respite From Air Pollution

By **Nicholas Bakalar** May 21, 2012 2:31 pm

Chinese officials clamped down on air pollution during the 2008 Olympics in Beijing, giving researchers an unusual opportunity to assess the effects of polluted air on the risks for cardiovascular disease.

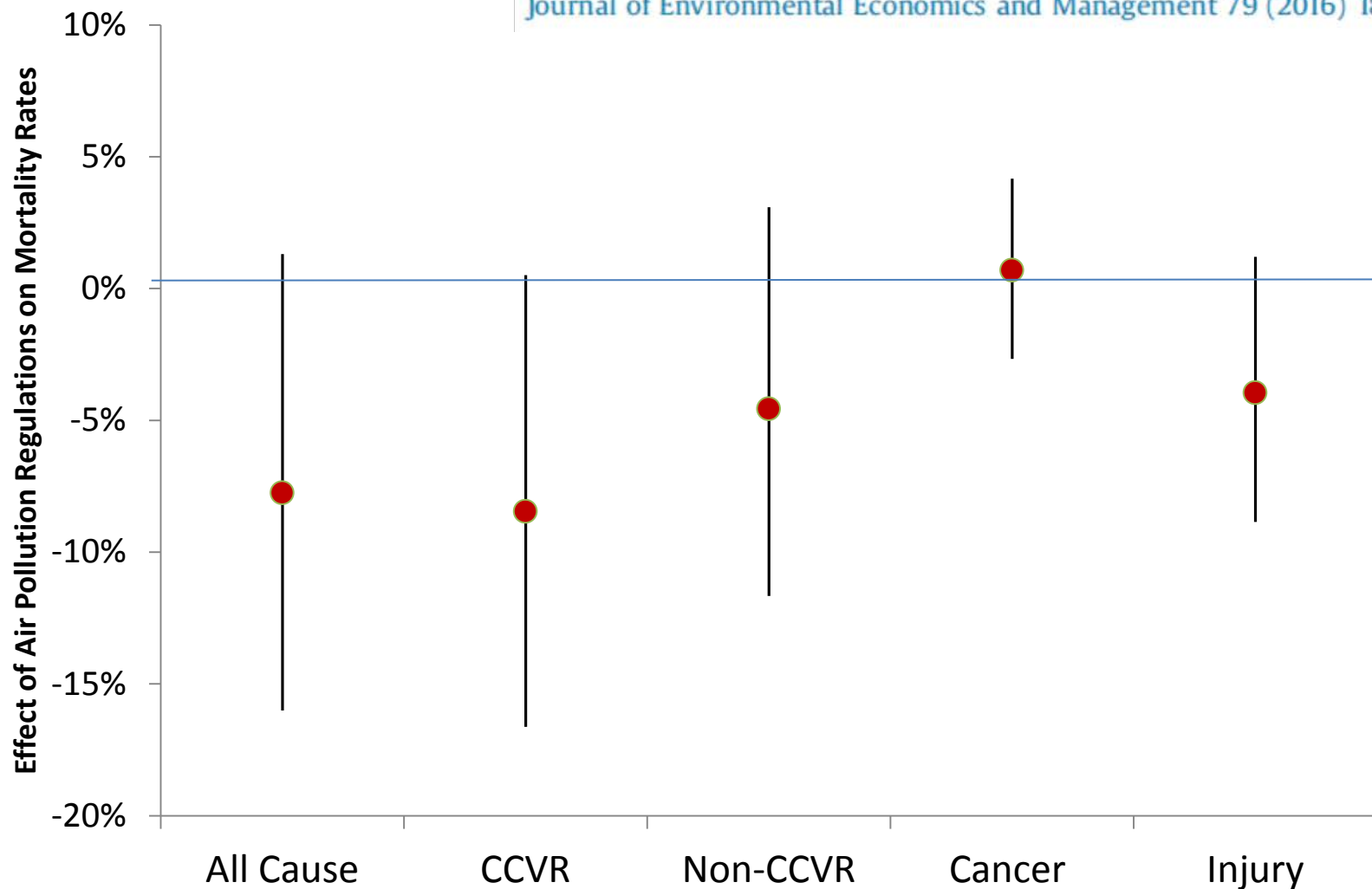


# The effect of air pollution on mortality in China: Evidence from the 2008 Beijing Olympic Games<sup>☆</sup>

Guojun He<sup>a</sup>, Maoyong Fan<sup>b</sup>, Maigeng Zhou<sup>c</sup>



Journal of Environmental Economics and Management 79 (2016) 18–39





# Air quality and outpatient visits for asthma in adults during the 2008 Summer Olympic Games in Beijing

Yi Li <sup>a</sup>, Wen Wang <sup>b</sup>, Haidong Kan <sup>c,\*</sup>, Xiaohui Xu <sup>d</sup>, Bingheng Chen <sup>c</sup>

Science of the Total Environment 408 (2010) 1226–1227

Periods	PM <sub>2.5</sub> ( $\mu\text{g}/\text{m}^3$ )	O <sub>3</sub> (ppb)	Asthma Events (per day)	Relative Risk of Outpatient Visit for Asthma Adjusted RR (95% CI)
Baseline	78.8	65.8	12.5	1.00 (Ref)
Pre-Olympic	72.3	74.6	16.5	1.12 (0.85 - 1.50)
During Olympics	46.7	61.0	7.3	0.54 (0.39 - 0.75)





## RESEARCH REPORT

HEALTH  
EFFECTS  
INSTITUTE

Number 174  
February 2013

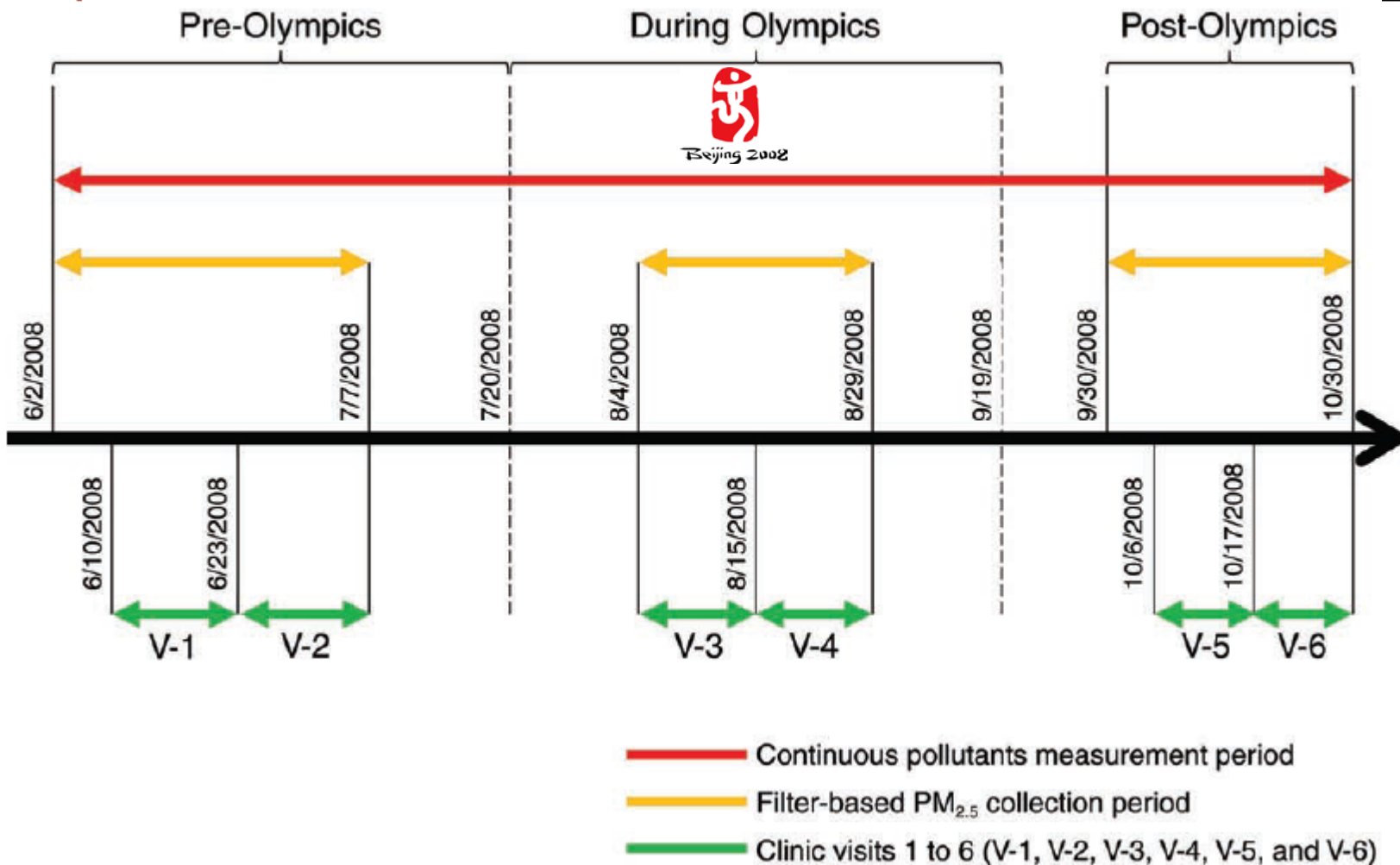
### **Cardiorespiratory Biomarker Responses in Healthy Young Adults to Drastic Air Quality Changes Surrounding the 2008 Beijing Olympics**

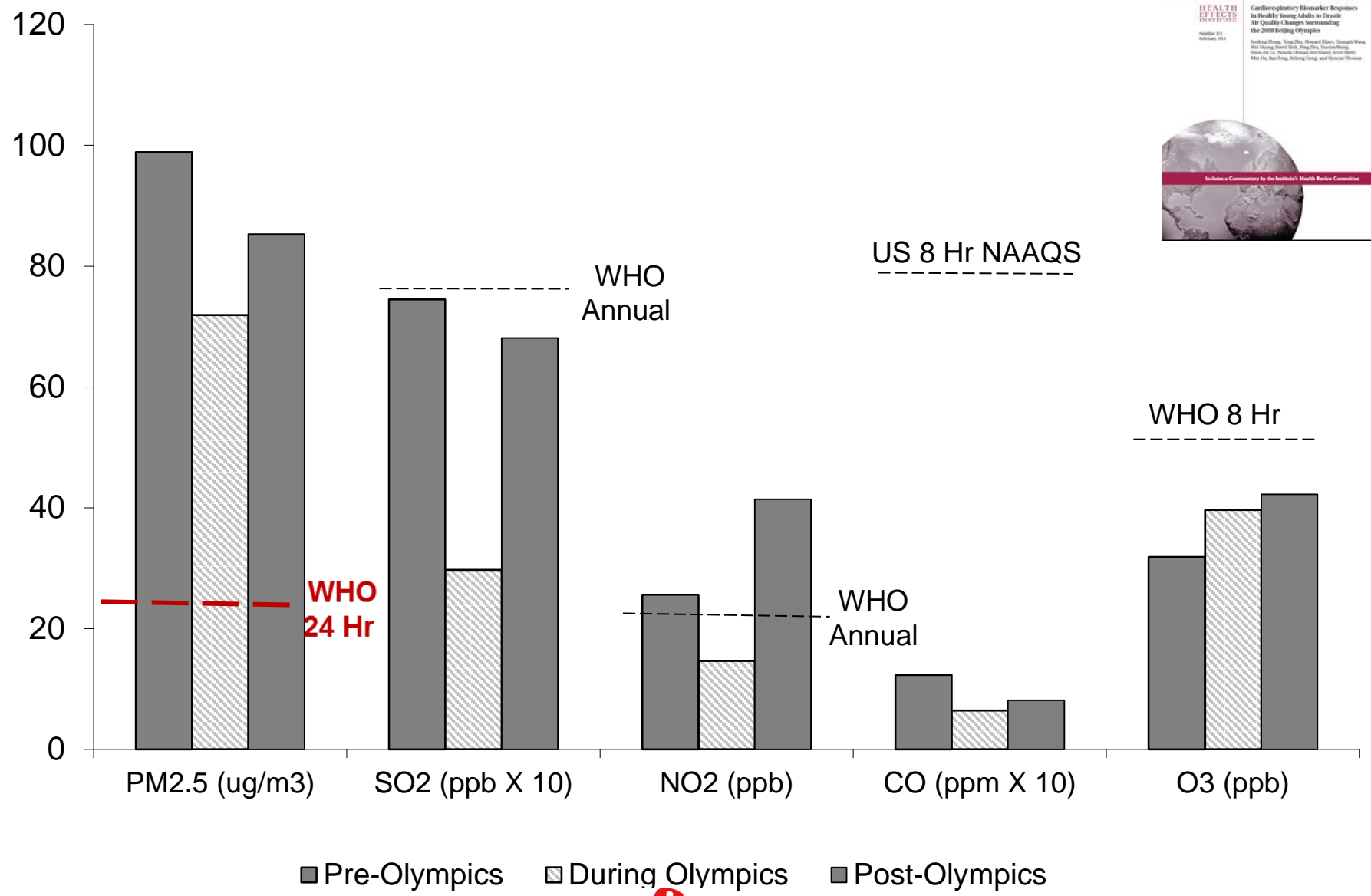
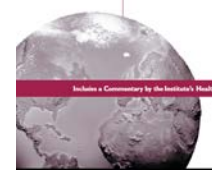
Junfeng Zhang, Tong Zhu, Howard Kipen, Guangfa Wang,  
Wei Huang, David Rich, Ping Zhu, Yuedan Wang,  
Shou-En Lu, Pamela Ohman-Strickland, Scott Diehl,  
Min Hu, Jian Tong, Jicheng Gong, and Duncan Thomas

# Beijing HEART Study

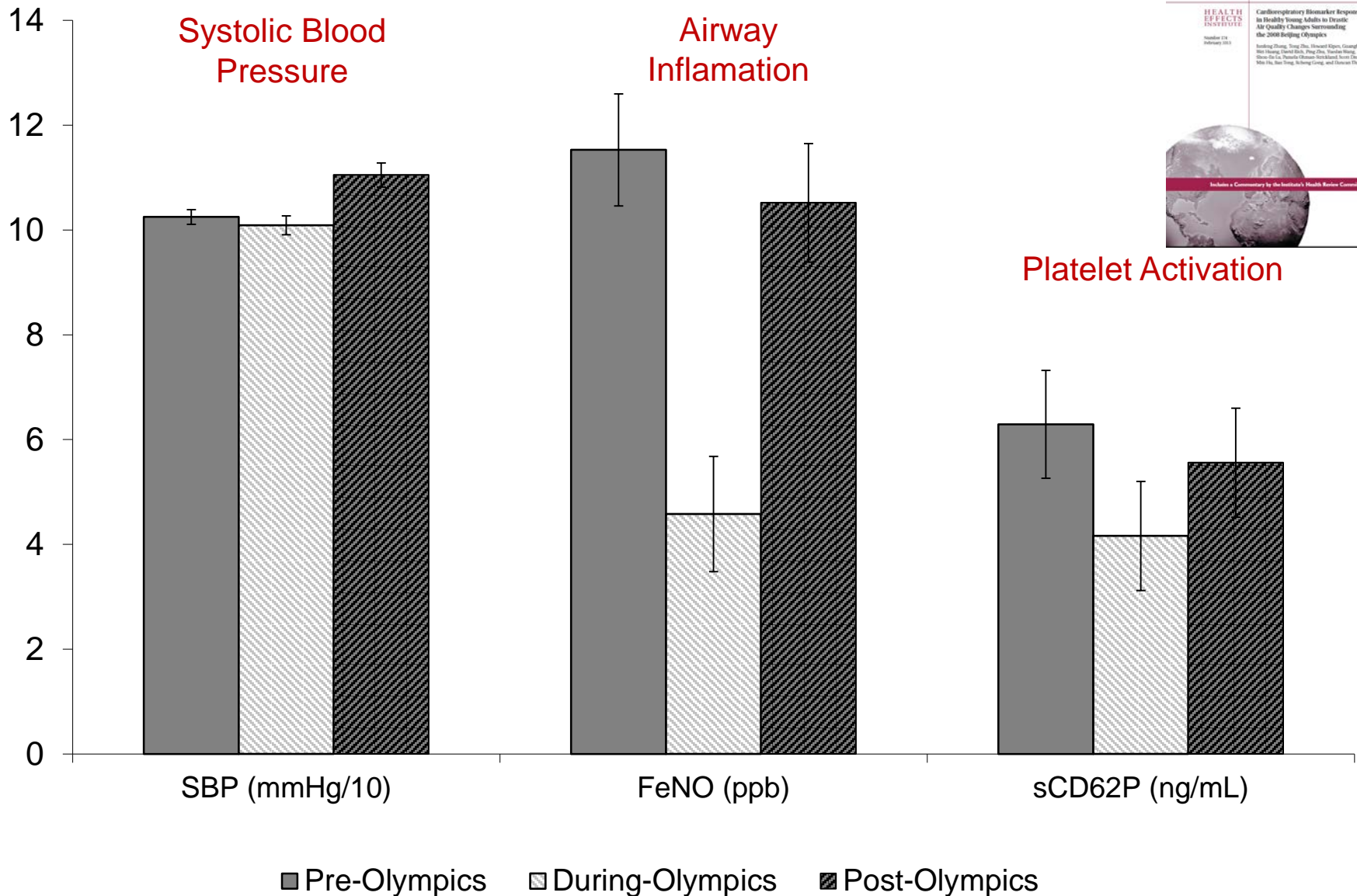
Panel study of 125 healthy medical residents

6 repeated clinical and biomarker measures



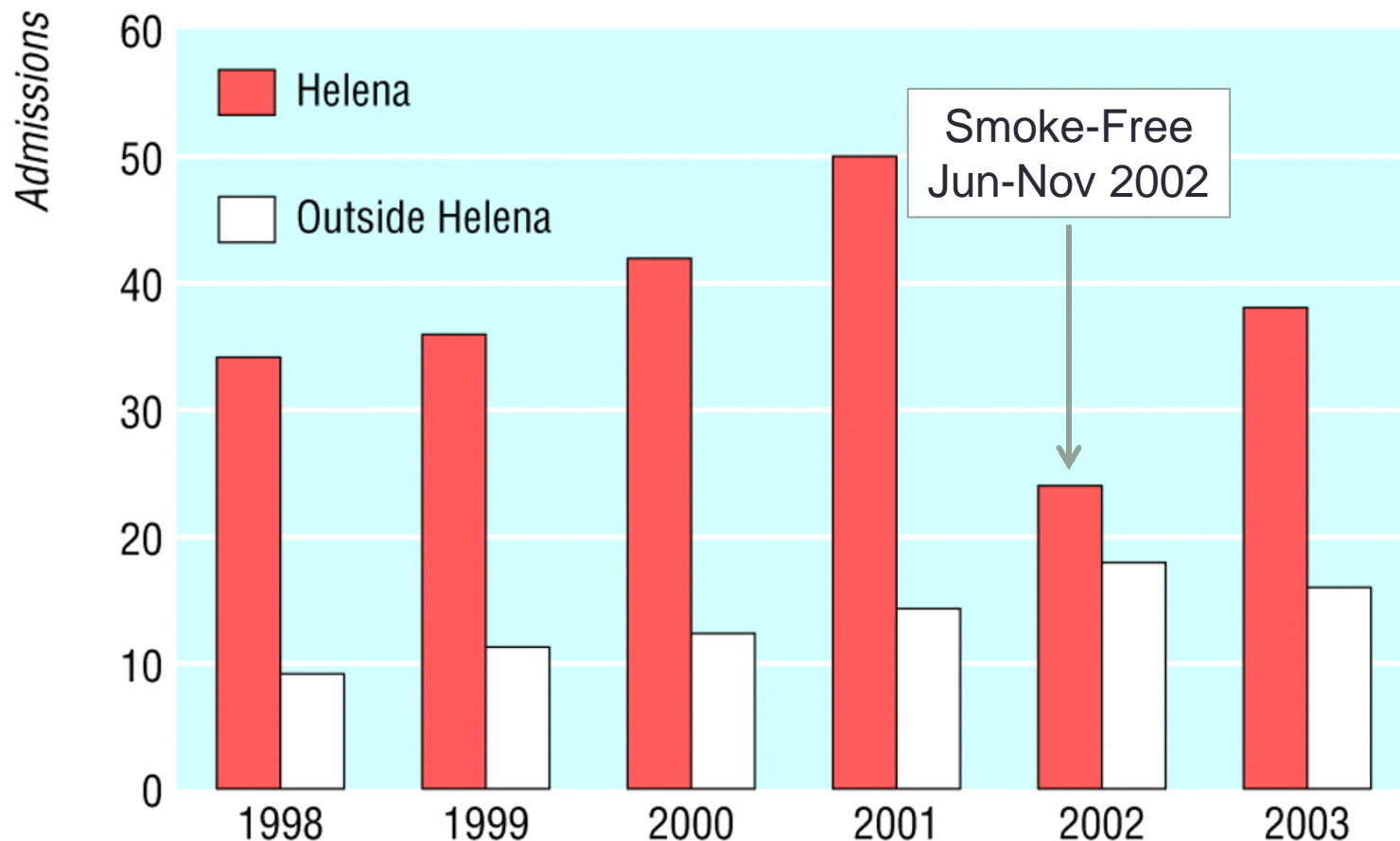






# Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study

Richard P Sargent, Robert M Shepard, Stanton A Glantz



Admissions for acute myocardial infarction during six month periods June-November before, during (2002), and after the smoke-free ordinance (ordinance did not apply outside Helena).

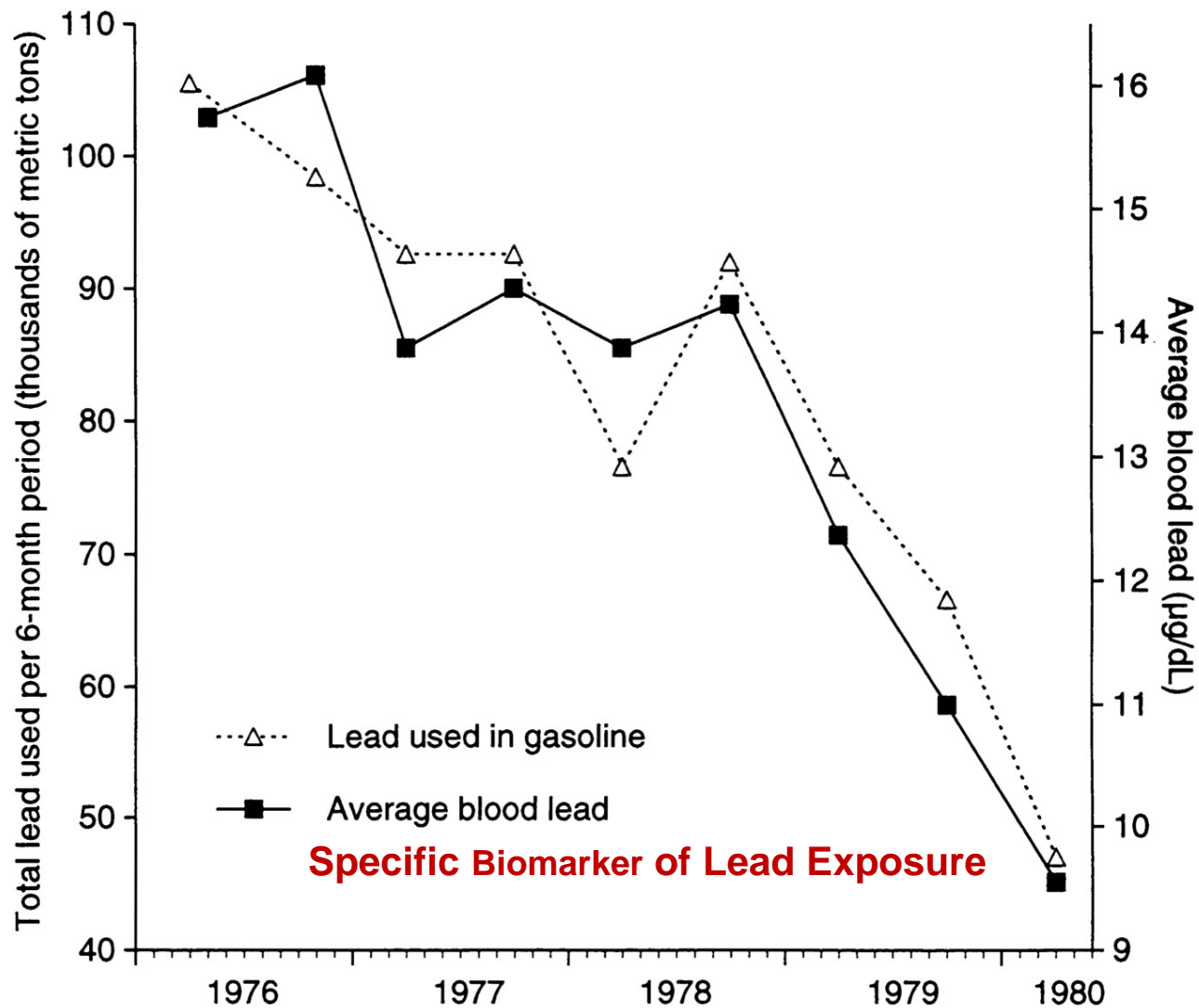
# Policy Evaluation



Clean  
Up



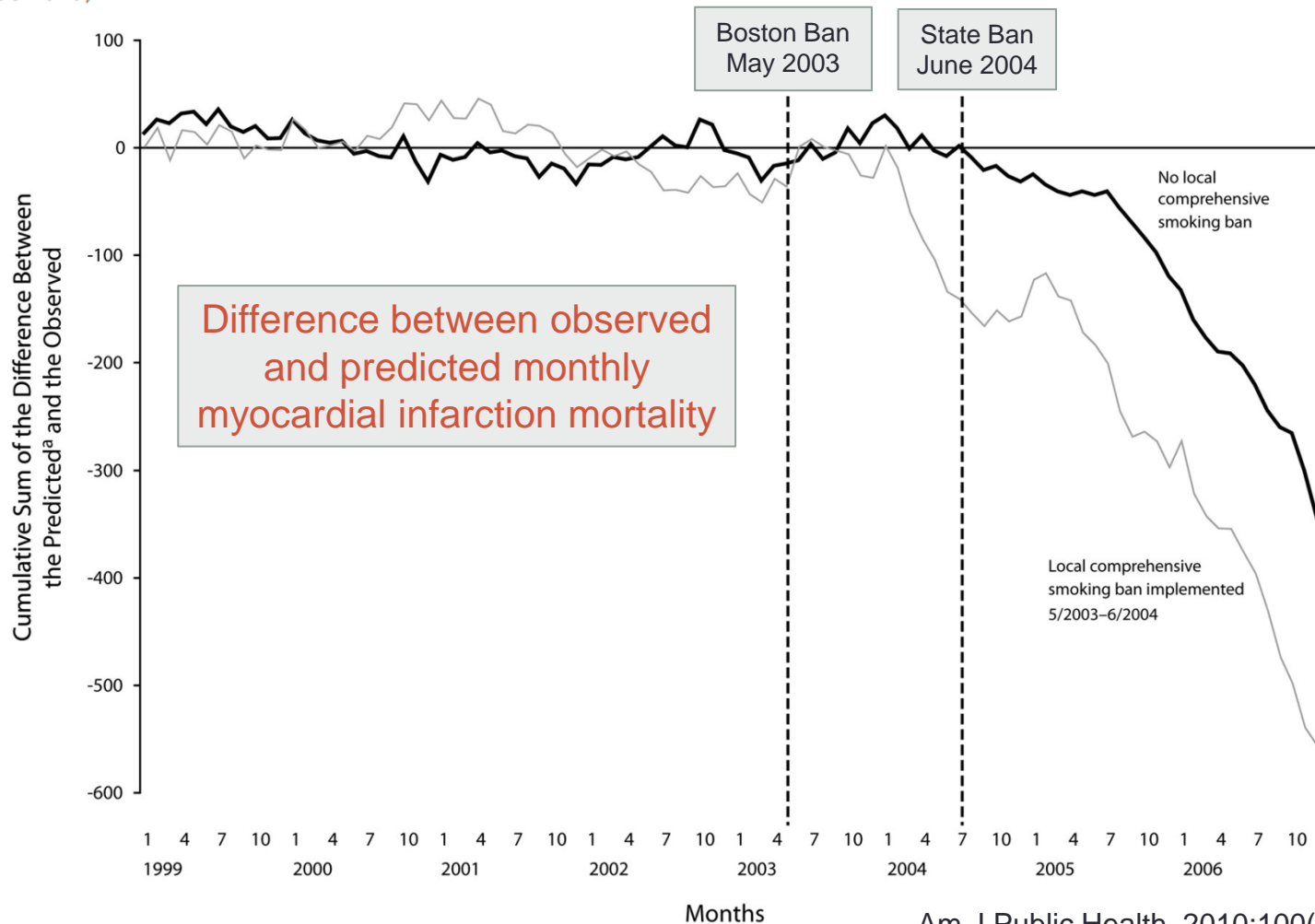
# Lead in Gasoline and Average NHANES Blood Lead



# The Impact of Massachusetts' Smoke-Free Workplace Laws on Acute Myocardial Infarction Deaths



Melanie S. Dove, ScD, Douglas W. Dockery, ScD, Murray A. Mittleman, MD, DrPH, Joel Schwartz, PhD, Eileen M. Sullivan, MS, Lois Keithly, PhD, and Thomas Land, PhD



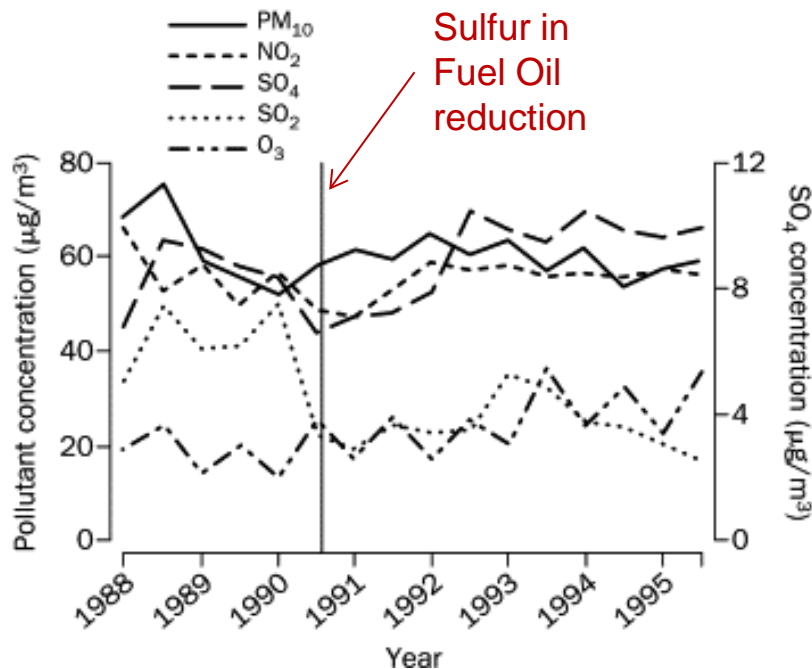




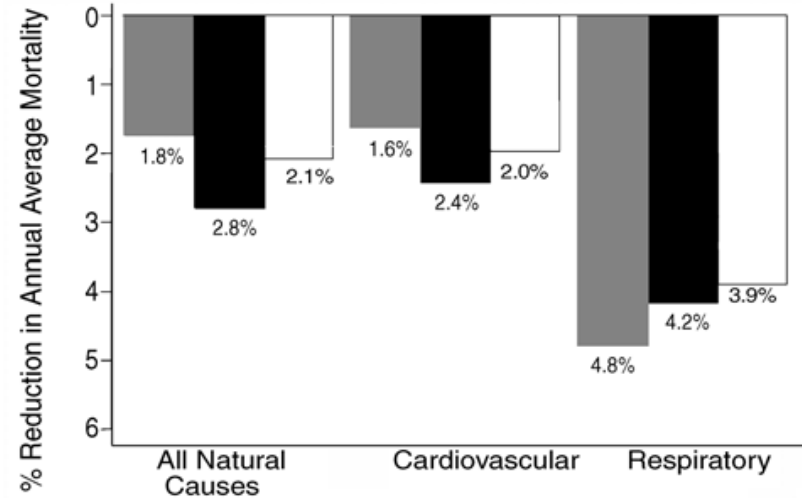
# Cardiorespiratory and all-cause mortality after restrictions on sulphur content of fuel in Hong Kong: an intervention study

Anthony Johnson Hedley, Chit-Ming Wong, Thuan Quoc Thach, Stefan Ma, Tai-Hing Lam, Hugh Ross Anderson

Lancet\_2002 Nov 23;360(9346):1646-52.



Average of pollutant concentrations at five monitoring stations



Percent reduction in annual average mortality due to all causes, cardiovascular disease, or respiratory disease after intervention to reduce sulfur content of fuel oil.

# Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study

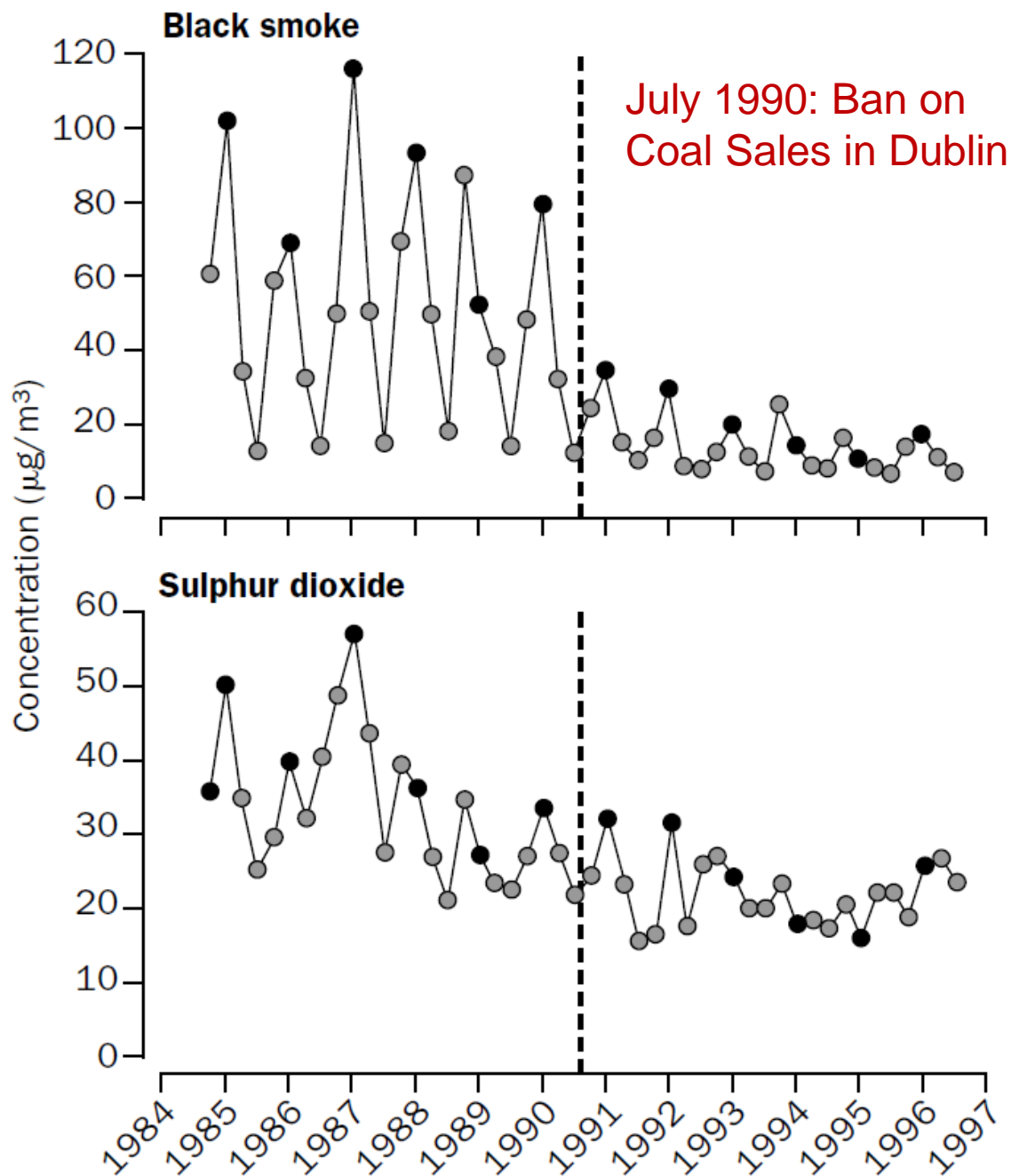
Luke Clancy, Pat Goodman, Hamish Sinclair, Douglas W Dockery

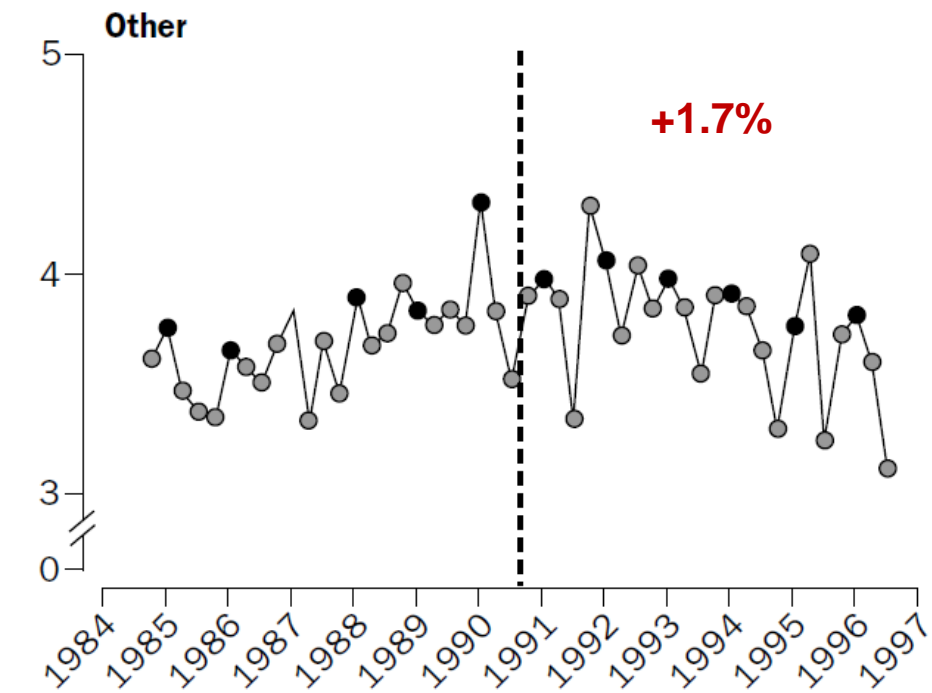
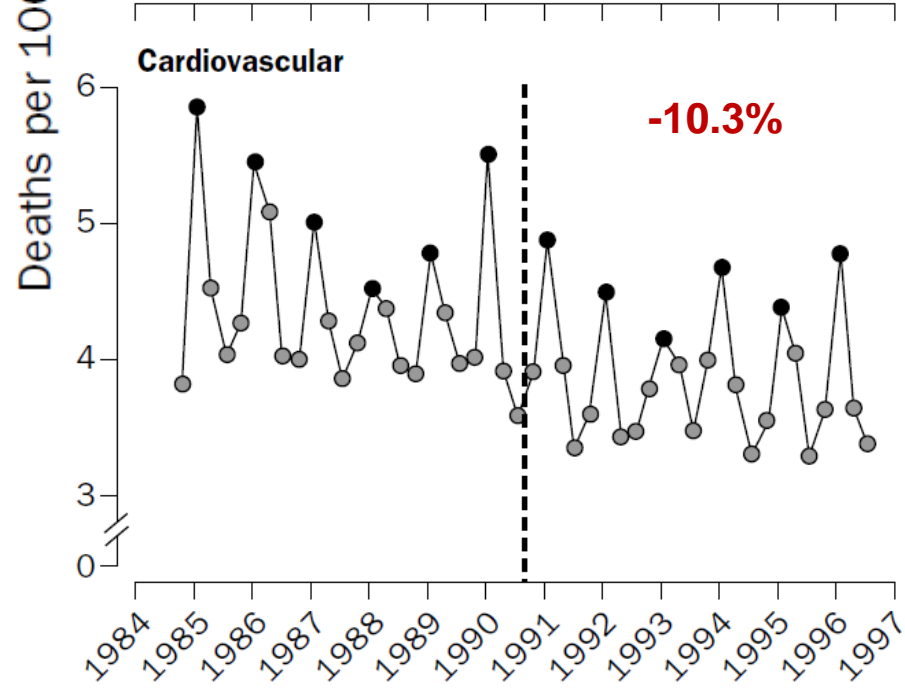
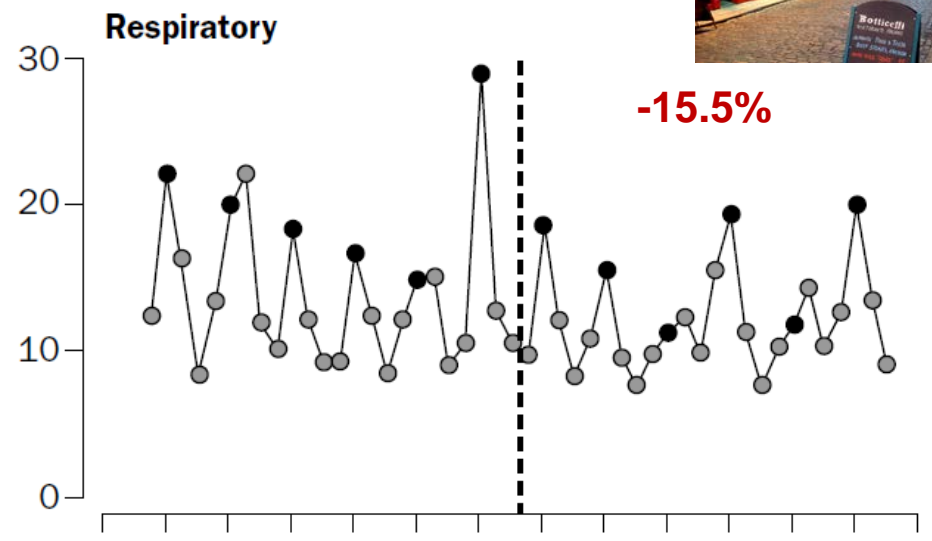
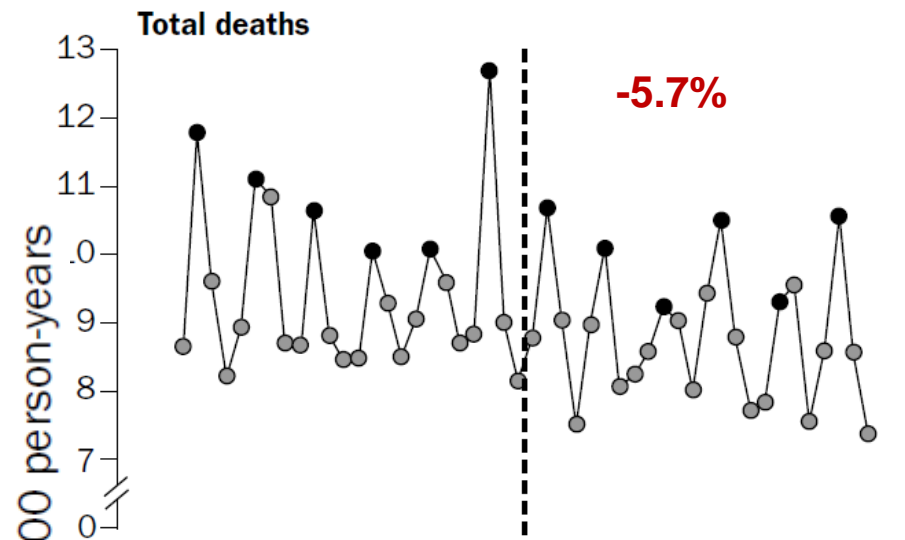
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*Lancet* 2002; **360**: 1210–14



- On September 1, 1990, the Irish Government banned the marketing, sale, and distribution of bituminous coals within Dublin County Borough, that is the city of Dublin (*Air Pollution Act, 1987*).







## RESEARCH REPORT

HEALTH  
EFFECTS  
INSTITUTE

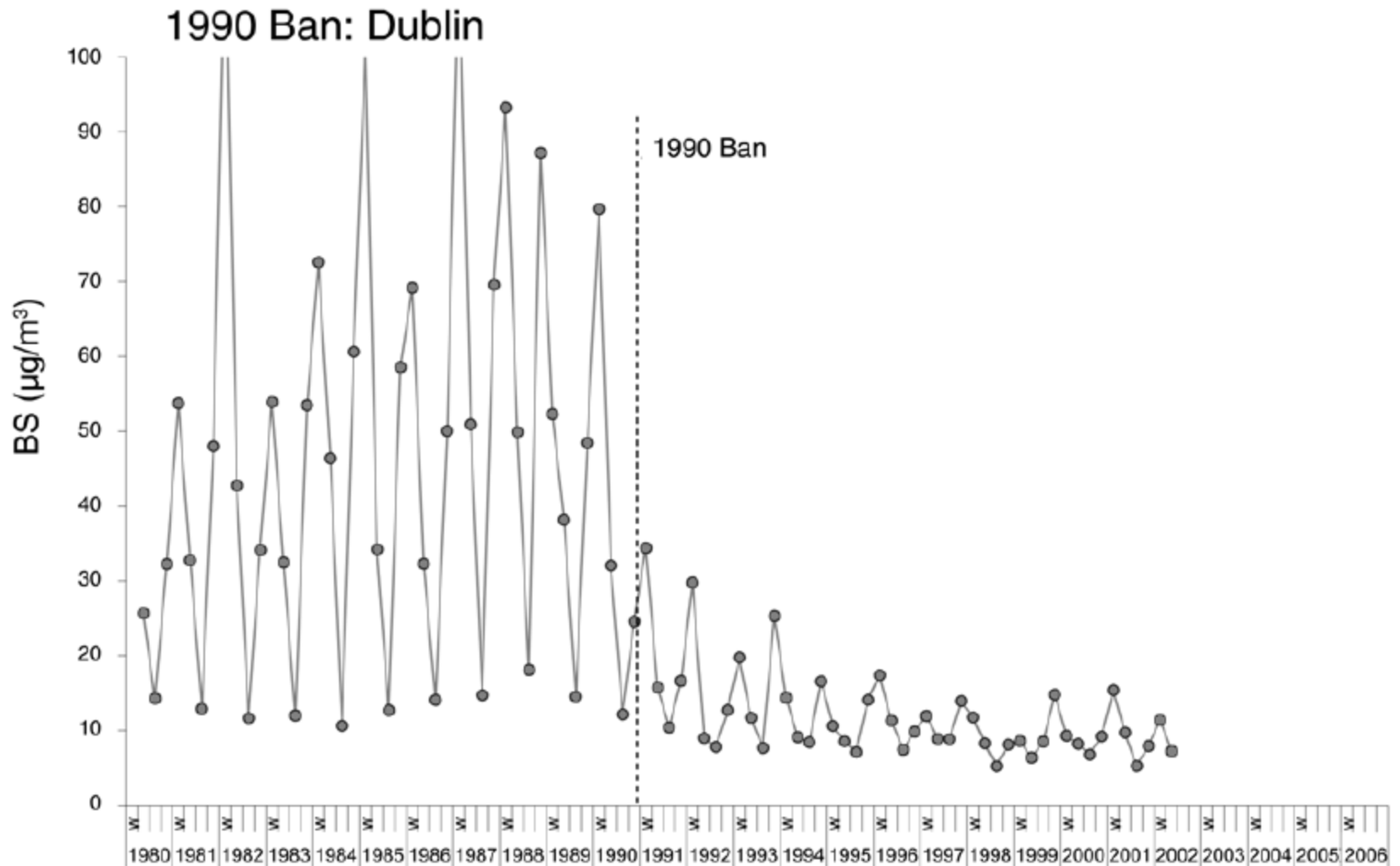
Number 176  
July 2013

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

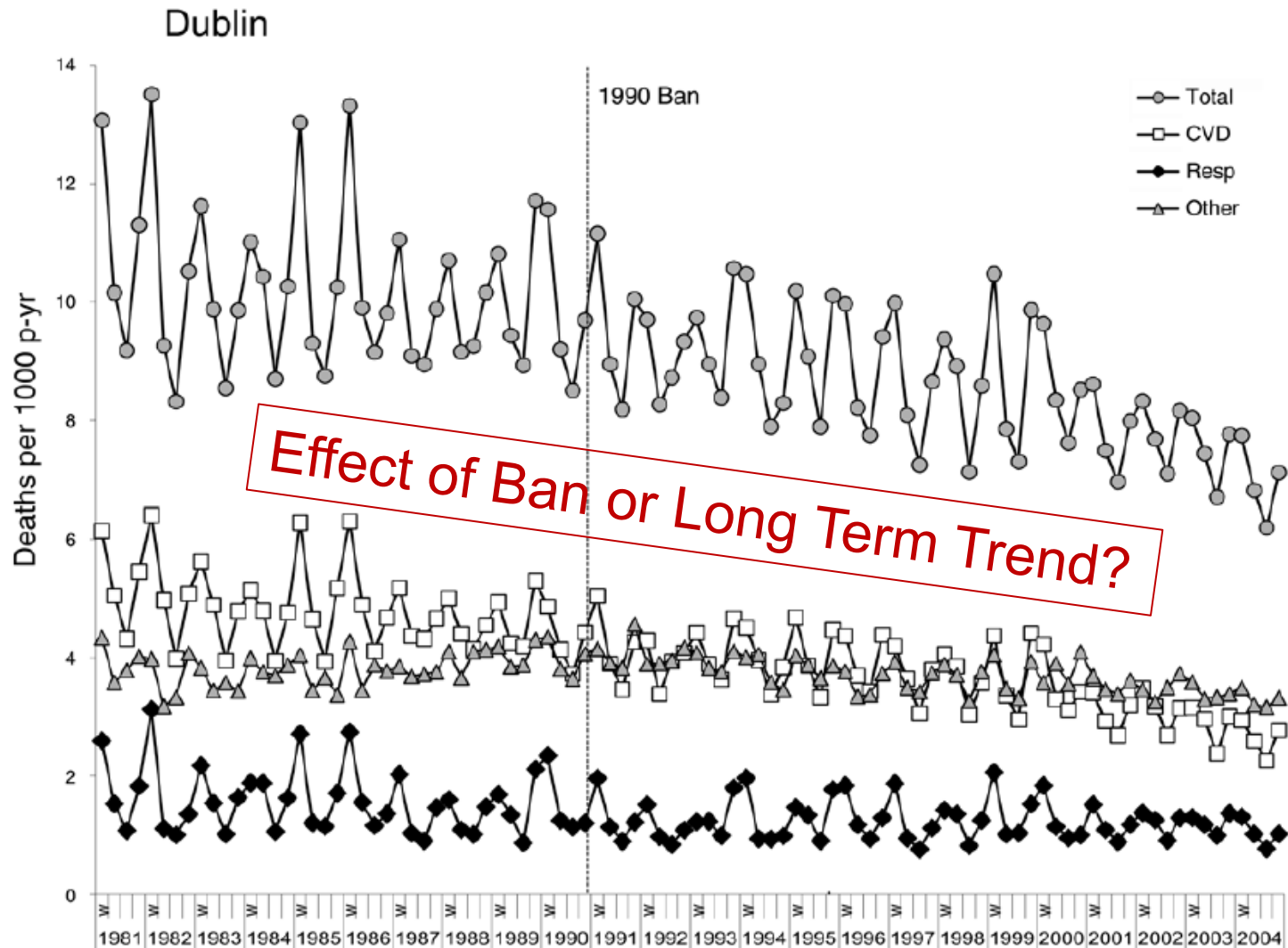
Douglas W. Dockery, David Q. Rich,  
Patrick G. Goodman, Luke Clancy,  
Pamela Ohman-Strickland, Prethibha George,  
and Tania Kotlov



# Effect of Dublin 1990 Ban on Coal Sales 1980-2004



# Dublin mortality rates 1981-2004



# Policy Evaluation



Clean  
Up



Intervention  
Community



NO  
Clean  
Up

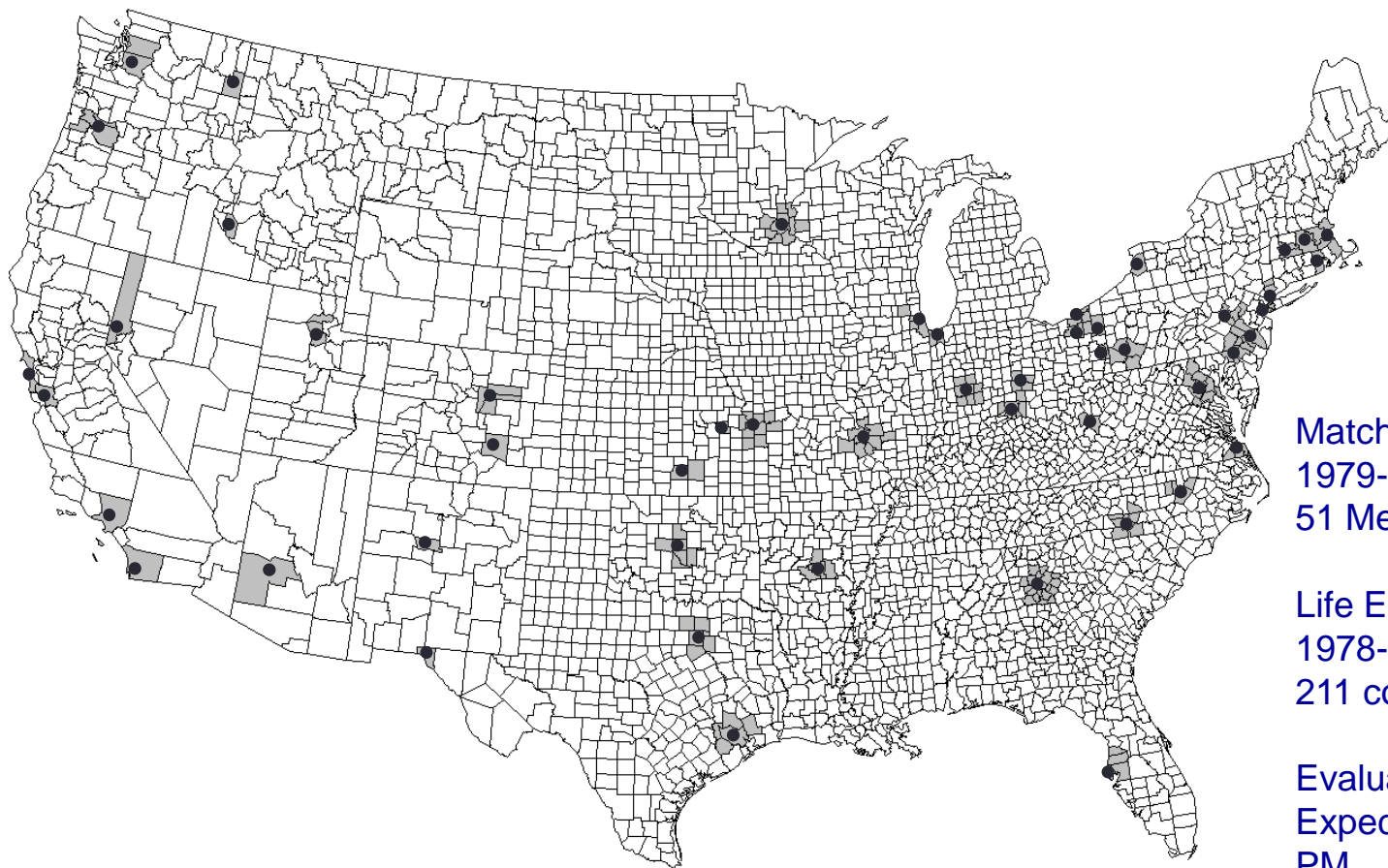


Comparison  
No Intervention  
Community



## Fine-Particulate Air Pollution and Life Expectancy in the United States

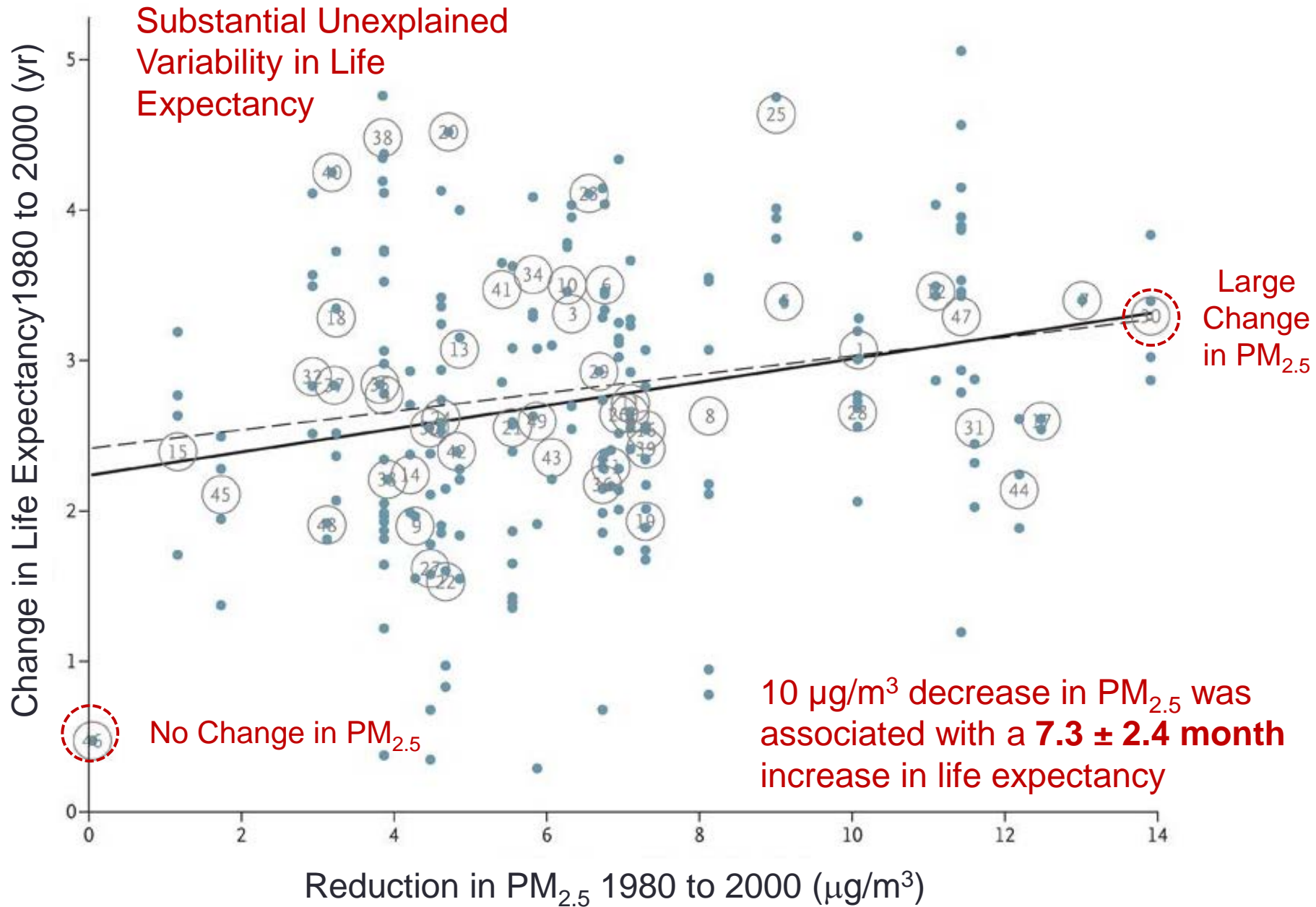
*C. Arden Pope, III, Ph.D., Majid Ezzati, Ph.D., and Douglas W. Dockery, Sc.D.*



Matching PM<sub>2.5</sub> data for  
1979-1983 and 1999-2000 in  
51 Metro Areas

Life Expectancy data for  
1978-1982 and 1997-2001 in  
211 counties in 51 Metro areas

Evaluate changes in Life  
Expectancy with changes in  
PM<sub>2.5</sub> for the 2-decade period  
of approximately 1980-2000.



# To Measure Effects of Air Pollution Control

**Population  
Habits and  
Behaviors**



**Air Quality**



**Population  
Characteristics**





# 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; need comparison populations; need advances in analyses
  - Best potential for showing long-term benefits of air pollution control

# HEI

## COMMUNICATION 11

Assessing Health Impact of Air Quality Regulations: Concepts and Methods for Accountability Research



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journal homepage: [www.elsevier.com/locate/envint](http://www.elsevier.com/locate/envint)

Review article

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

David Q. Rich \*

Environment International 100 (2017) 62–78

