

# Accountability studies: Where have we been and where are we going?

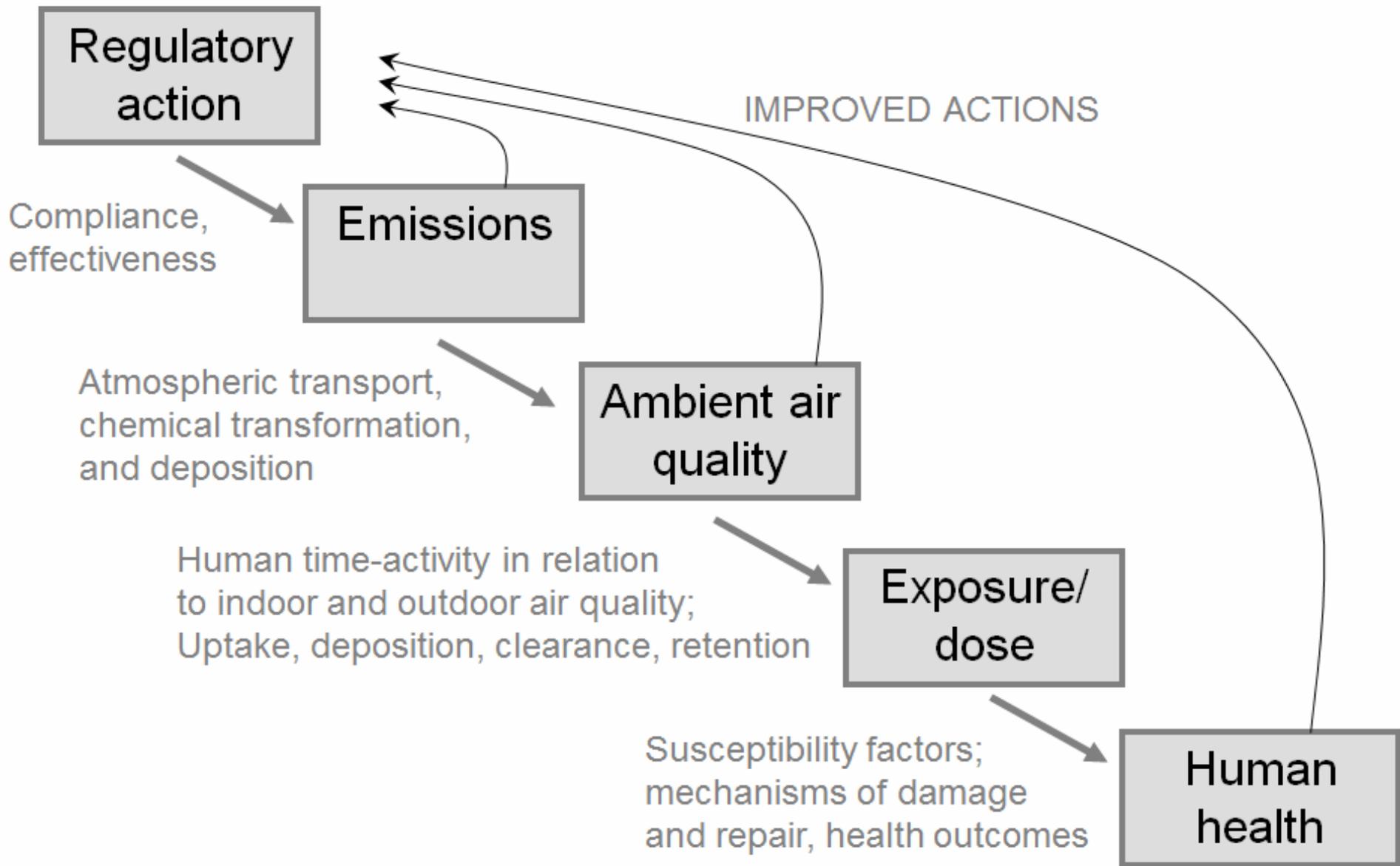
<http://robinsonglass.com/auto-glass/rear-view-mirrors/>

Michael Brauer

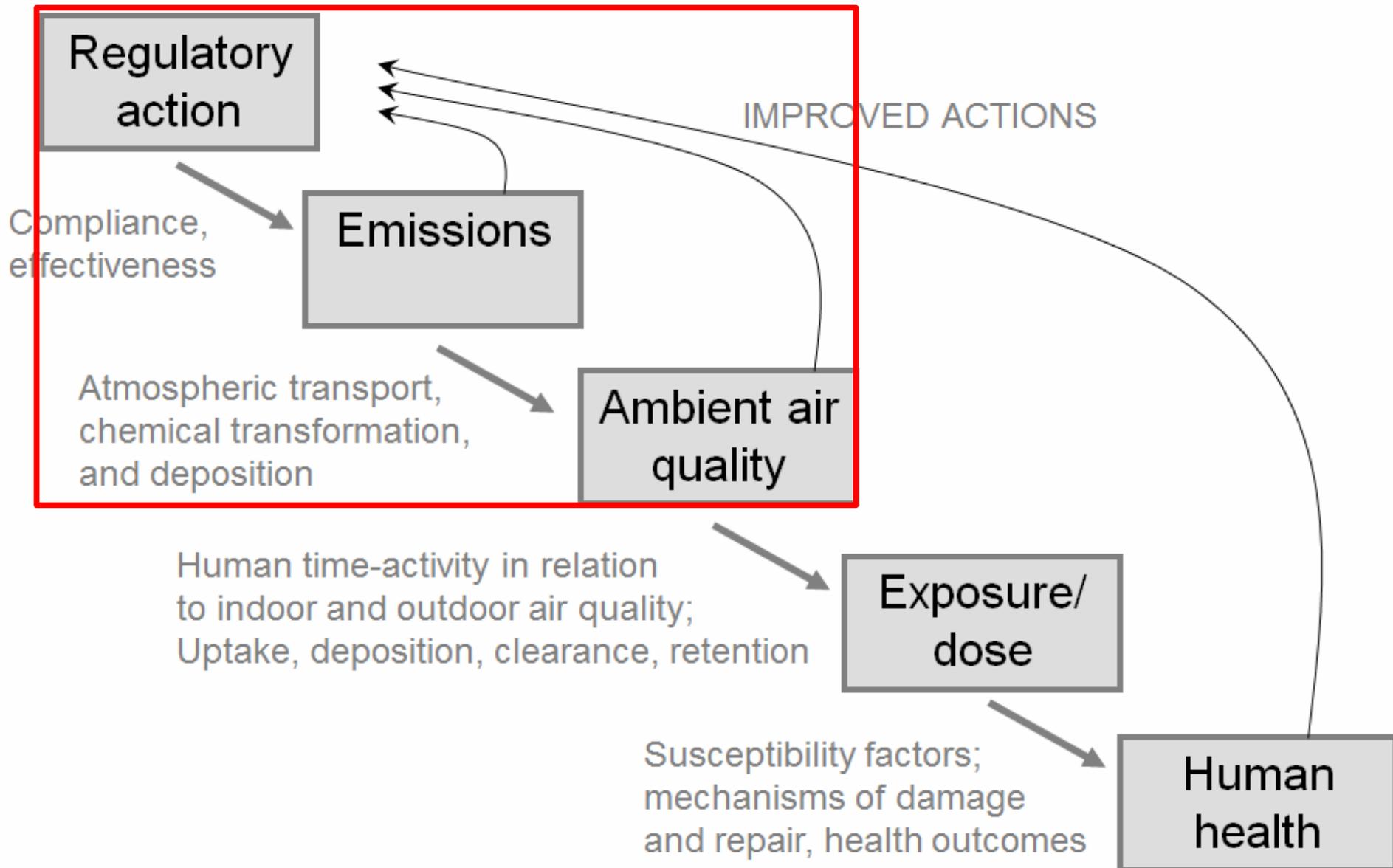


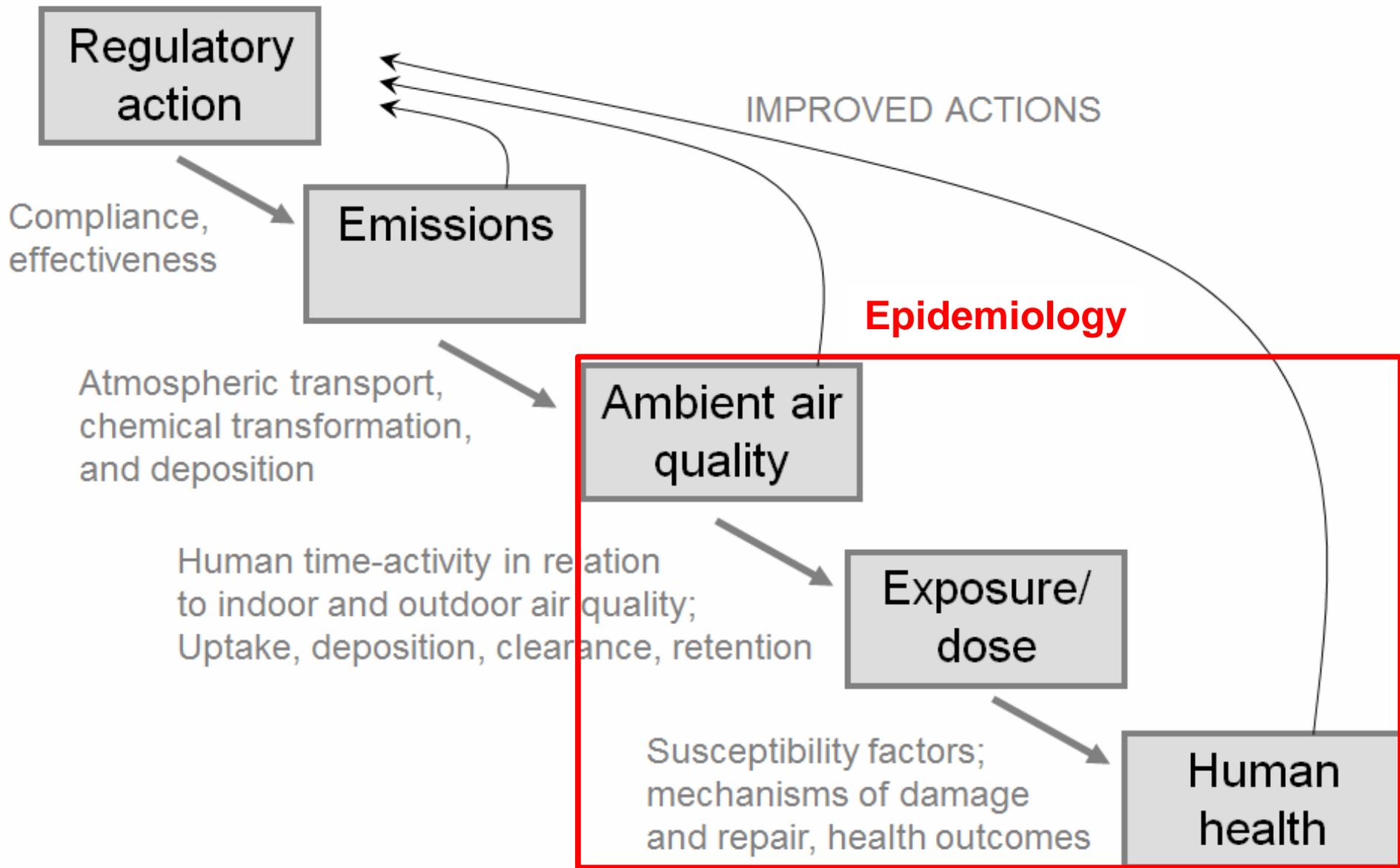
THE UNIVERSITY  
OF BRITISH COLUMBIA

*HEI Annual Conference  
Alexandria VA. May 1, 2017*

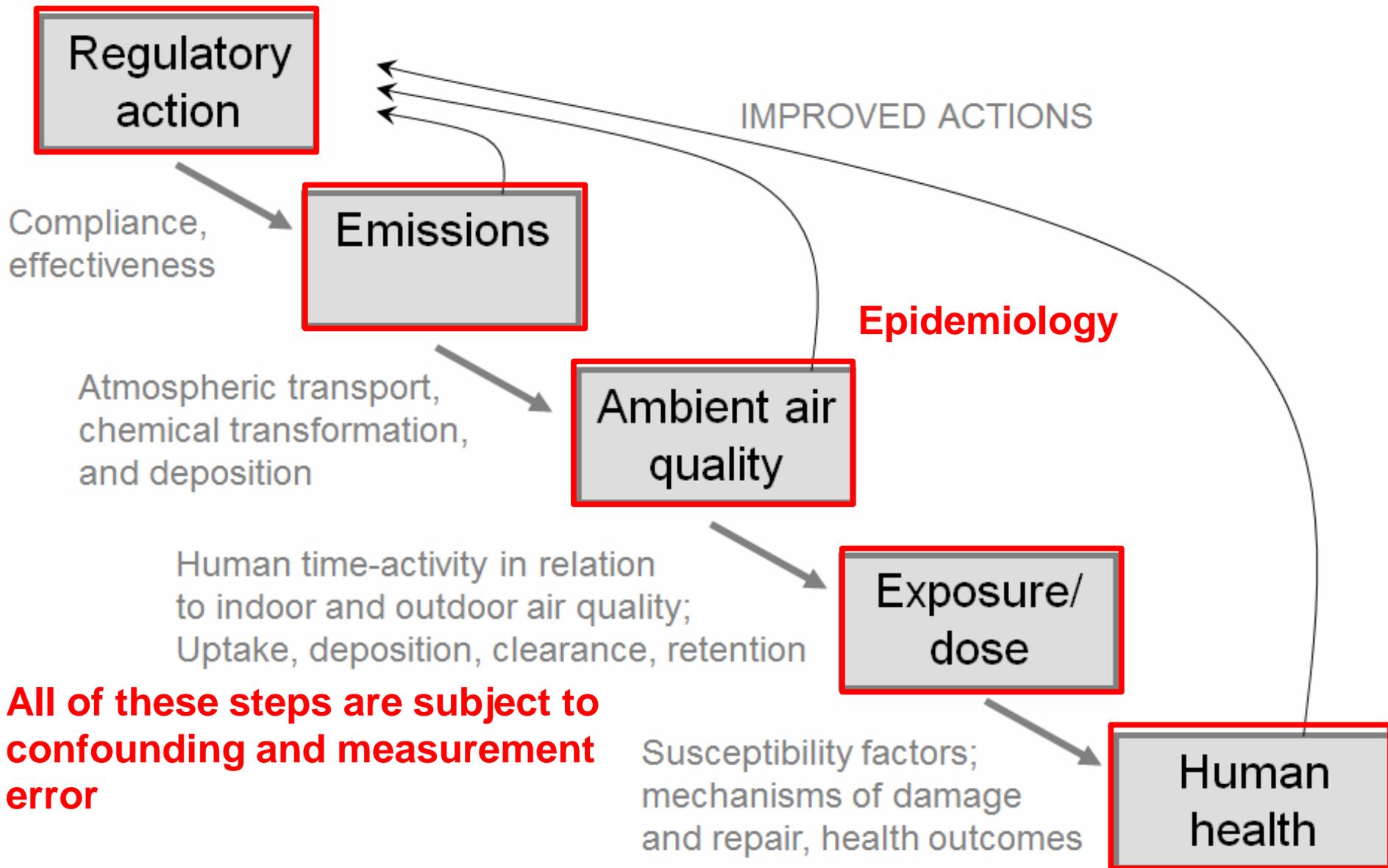


## Atmospheric Science (Measurements / Models)





# Atmospheric Science



**All of these steps are subject to confounding and measurement error**

**Beware of non-linearity**

# Counterfactual



# Where have we been?



JOURNAL OF THE AIR & WASTE MANAGEMENT ASSOCIATION   
2017, VOL. 67, NO. 2, 144–172  
<http://dx.doi.org/10.1080/10962247.2016.1242518>



REVIEW PAPER

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

Lucas R.F. Henneman <sup>a</sup>, Cong Liu<sup>b</sup>, James A. Mulholland<sup>a</sup>, and Armistead G. Russell<sup>a</sup>

Environment International 100 (2017) 62–78



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Review article

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

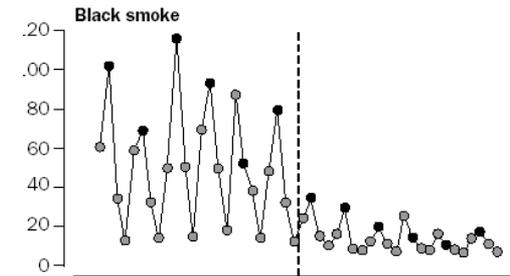
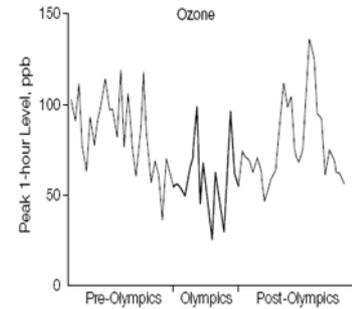


David Q. Rich \*

**Forthcoming Cochrane Systematic Review**

# Study types

- N=52 emissions and air quality (~30% short-term)
- N=27 health endpoints (~50% short-term)
- Large-scale events
  - Olympics (Atlanta, Beijing) [A – B – A]
- Natural experiments [A – B]
  - Industrial sources (Utah steel)
  - Residential heating (Ireland coal)
  - Traffic-related air pollution (E-Z Pass, Atlanta)
  - National/Regional reductions - structural / regulatory (German unification, Southern California air quality management)



# Where have we been?



Short term studies of abrupt localized interventions

- Useful to demonstrate (causal) impact of air quality on (population) health
- Less likely to be confounded by other (temporally-varying) factors
- Interventions often not generalizable or typical (and sometimes transient)





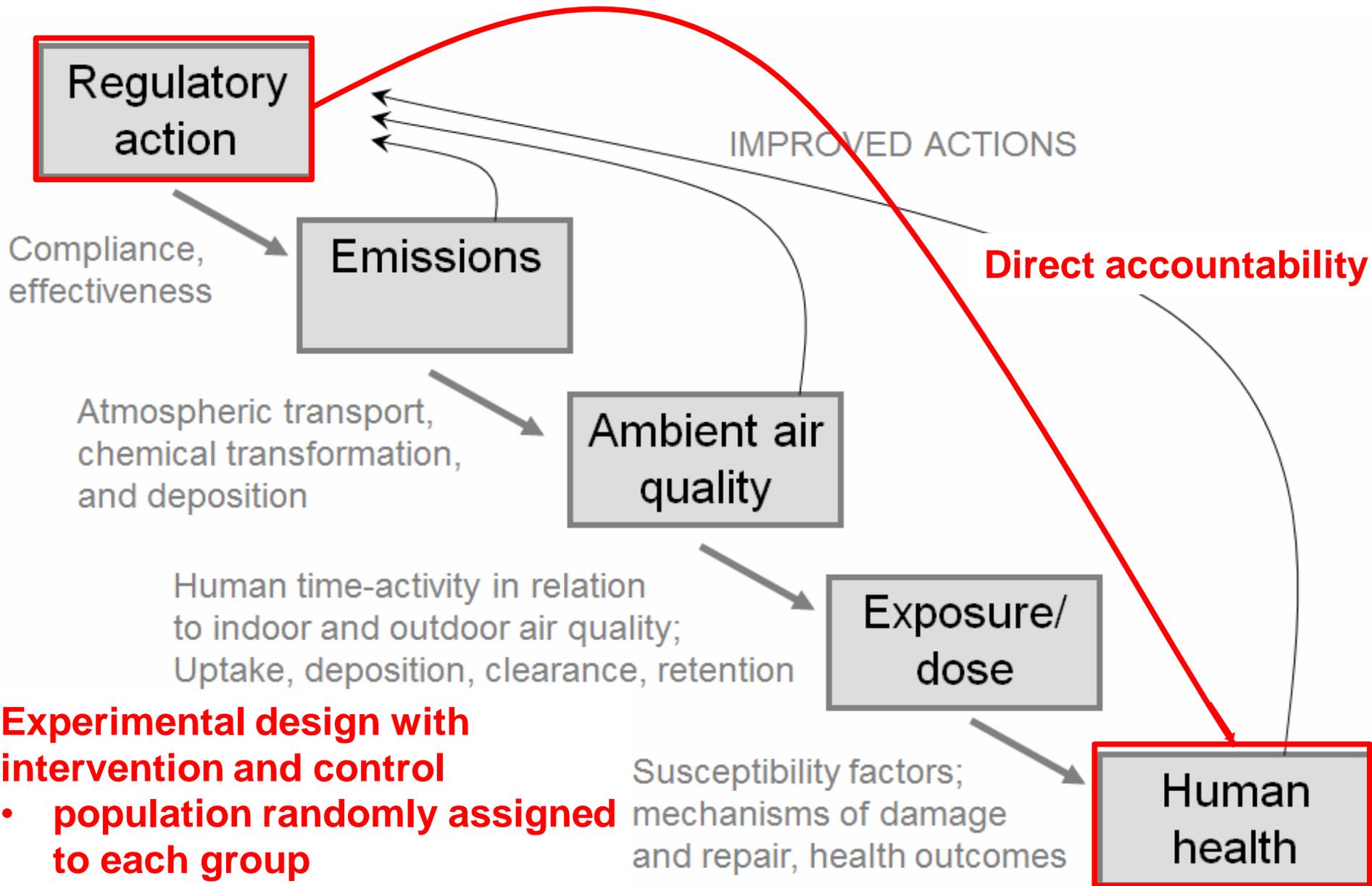
# Where are we going?

- Studies of complex large-scale, multiyear regulatory programs
- Inherent challenges
  - Complex: measurement of signal of intervention itself may be complicated
  - Timescale sufficient for temporal confounding
    - Health, economy, risk factors
  - Spatial scale: variation in effectiveness / health
- Counterfactual should reflect other changes not due to intervention



# Where are we going?

- Studies of local and individual-level interventions
  - Strategies to reduce exposure near high-volume roads (urban design, barriers, vegetation)
  - HEPA filters
  - Respirators
- In some cases amenable to randomized control trials
  - Sustained effectiveness



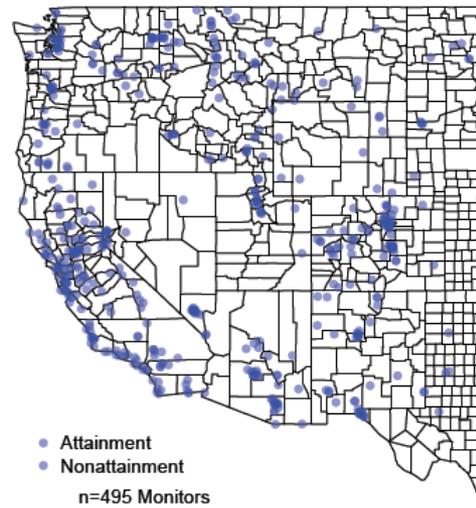
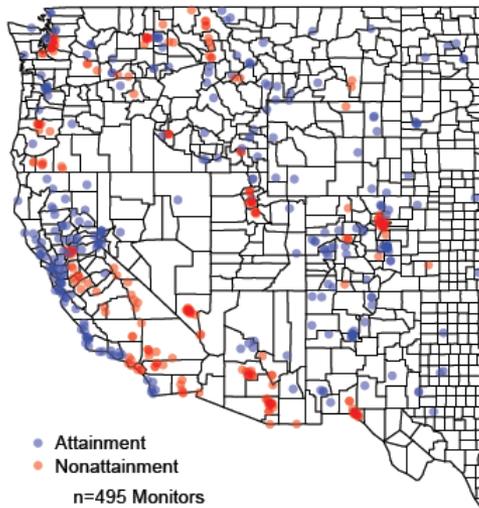
- Experimental design with intervention and control**
- **population randomly assigned to each group**
  - **Statistical approaches to account for confounding**

**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

**Framing As Hypothetical Experiment**

- **“Treatment:”** Initial nonattainment designations for PM<sub>10</sub> NAAQS following 1990 Clean Air Act Amendments.
- **“Control:”** EPA takes no nonattainment action (hypothetical).



**Question:** What is the causal effect (on health outcomes, pollution, etc. ...) of the initial PM<sub>10</sub> nonattainment designations vs. what would have happened if the designations had not occurred?

# Direct accountability

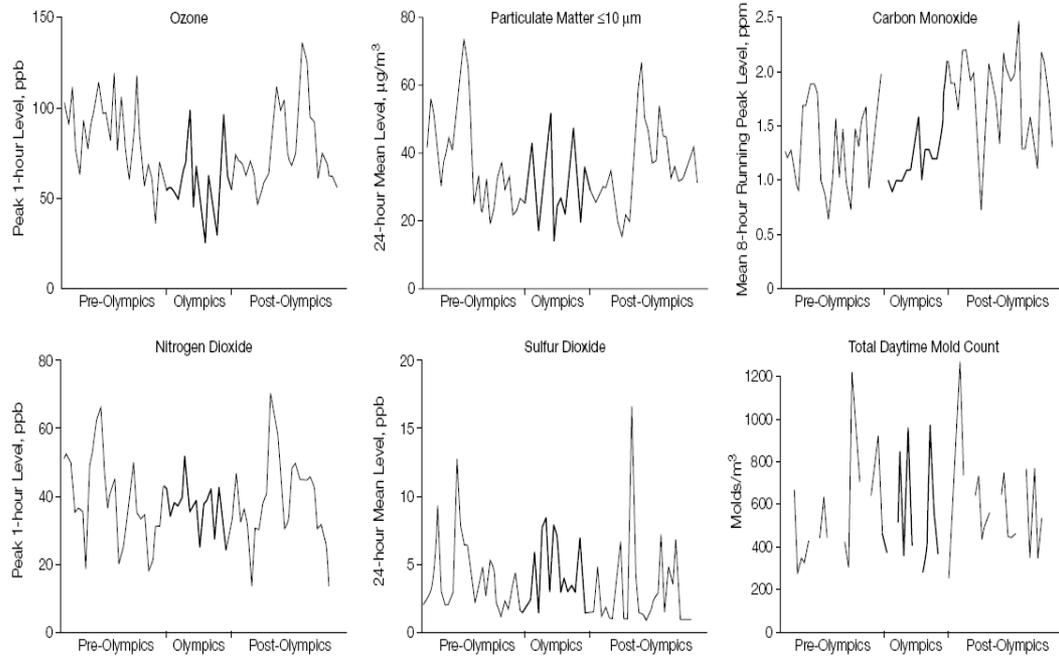
- Did a policy cause health improvements?
- Which effects attributed to which policies?
- Which policies most effective?
  
- Challenges in identifying appropriate control areas or populations
- Residual confounding still may be present
- Interpretation

I WILL LEARN MY LESSON

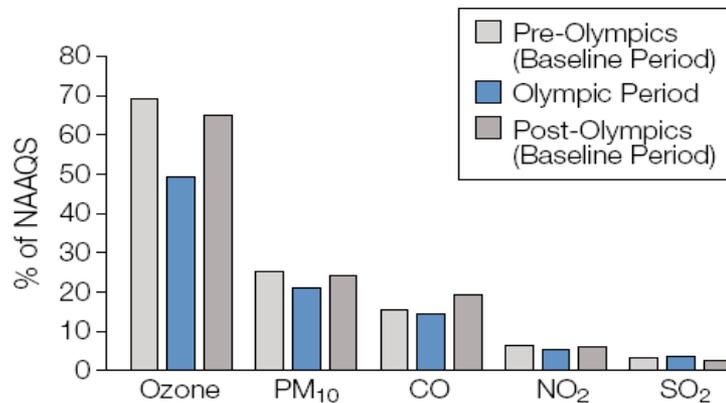
# Atlanta Olympics

22% decrease in peak weekday morning traffic counts

11 - 44% decrease in asthma acute care events



Broken line indicates incomplete data (eg, mold counts were available weekdays only).



# *Peel et al. expanded analysis*

- Effectiveness of traffic measures on traffic
  - Did traffic measures reduce pollution?
  - Expanded set of health outcomes
  - Role of seasonal effects
- 
- Traffic measures shifted traffic patterns, overall traffic not reduced
  - Ozone decreased, but likely due to weather patterns across the Southeast
  - Little evidence of reductions in emergency department (ED) visits after controlling for seasonal patterns



# Atlanta Olympics

- Working through the chain or incorporating a control population
  - More comprehensive analysis of traffic
  - Role of regional meteorology
  - Control for seasonal patterns in ED visits
- Led to advance planning and improved designs for Beijing Olympics
  - coherence
  - multiple scales, populations

# Dublin Coal Ban

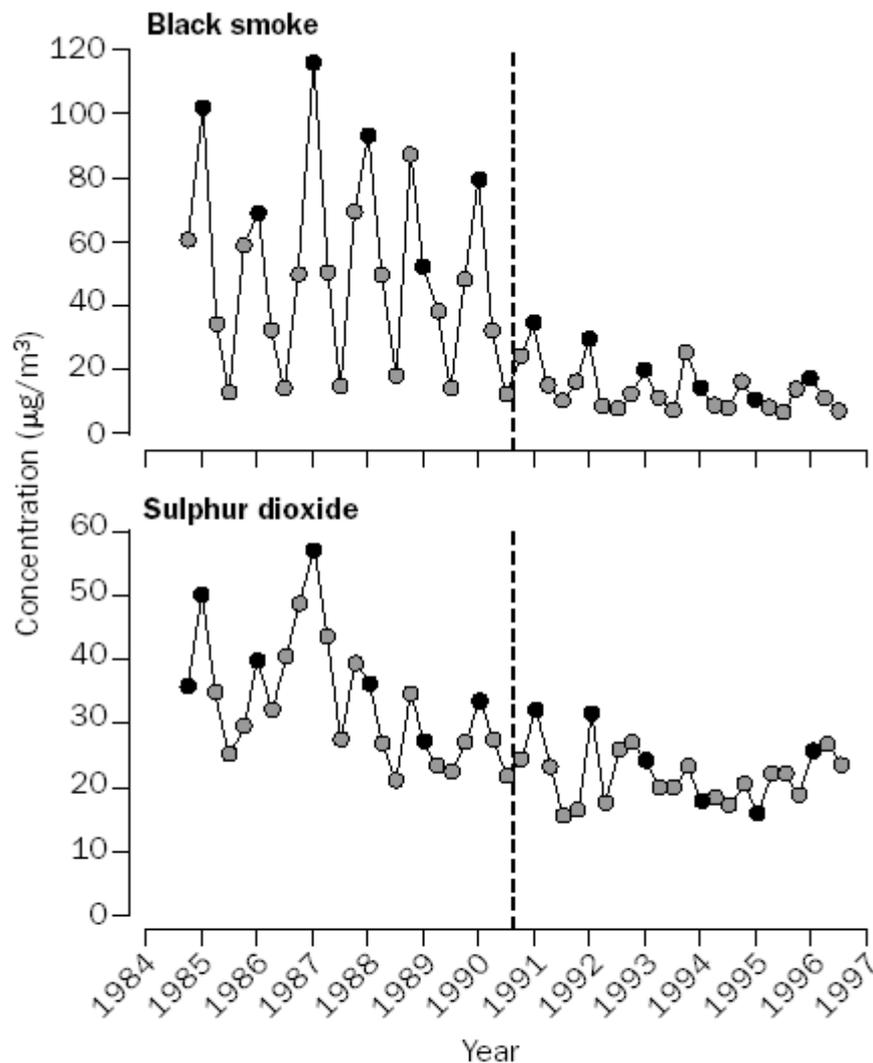


Figure 1: **Seasonal mean black smoke (upper) and sulphur dioxide (lower) concentrations, September 1984–96**

Vertical line shows date sale of coal was banned in Dublin County Borough. Black circles represent winter data.

5.7 % decrease in total non-trauma deaths

15.5% decrease in respiratory deaths

10.3% decrease in cardiovascular deaths

controlling for temperature, humidity, day of week, respiratory epidemics, death rates in the rest of Ireland

# *Dockery et al. expanded analysis*

- Dockery et al extended original study (in space and time):
  - Irish government extended coal ban to 11 other cities in 1995, 1998 and 2000
  - Doubled study period (12 -> 24 years)
  - Added Midland counties where coal ban was **not** instituted as comparison population
- Improvement in air pollution and mortality from coal ban
- Importance of / difficulty in control of secular trends
- Original study probably overestimated effect in Dublin coal ban on total and cardiovascular mortality



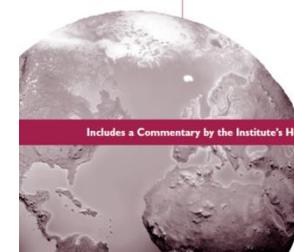
RESEARCH REPORT

HEALTH  
EFFECTS  
INSTITUTE

Number 176  
July 2013

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

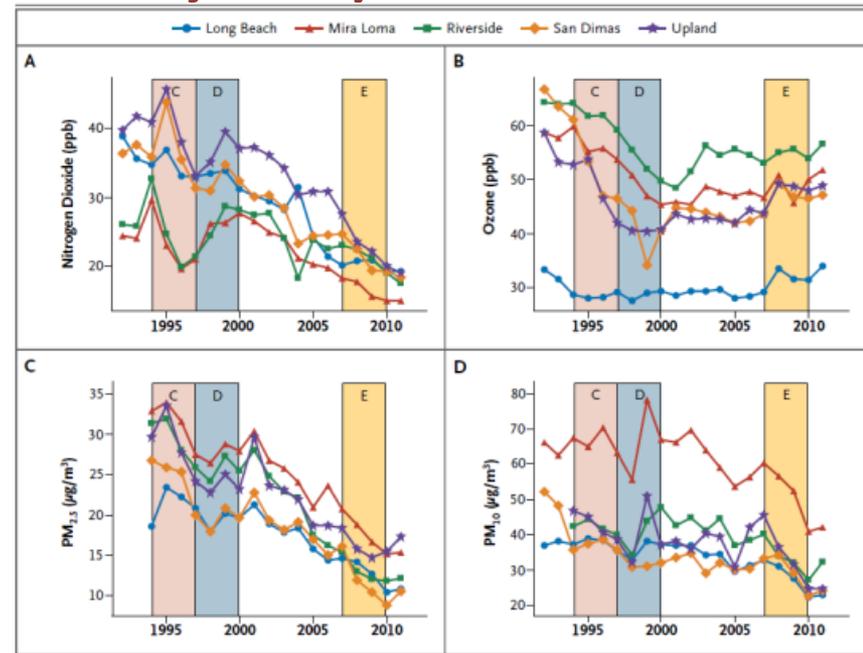
Douglas W. Dockery, David Q. Rich,  
Patrick G. Goodman, Luke Clancy,  
Pamela Ohman-Strickland, Prethilba George,  
and Tania Kodov



Includes a Commentary by the Institute's Health Review Committee

# Gilliland et al. SoCal air quality improvements

- Policies -> Emissions -> Ambient AQ
- Ambient AQ -> Health
  - Control population
  - Exposure misclassification



RESEARCH REPORT

HEALTH  
EFFECTS  
INSTITUTE

The Effects of Policy-Driven Air  
Quality Improvements on Children's  
Respiratory Health

Number 190  
January 2017

Frank Gilliland, Edward Avol, Rob McConnell, Keros Berhane,  
W. James Gauderman, Fred W. Lurmann, Robert Urman,  
Roger Chang, Edward B. Rappaport, and Stephen Howland



Includes a Commentary by the Institute's Review Committee

Gauderman WJ et al. Association of improved air quality with lung development in children. *N Engl J Med.* 2015 Mar 5;372(10):905-13. doi: 10.1056/NEJMoa1414123.; Berhane K et al. Association of Changes in Air Quality With Bronchitic Symptoms in Children in California, 1993-2012. *JAMA.* 2016 Apr 12;315(14):1491-501. doi: 10.1001/jama.2016.3444

# Lessons learned (I)

- Limitations in modelling meteorologic effects for short-term studies
  - statistical, design (e.g. control periods/areas)
- Confounding by subject behavior (short-term studies)
  - assess subject behavior, control periods / populations
- Confounding by long-term trends in health (for longer-term studies)
  - statistical, design (e.g. control populations)

# Lessons learned (II)

- Specificity of response measures (coherence)
  - biomarkers -> clinical / mortality outcomes
- Spatial misalignment / exposure error
  - specificity of exposure measures
- Robustness
  - **torture the data!**
  - causal inference design frameworks / methods
- Counterfactual
  - baseline levels (of pollution and health measures)
  - spatial domain

# Closing thoughts

- Prospective designs (vs natural experiments)
  - Causal inference framing
- Also consider impacts of actions not initially focused on air quality...
  - ...otherwise may miss new, less costly, approaches with co-benefits (e.g. E-Z pass)
- As important to evaluate unintended air quality/health consequences of other actions
  - e.g. vehicle CO<sub>2</sub> emissions tax in UK

what a long strange trip its been

