

Can we Link Cause and Effect?

The role and value of Accountability Research

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The Health Effects Institute

Trusted Science – Cleaner Air – Better Health

www.healtheffects.org

- Independent Non-profit Research Institute since 1980
- Balanced Core Support
 - US EPA and Industry (Worldwide Motor Vehicle)
- Independent Board and Expert Science Committees
 - Board agreed to by EPA Administrator and core industry sponsors
 - **Research Committee** selects all research competitively
 - Separate **Review Committee** intensively peer reviews all results
- Full Transparency
 - All Results – positive and negative – published
 - Works to make all data accessible to others
- Does not take policy positions

HEI

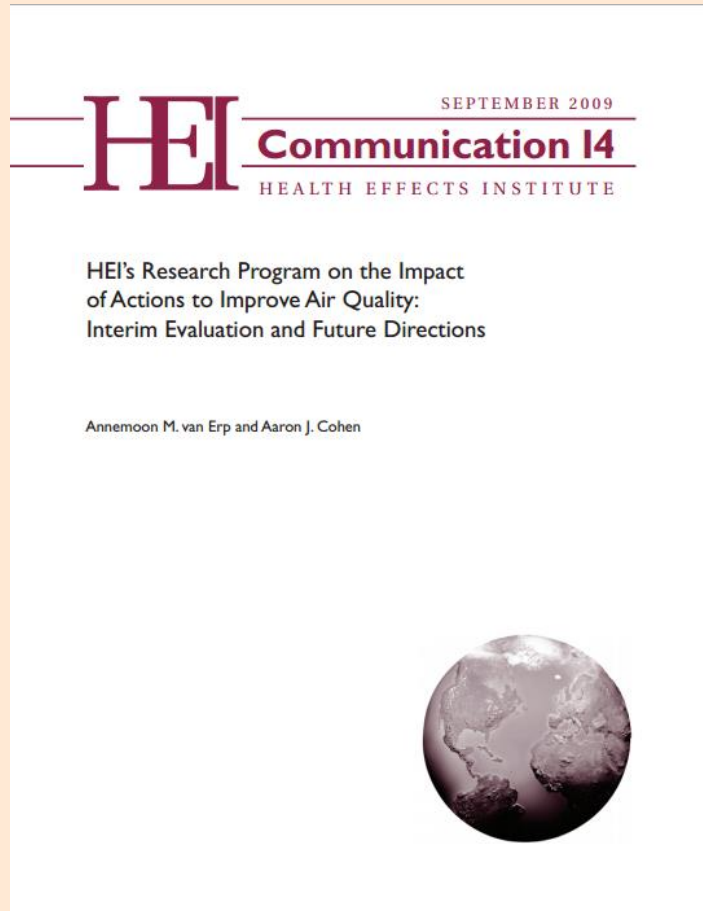
HEI Products

- **Targeted research**
 - Key regulatory questions: PM, ozone, diesel, air toxics, others
 - Health impacts – effectiveness of regulations
- **Re-Analysis of major studies**
 - e.g. Harvard Six Cities and American Cancer Society Studies on PM; 30 revised “time-series” PM studies
- **Rapid Scientific Review**
 - Health Effects of Ultrafine Particles
 - The Health Effects of Exposure to Traffic
 - MTBE, Diesel Exhaust Epidemiology, Air Toxics

Output: Over 350 Studies on a wide variety of air pollutants

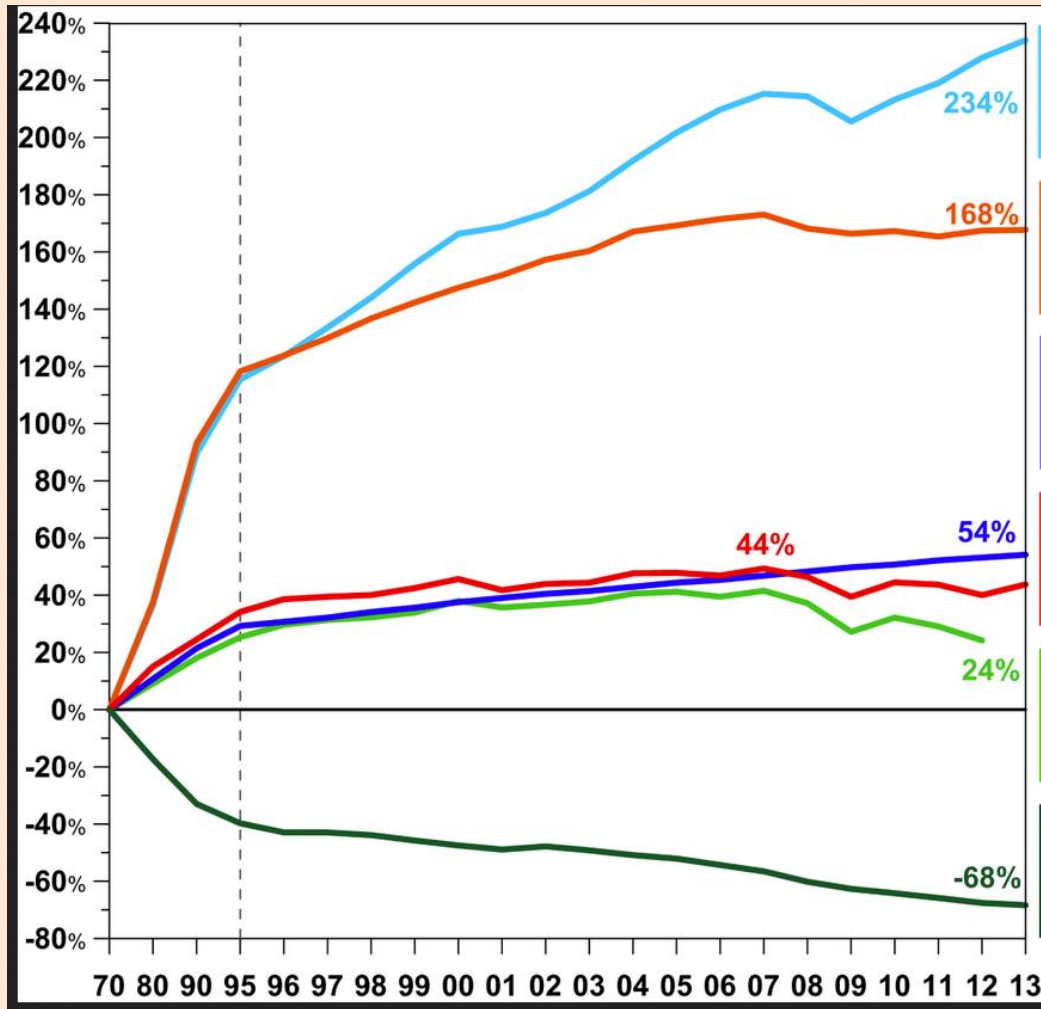
Impact: Widely cited by Government Agencies in US and Worldwide

Accountability Research



- How do we know that environmental policies “work”?
- Accountability Research: Testing the extent to which air quality interventions improve public health
- Part of a broad effort to assess the performance of environmental regulatory policies

You have all seen this....



Gross Domestic Product



Vehicle Miles Traveled



Population



Energy Consumption



CO₂ Emissions



Aggregate Emissions
(Six Common Pollutants)

And this from the EPA Section 812 Report...

◆	Year ◆ 2010 (in cases)	Year ◆ 2020 (in cases)
Adult Mortality - particles	160,000	230,000
Infant Mortality - particles	230	280
Mortality - ozone	4300	7100
Chronic Bronchitis	54,000	75,000
Heart Disease - Acute Myocardial Infarction	130,000	200,000
Asthma Exacerbation	1,700,000	2,400,000
Emergency Room Visits	86,000	120,000
School Loss Days	3,200,000	5,400,000
Lost Work Days	13,000,000	17,000,000

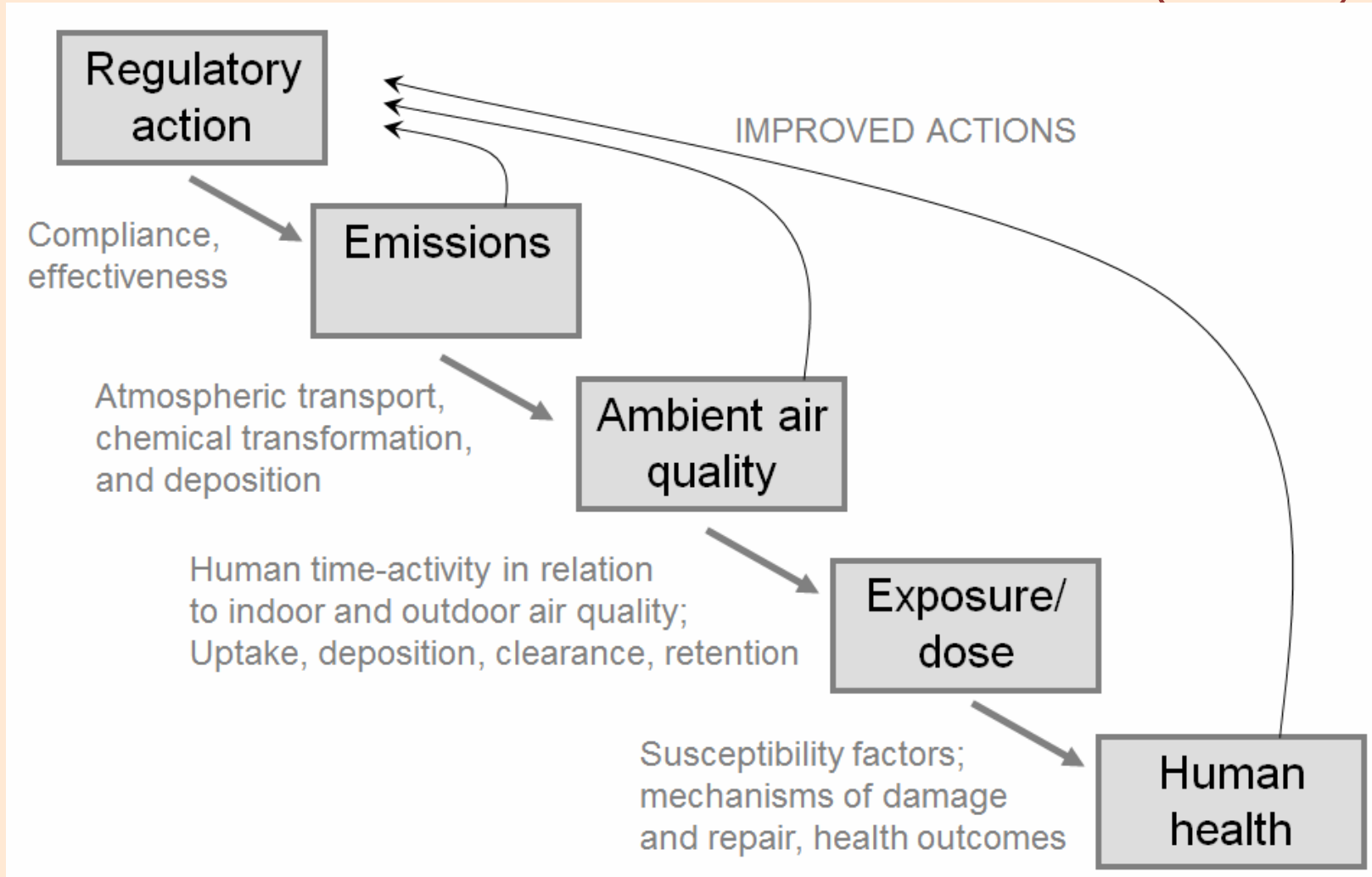
<http://www2.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study>

The Key Question

How do we know that actions taken for clean air have actually reduced the air pollution – and benefitted public health?

One way of answering: By following the **Chain of Accountability**

(HEI 2016)



HEI Accountability Studies

- Over a dozen short and longer term intervention studies to date...
- Today, a sample of those results
 - Shorter term:
 - Atlanta Olympics
 - Ireland Coal Ban
 - Longer term
 - AQ Actions in the LA Basin
 - AQ Actions in the Atlanta Region

Impact of Improved Air Quality During the 1996 Atlanta Olympic Games

HEI Research Report 198

Jennifer Peel and colleagues; Colorado State University

- New study to assess impact of traffic reduction measures in downtown Atlanta during the Olympic Games and the effect on air quality and health
- An earlier study by the CDC reported a decrease in ozone and childhood asthma hospital admissions (Friedman et al, JAMA 2001)

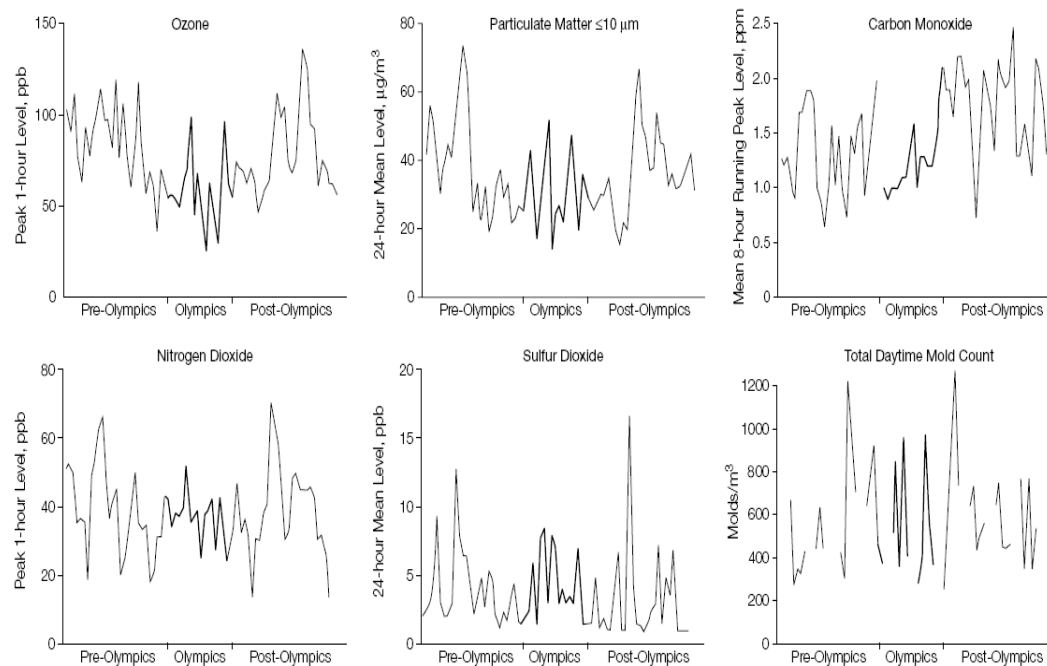


Atlanta Olympics – Earlier Study

Michael Friedman et al, JAMA 285 (2001) 897-905

Reported significant reduction in morning traffic (-22%), reduced peak daily ozone levels (-28%), and reduced asthma acute care events (-41%)

Figure 2. Daily Time Series of Individual Air Pollutant Levels and Mold Counts During the 1996 Summer Olympic Games and Baseline Period

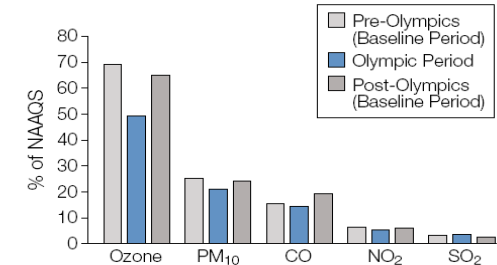


Broken line indicates incomplete data (eg, mold counts were available weekdays only).

©2001 American Medical Association. All rights reserved.

(Reprinted) JAMA, February 21, 2001—Vol 285, No. 7 901

Figure 3. Mean Levels of Major Pollutants Before, During, and After the 1996 Summer Olympic Games as a Percentage of the National Ambient Air Quality Standard (NAAQS)



National Ambient Air Quality Standard at time of study: ozone 1-hour peak average, 120 ppb; particulate matter of $10 \mu\text{m}$ or smaller (PM_{10}) 24-hour average, $150 \mu\text{g}/\text{m}^3$; carbon monoxide (CO) 8-hour average, 9 ppm; nitrogen dioxide (NO_2) 1-hour peak average, 600 ppb; sulfur dioxide (SO_2) 24-hour average, 140 ppb.³⁵

Objectives of HEI Analysis

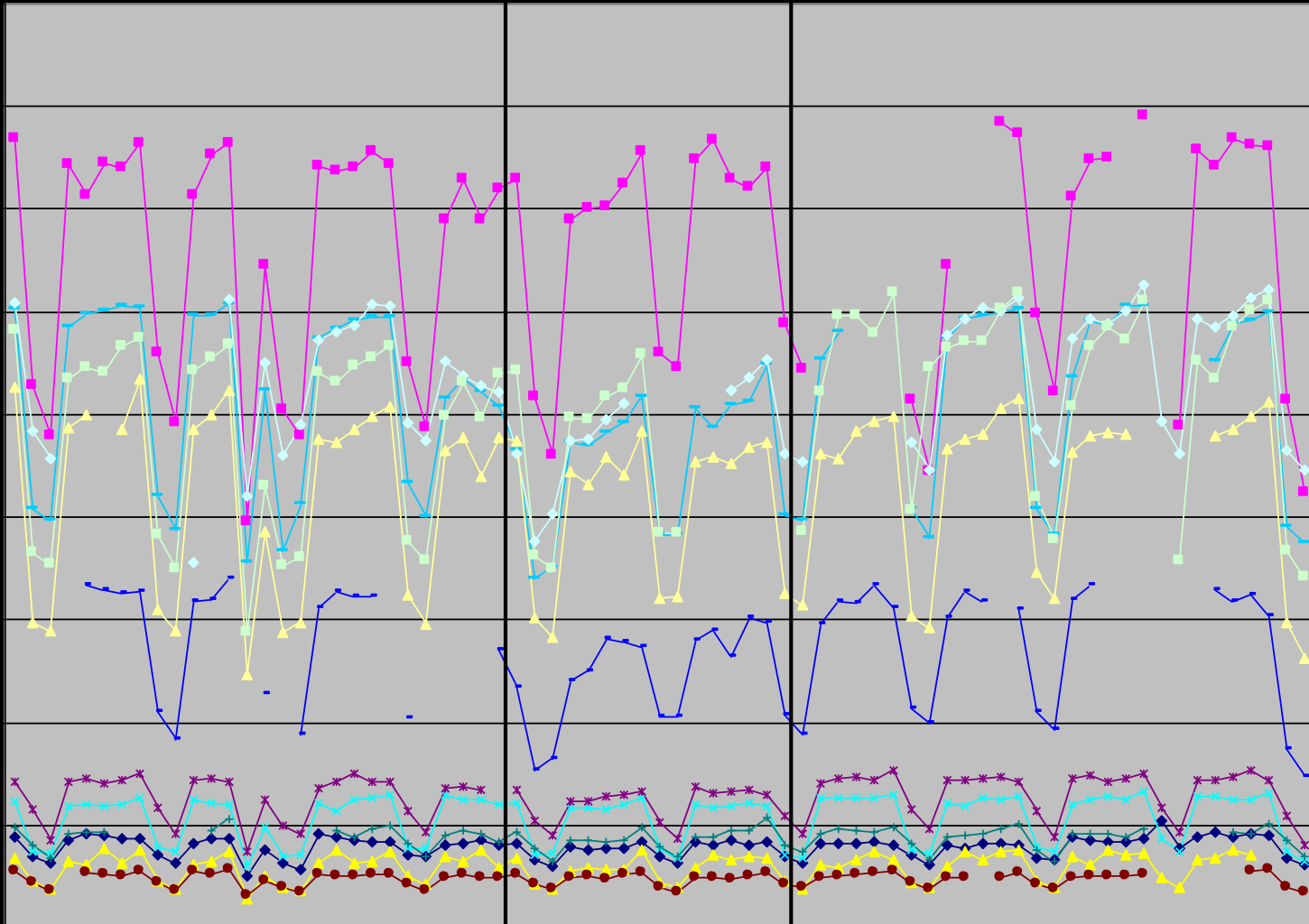


- Take a deeper look at
 - Did the measures to control traffic reduce traffic?
 - Did traffic changes reduce Ozone, PM and other pollutants?
 - What happened to Emergency Department Visits for multiple cardiovascular and respiratory cases?
 - And what happened in the same periods in the years before and after the Olympics?

Results – Traffic Counts

~10-15% decline in morning rush hour peak

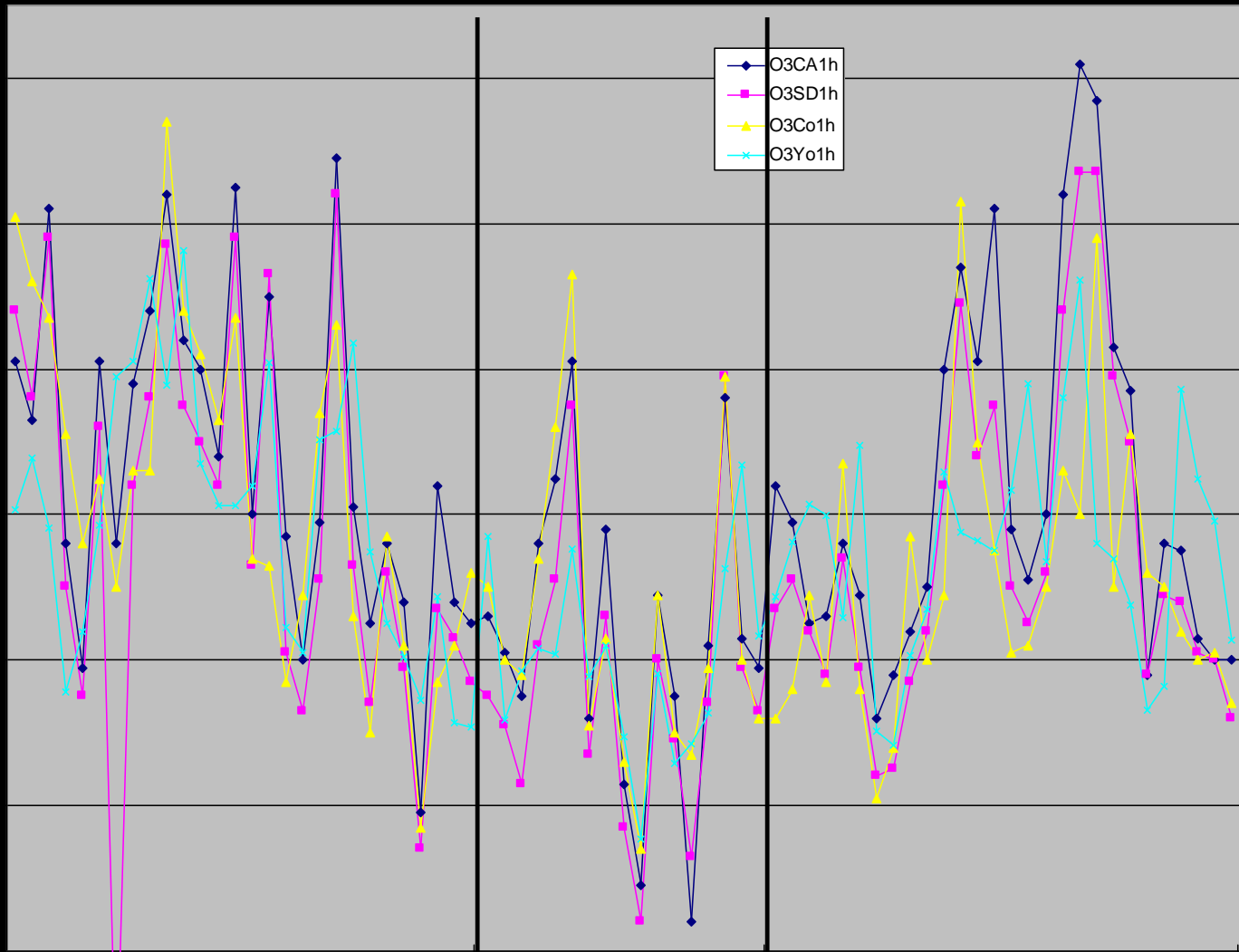
BUT overall daily count unchanged



Results – Ozone (1-hour max)

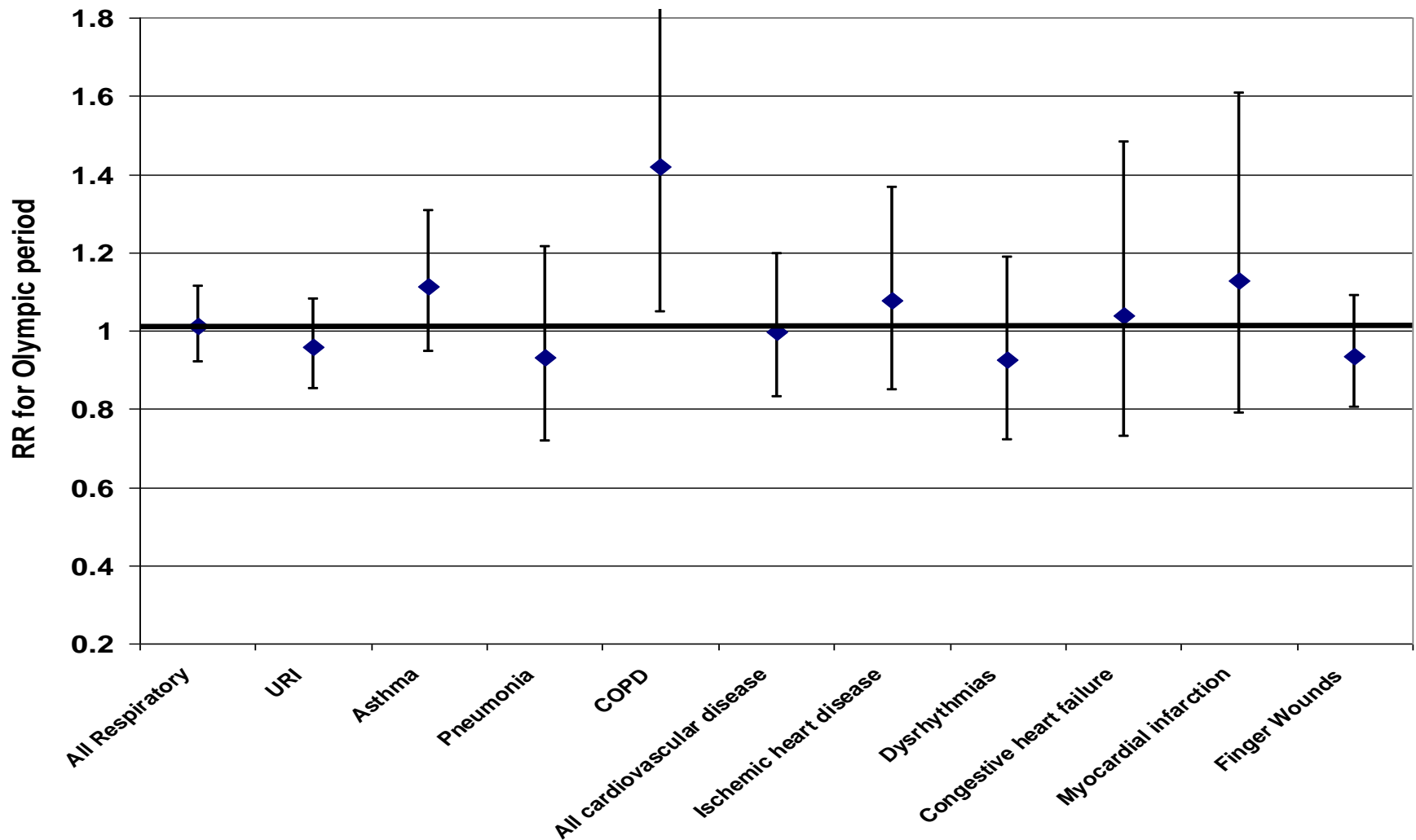
~30% Reduction Pre-During-Post

BUT, Similar Reductions Throughout the Southeast



Emergency Department Visits (all ages)

Little evidence of reduced visits when the same trends in other years are included



So What Happened?

- The traffic “controls” were voluntary – and basically seemed to just shift the times of traffic
 - 1-hour max (morning rush hour) traffic counts reduced ~10-15% but overall traffic not reduced
- Ozone levels were down, but likely due to weather patterns across the Southeast
 - Ozone levels ~30% lower during Olympics compared to 4 weeks before and after
 - Observed similar reductions in ozone at various sites throughout the Southeast not impacted by traffic changes
- There was little evidence of reductions in emergency visits
 - After controlling for seasonal patterns that showed up each year
- **Bottom Line:** *It is possible that traffic changes could have had benefits, but they would have had to be much more comprehensive and effective*

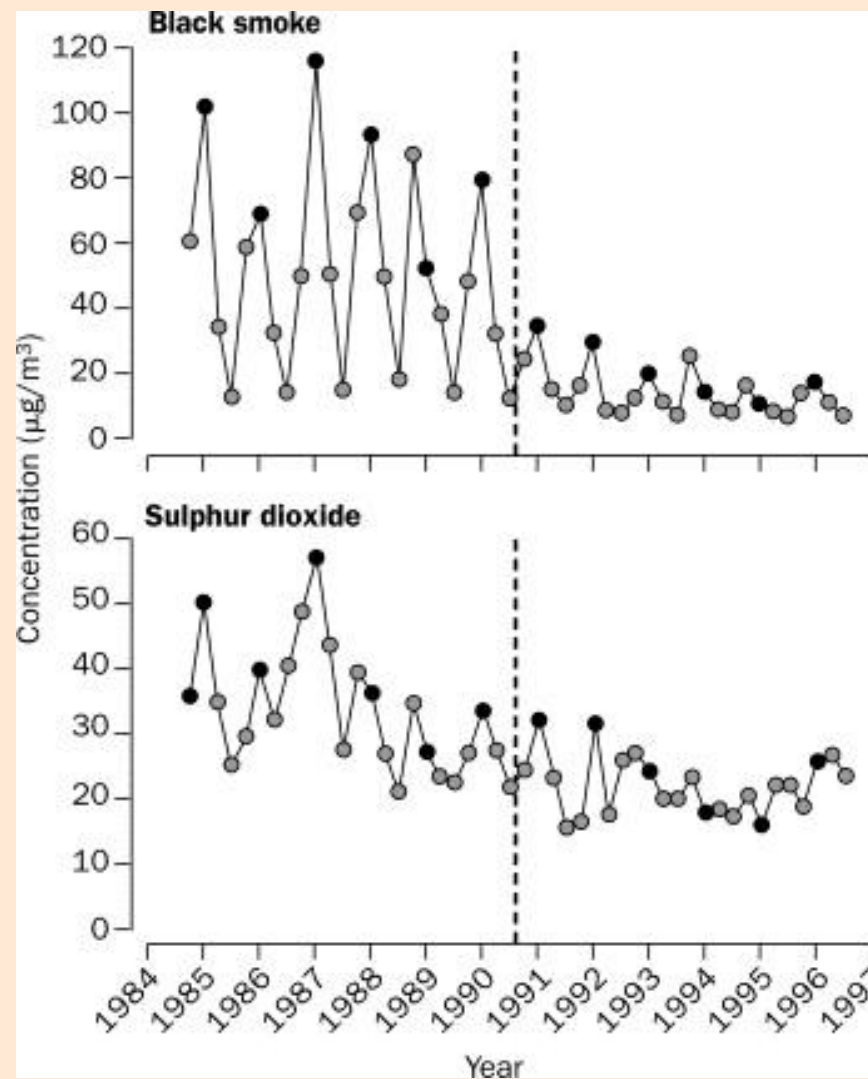
A second example:

Making sure you have a control group that was not affected by the action



A 2002 Study in Ireland: A ban on home coal use in Dublin reduced air pollution

Seasonal mean black smoke and SO₂ concentrations, September 1984-96



Clancy et al.
(2002)
Lancet
360:1210-14

Also, the authors reported that heart and lung mortality declined over the next 6 years

	Unadjusted % change (95% CI)	p	Adjusted % change* (95% CI)	p
Total				
Non-trauma	-8.0 (-9.8 to -6.2)	<0.0001	-5.7 (-7.2 to -4.1)	<0.0001
Cause-specific				
Cardiovascular	-13.4 (-15.9 to -10.8)	<0.0001	-10.3 (-12.6 to -8.0)	<0.0001
Respiratory	-16.1 (-20.4 to -11.6)	<0.0001	-15.5 (-19.1 to -11.6)	<0.0001
Other	1.4 (-1.6 to 4.6)	0.36	1.7 (-0.7 to 4.2)	0.17
Age-specific				
Younger than age 60 years	-8.1 (-12.3 to -3.7)	<0.0001	-7.9 (-12.0 to -3.6)	<0.0001
Age 60-74 years	-8.6 (-12.3 to -9.6)	<0.0001	-6.2 (-8.8 to -3.5)	<0.0001
Age 75 years or older	-7.6 (-8.1 to -7.0)	<0.0001	-4.5 (-6.7 to -2.3)	<0.0001

*Adjusted in robust Poisson regression for temperature, relative humidity, day of week, respiratory epidemics, and standardised cause-specific death rates in rest of Ireland.

Table 3: Change in age-standardised total, cause-specific, and age-specific mortality rates for Dublin County Borough for 72 months before and after ban of sale of coal in Dublin

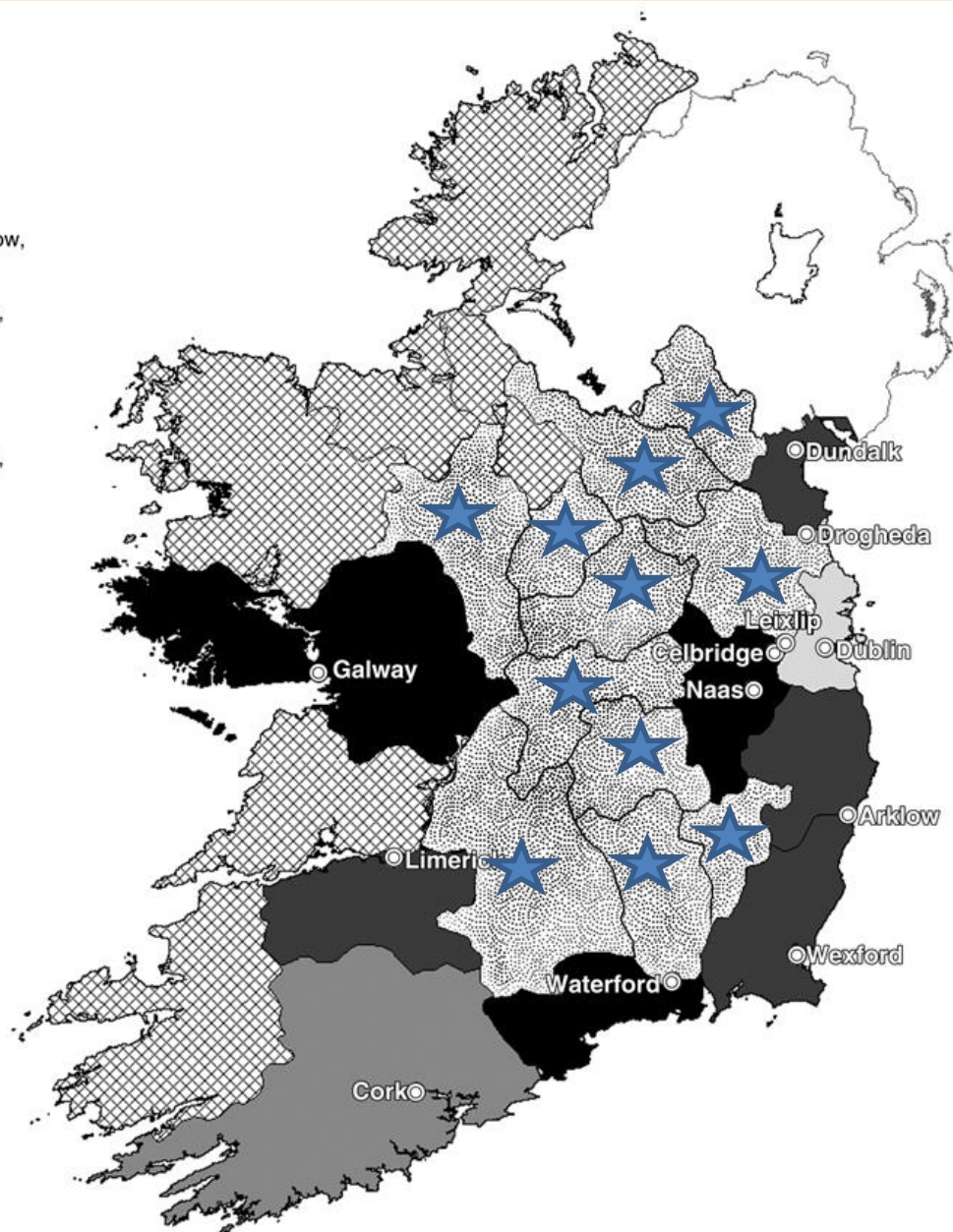
Clancy et al. (2002) Lancet 360:1210-14

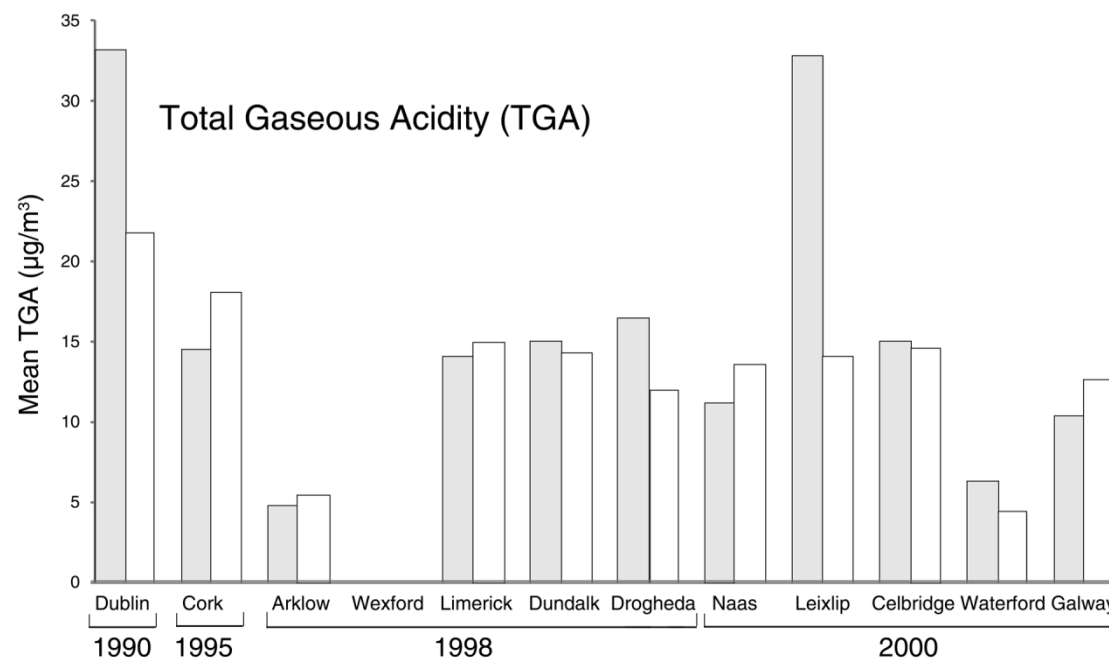
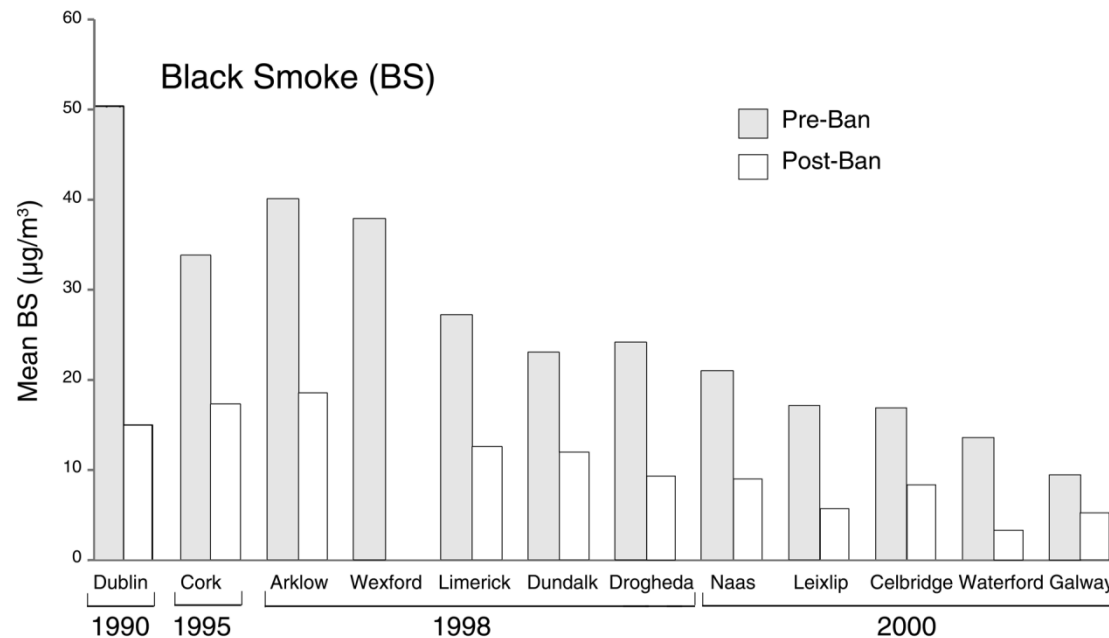
*A Deeper Look Funded by HEI**

- Clancy et al., focused on changes in Dublin only
- Dockery et al extend the original study:
 - Irish govt. extended coal ban to 11 other cities in 1995, 1998 and 2000
 - Study doubled the study period from 12 to 24 years;
 - Added a “comparison” population: residents of the Midland counties where coal ban was **not** instituted



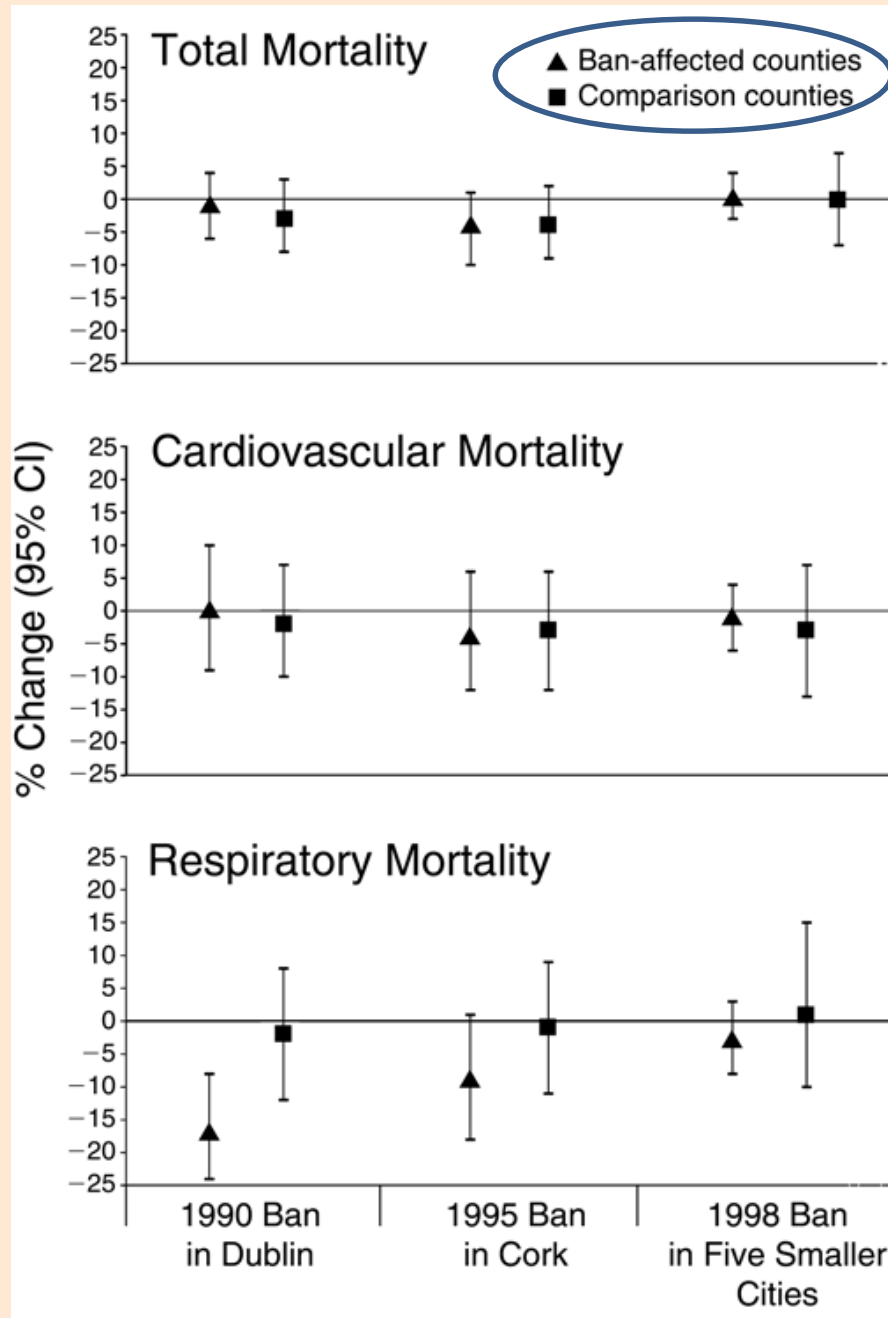
* Dockery et al. 2013. Effect of Coal Bans on Air Quality and Health in Ireland. Research Reports of the Health Effects Institute, 176.





***Confirmed
that air
pollution
went down...***

Mean BS and TGA
concentrations 5
years before and 5
years after the
coal bans



Key result: However, comparison counties saw same changes in heart deaths as those that had reduced air pollution (likely because of improving heart health overall)

Key result: There did appear to be reductions in respiratory deaths

Percent changes in cause-specific mortality for the ban-affected and comparison counties after the 1990, 1995, and 1998 coal bans.

Summary of Findings

- There was an improvement in air pollution from this action – and improved lung health
- But the original study probably overestimated the effect of the Dublin coal ban on total and cardiovascular mortality,
- “Detecting changes in public health indicators associated ... with clear improvements in air quality, as in this case, remains difficult when there are simultaneous secular improvements in the same health indicators.” (Dockery et al.)

Another Approach to a “control”

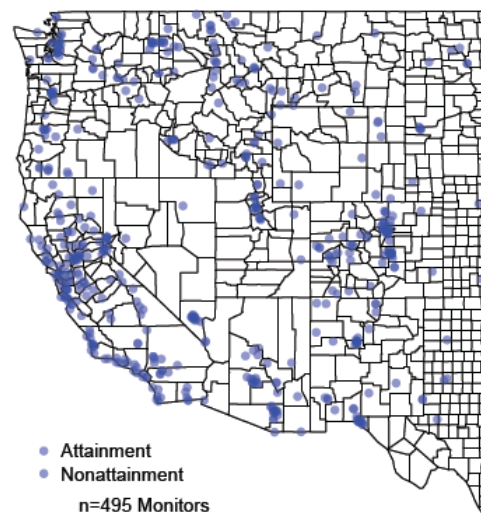
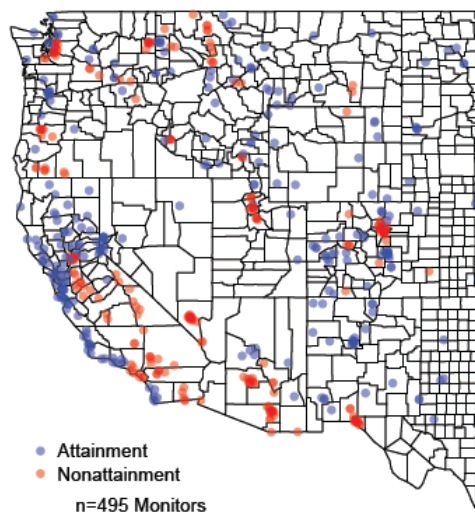
New HEI report examining what happened in western state nonattainment areas – and how that compares to what would have happened without EPA taking attainment action

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 PM₁₀ 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 PM₁₀ nonattainment designations vs. what would have happened if the designations had not occurred?

The Newest HEI Accountability Study: *Los Angeles Then and Now*



Source: New York Times

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

MARCH 5, 2015

VOL. 372 NO. 10

Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S.,
Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M.D.

*After Substantial numbers of
mobile source and other
action, Air Quality Improved
(though not Ozone)*

HEI Report 190:
The Effects of Policy-Driven Air
Quality Improvements
on Children's
Respiratory Health
By Frank Gilliland et al.
(January 2017)

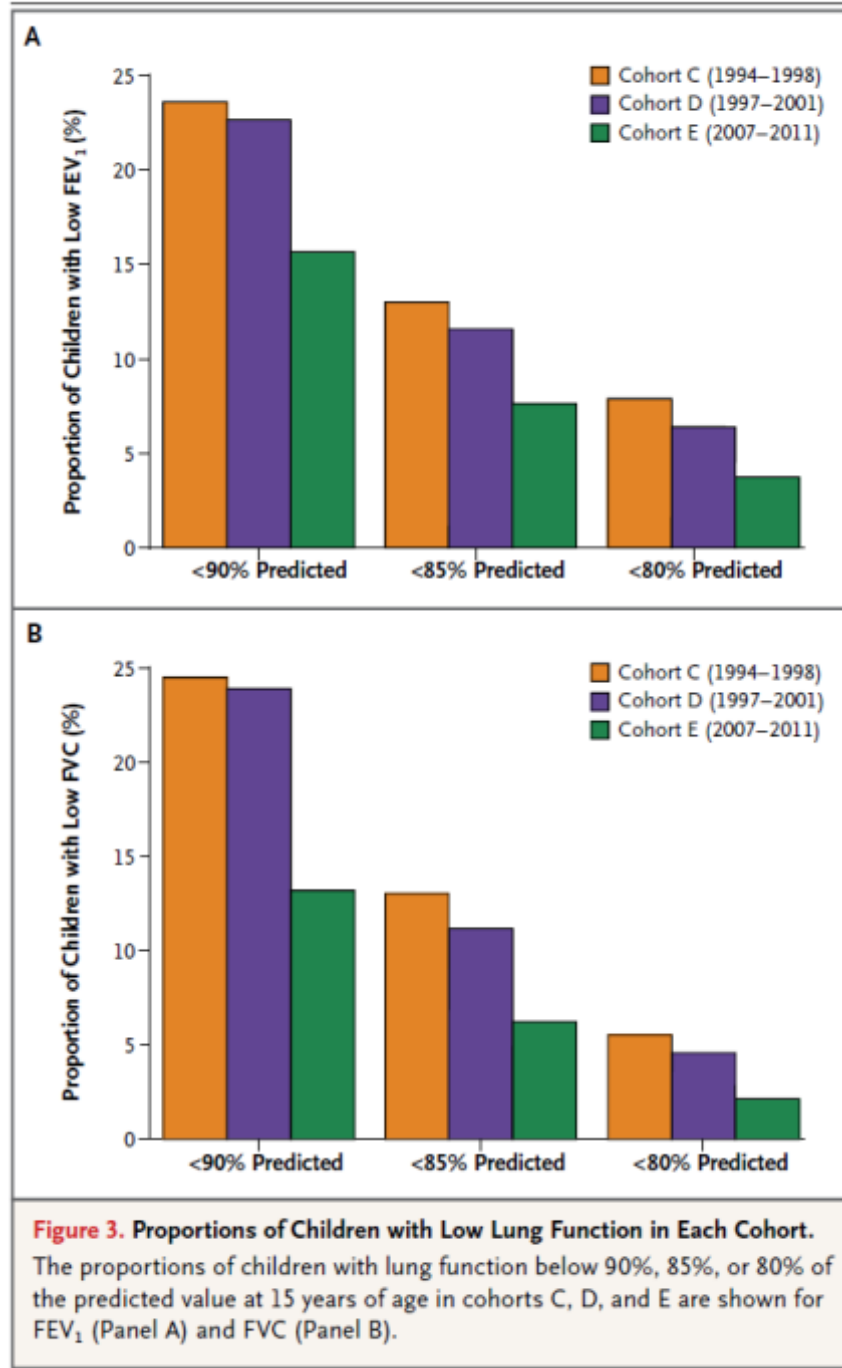


Figure 1. Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.

Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. PM_{2.5} denotes particulate matter with an aerodynamic diameter of less than 2.5 µm, and PM₁₀ particulate matter with an aerodynamic diameter of less than 10 µm.

Cleaner Air and Improved Lung Health

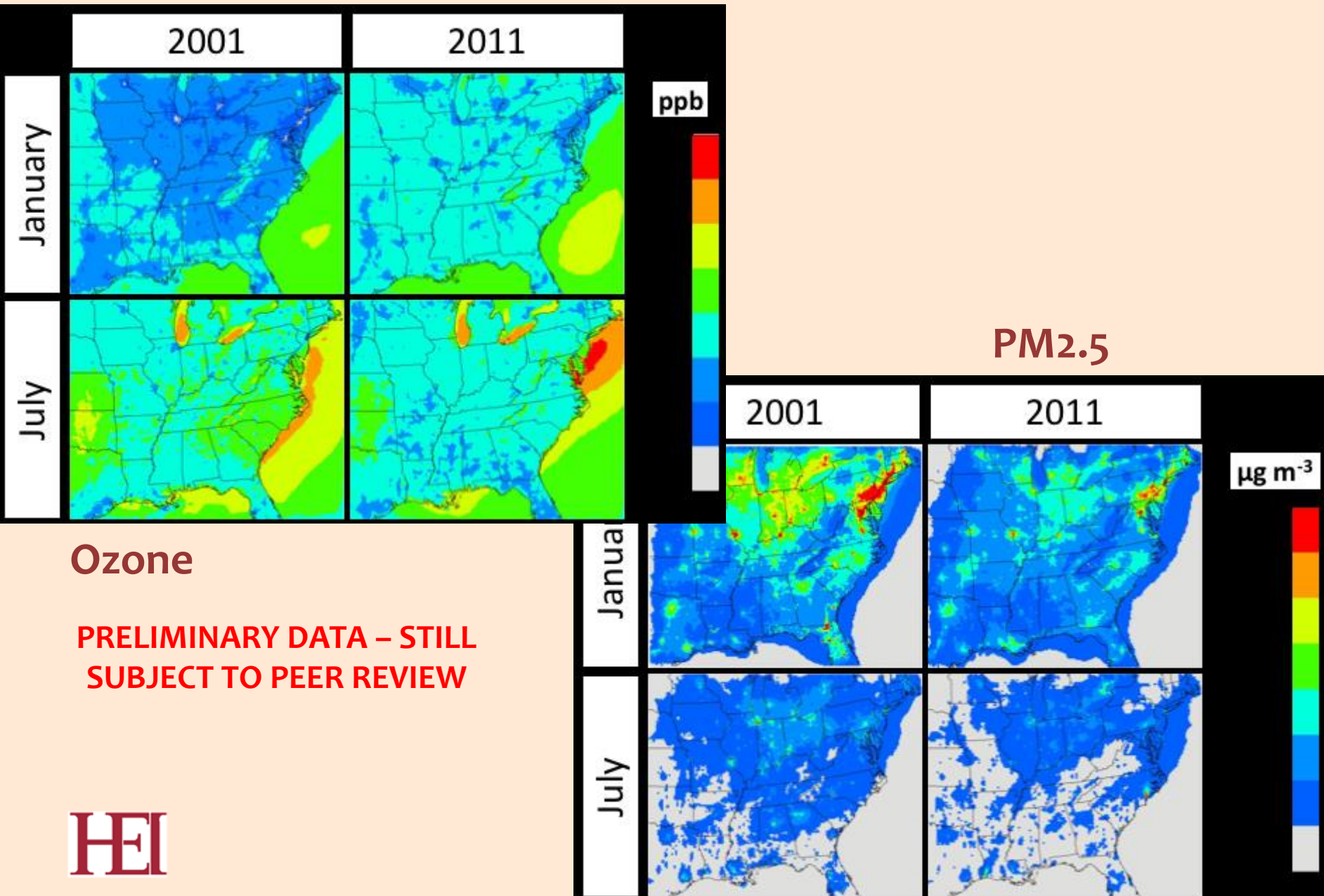
- Tracked growth in Lung Function in 3 “cohorts” (2,100 children total) in Southern California 1994 – 2011
- Reported notable improvement in lung function in the most recent cohort (who grew up 2007 – 2011 in cleaner air)
- Still some questions about other differences in the 3 cohorts (e.g. more Hispanics in the latest one)
 - And not possible to isolate a specific action that had an effect
 - But overall strong relationship



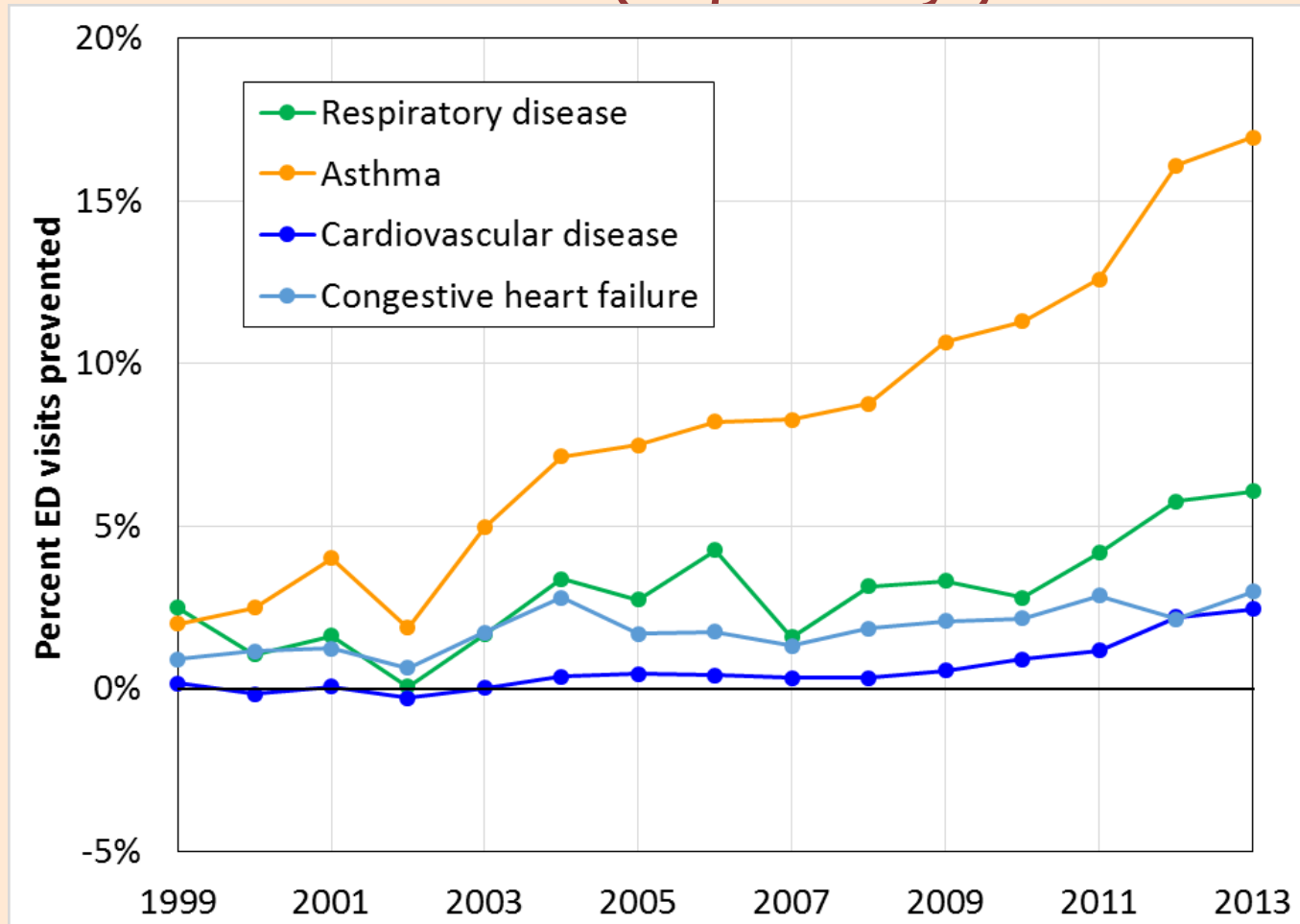
An HEI Accountability Study in the Works

- A Georgia Tech/Emory Assessment of major stationary and mobile source actions over 15 years in the Atlanta region.
- Used measurements, emission inventories and air quality models to assess change
 - Also calculated a “counterfactual” i.e. their best estimate of what would have happened without any AQ actions
- Attempted to tie the AQ changes to “prevented” emergency department visits
- ***PRELIMINARY RESULTS: Still in intensive HEI peer review...***

Changes in Air Quality across the Southeast

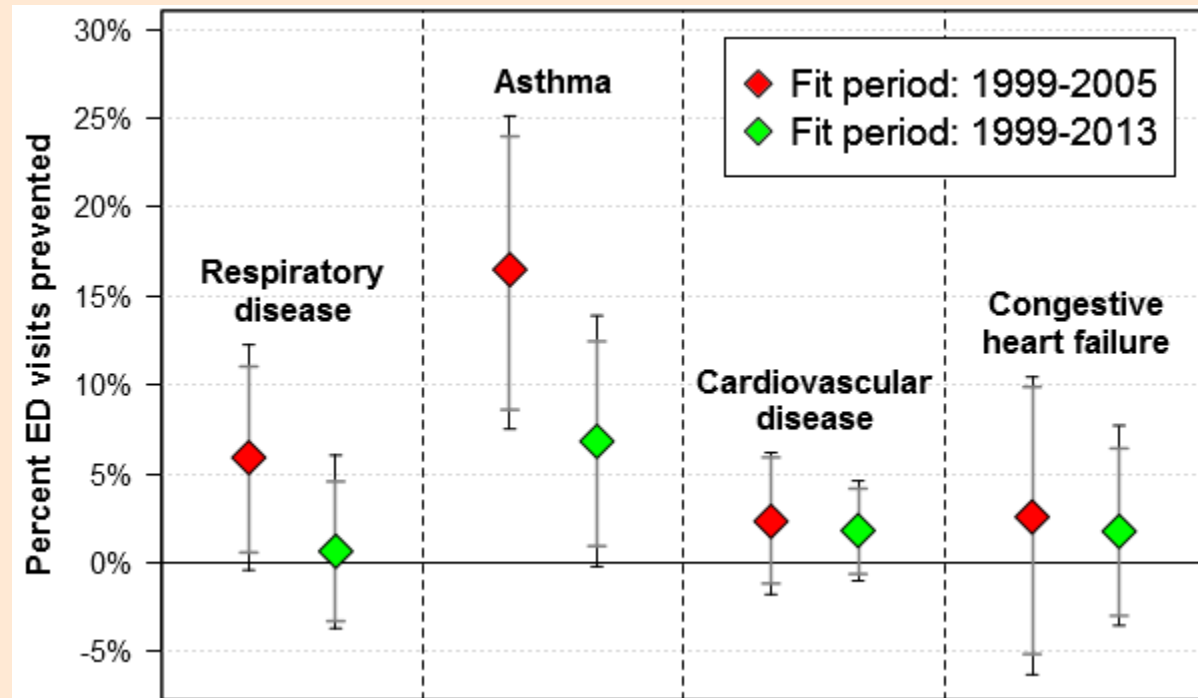


Increased Prevented Emergency Department Visits across Time (especially for asthma)



But the results depended on which period they studied

**PRELIMINARY
DATA – STILL
SUBJECT TO
PEER REVIEW**



- HEI's Review Committee seeking answers and revised analyses
- Stay tuned....

So can we link cause and effect?

- Using the “chain of accountability” provides a useful construct to assess the effectiveness of regulatory actions
 - Did the actions “cause” the targeted improvements in AQ and health?
 - Could the actions have been designed better, or better implemented?
- Regulatory changes often overlap with (many) other changes and trends (e.g. changes in health care and status)
 - Important – and challenging – to separate these out
- Overall, AQ actions have improved air quality in the US
 - But it continues to be useful to examine what the benefits have been, and how we might have done better
- ***And we at HEI would love to know of any forthcoming actions you may know of which may merit study?***

Thank you

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All HEI Reports are available for free download at:
www.healtheffects.org