HEI

APPENDIX AVAILABLE ON REQUEST

Communication 15

Proceedings of an HEI Workshop on Further Research to Assess the Health Impacts of Actions Taken to Improve Air Quality

Health Effects Institute

Appendix E. Accountability Workshop Presentations

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This document did not undergo the HEI scientific editing and production process.

Appendix E. Accountability Workshop Presentations:

What Has Accountability Done for Us? Jonathan M. Samet

Evaluating the Effectiveness of Air Quality Interventions: HEI's Research Program on Accountability, Annemoon van Erp

Data Sources and Access: A Street Level View from a City Health Department, Thomas Matte

Accountability Studies: Exposure Contrasts, Bert Brunekreef

Accountability Assessment of Long-Term Regulatory Action: Warm Season O_3 and Cardiac Mortality, Ira B. Tager

Statistical Methods for Accountability Research, Francesca Dominici

Accountability Studies: Evaluating Shorter-Term and Small Scale Actions, Jennifer L. Peel

Evaluating Shorter-Term and Small Scale Actions, Douglas W. Dockery

What has accountability done for us?

Jonathan M. Samet, MD, MS
Professor and Flora L. Thornton Chair
Department of Preventive Medicine
USC Keck School of Medicine
Director, USC Institute for Global Health

HEI Workshop
December 17-18, 2009

What is accountability?

Accountability is a concept in ethics and governance with several meanings. It is often used synonymously with such concepts as responsibility,[1] answerability, blameworthiness, liability, and other terms associated with the expectation of account-giving. As an aspect of governance, it has been central to discussions related to problems in the public sector, nonprofit and private (corporate) worlds. In leadership roles, accountability is the acknowledgment and assumption of responsibility for actions, products, decisions, and policies including the administration, governance, and implementation within the scope of the role or employment position and encompassing the obligation to report, explain and be answerable for resulting consequences. (*Wikipedia 2009)*

Accountability: Communication 11

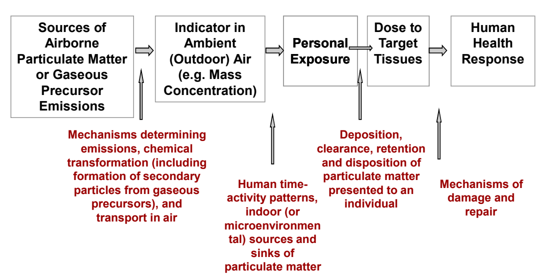
"Evaluating the extent to which air quality regulations improve public health is part of a broad effort—termed *accountability*—to assess the performance of all environmental regulatory policies."

Accountability Assessment

- To answer the question: What benefits have been realized from regulation?
- Look along "accountability chain"—from sources to health effects
- How to assess?
  - "Found experiments"
  - Surveillance approach

National Research Council's PM Committee

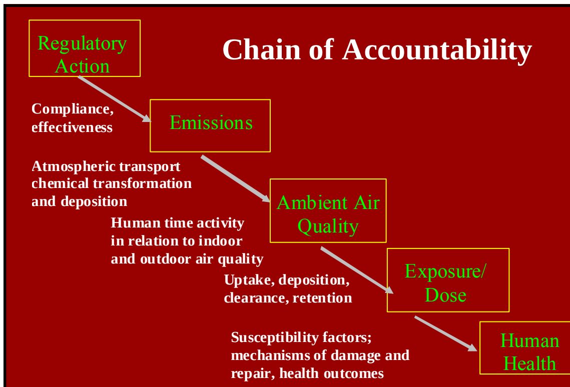
Source-to-Response Framework



NRC PM Committee 1998

What did Communication 11 propose?
- Chain of accountability
- Conceptual framework
- Research recommendations

Chain of Accountability



Rationale for accountability studies

- There is a call for it.
- Strengthen case for causal inference (β+ vs β-).
- Assess consequences of specific interventions.
- Provide "validation" of risk assessments.

Communication 11: Recommendations

- Developing and implementing new study designs
- Identifying targets of opportunity
  - PM and O_3 NAAQS implementation
  - Air Toxics Control Plan
  - Targets at local level
- Developing surveillance systems

What has HEI funded?

- Shorter-term, step-change interventions
  - Source modification:
    - Woodstoves: Montana
    - Sulfur in fuels: Hong Kong
  - Source operation
    - Short-term limits: Atlanta and Beijing Olympics
    - Restriction: London CCS
- Longer-term
  - Title IV 1990 CAA Amendments
  - Coal bans in Irish cities

Has accountability been useful?

- For developing a research agenda?
- For providing evidence that is useful for evidence-based regulation?
- For benefitting public health?

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Steps in Evidence-Based Public Health

Step	Methods
Search for Problems	Surveillance
Identify Causes	Etiologic research Systematic reviews Meta-analysis Causal guidelines
Assess Size of Problem	Quantitative risk assessment
Policy & Intervention	Policy analysis Decision sciences Cost-benefit
Reassess	Surveillance Accountability studies

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The Clean Air Act

Section 109 (42 U.S.C. 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants identified under section 108. Section 109(b)(1) defines a primary standard as one *"the attainment and maintenance of which in the judgment of the Administrator, based on such criteria and allowing an adequate margin of safety, is requisite to protect the public health."*

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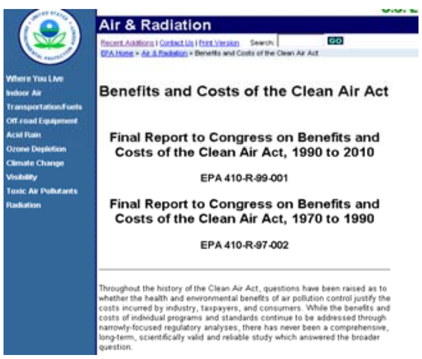
What are the Benefits and Costs of the CAA?



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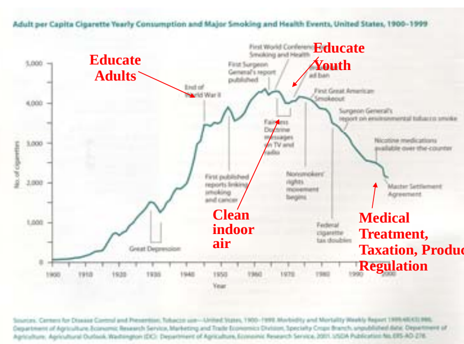
Success in the United States



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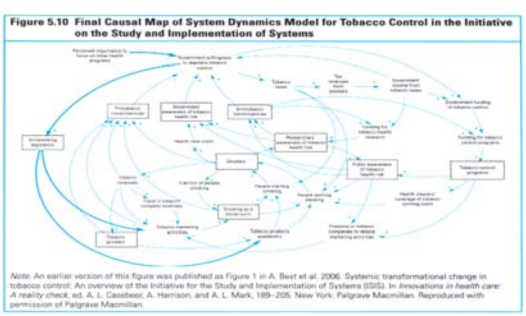
A Systems Approach: Final Causal Map



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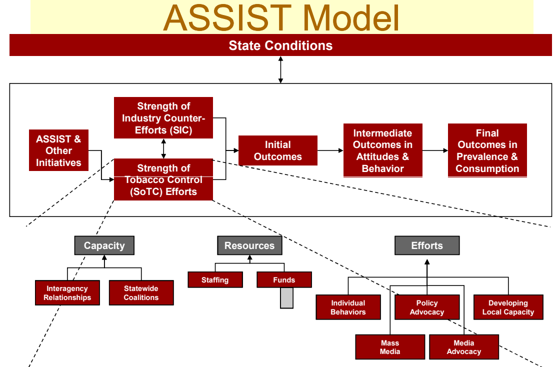
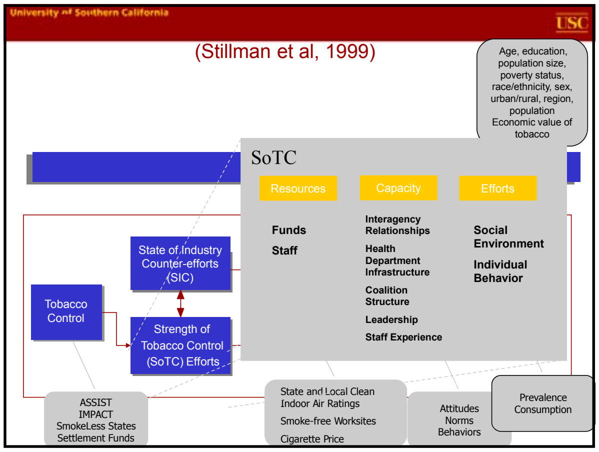
ASSIST Model

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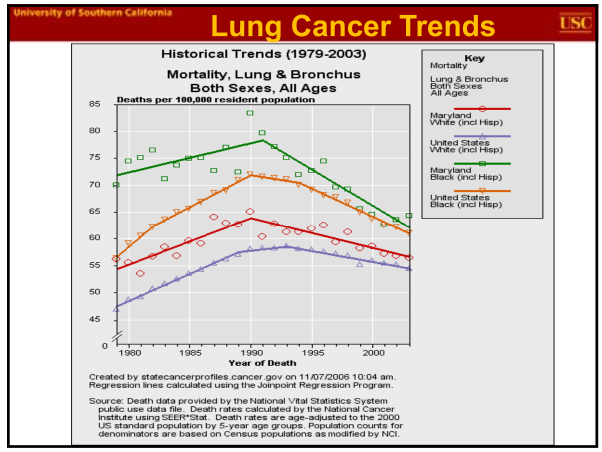
(Stillman et al, 1999)
Age, education, population size, poverty status, race/ethnicity, sex, urban/rural, region, population
Economic value of tobacco
SoTC
Resources
Capacity
Efforts
Funds
Staff
Interagency Relationships
Health Department Infrastructure
Coalition Structure
Leadership
Staff Experience
Social Environment
Individual Behavior
State of Industry Counter-efforts (SIC)
Tobacco Control
Strength of Tobacco Control (SoTC) Efforts
ASSIST
IMPACT
SmokeLess States
Settlement Funds
State and Local Clean Indoor Air Ratings
Smoke-free Worksites
Cigarette Price
Attitudes
Norms
Behaviors
Prevalence
Consumption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Lung Cancer Trends
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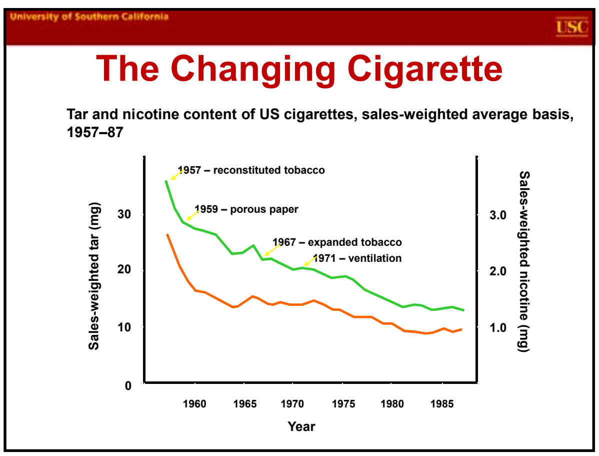
Historical Trends (1979-2003)
Mortality, Lung & Bronchus
Both Sexes, All Ages
Deaths per 100,000 resident population
Year of Death
Key
Mortality
Lung & Bronchus
Both Sexes
All Ages
Maryland White (incl Hisp)
United States White (incl Hisp)
Maryland Black (incl Hisp)
United States Black (incl Hisp)
Created by statecancerprofiles.cancer.gov on 11/07/2006 10:04 am.
Regression lines calculated using the Joinpoint Regression Program.
Source: Death data provided by the National Vital Statistics System public use data file. Death rates calculated by the National Cancer Institute using SEER*Stat. Death rates are age-adjusted to the 2000 US standard population by 5-year age groups. Population counts for denominators are based on Census populations as modified by NCI.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The Changing Cigarette
Tar and nicotine content of US cigarettes, sales-weighted average basis, 1957–87
1957 – reconstituted tobacco
1959 – porous paper
1967 – expanded tobacco
1971 – ventilation
Sales-weighted tar (mg)
Sales-weighted nicotine (mg)
Year


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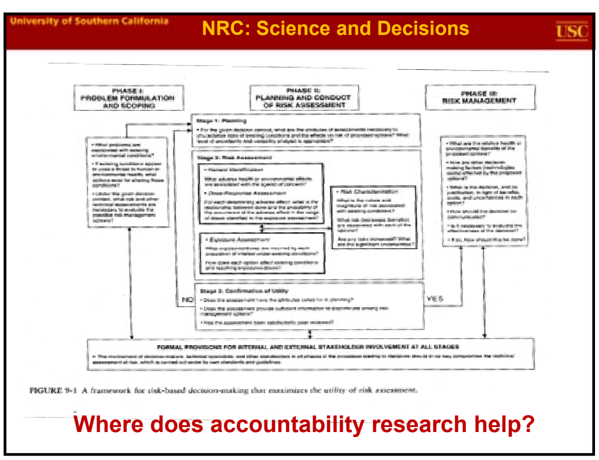
Judge Kessler Speaks:
"An immeasurable amount of human suffering"
The New York Times
Washingto
New Limits Set Over Marketing for Cigarettes
The tobacco industry has "marketed and sold their lethal product with zeal, with deception, with a single-minded focus on their financial success and without regard for the human tragedy or social costs that success exacted."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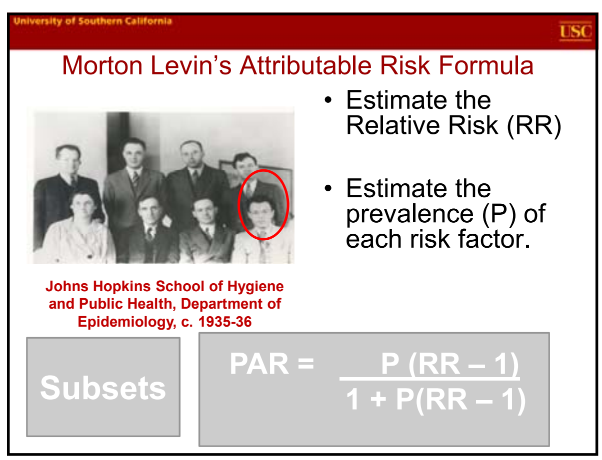
NRC: Science and Decisions
USC
PHASE I: PROBLEM FORMULATION AND SCOPING
PHASE II: PLANNING AND CONDUCT OF RISK ASSESSMENT
PHASE III: RISK MANAGEMENT
Stage 1: Planning
Stage 2: Risk Assessment
Stage 3: Confirmation of Utility
FORMAL PROVISIONS FOR INTERNAL AND EXTERNAL STAKEHOLDER INVOLVEMENT AT ALL STAGES
FIGURE 9-1 A framework for risk-based decision-making that maximizes the utility of risk assessment.
Where does accountability research help?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Morton Levin's Attributable Risk Formula
• Estimate the Relative Risk (RR)
• Estimate the prevalence (P) of each risk factor.
Johns Hopkins School of Hygiene and Public Health, Department of Epidemiology, c. 1935-36
Subsets
PAR = P (RR – 1) / 1 + P(RR – 1)

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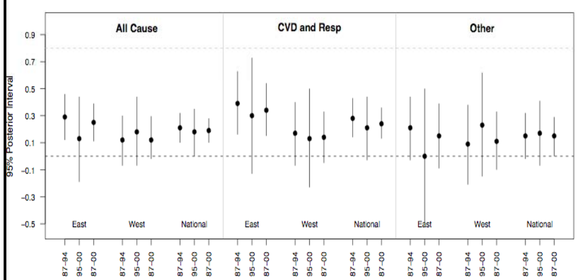
PM_{10} and Mortality: Have the Risks Changed from 1987 to 2000?



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NRC: Science and Decisions

USC

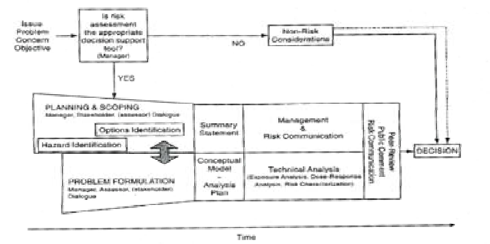


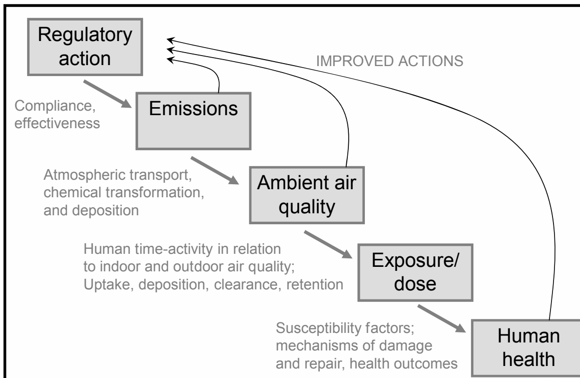
FIGURE 3-1 Schematic representation of the formative stages of risk-assessment design. Dotted line in figure denotes that decisions *informed* by risk assessment will be influenced by nonrisk considerations. Source: Adapted from EPA 1998, 2003.

Evaluating the Effectiveness of Air Quality Interventions:

HEI's Research Program on Accountability

Annemoon van Erp
Aaron Cohen
Health Effects Institute

HEI workshop
December 17-18, 2009



Focusing the challenge on health: *The Chain of Accountability*

Some issues and questions relevant to designing studies

- How do emissions, exposures, and health effects respond to different types of interventions?
  - Step-change vs. gradual change in air quality (AQ)
- Methodologic issues
  - Which study designs?
    - Large-scale, periodic monitoring to track population exposure versus smaller scale studies of specific subpopulations
  - Which health outcomes?
  - How to obtain adequate pre-intervention baseline data
  - Compare model-based predictions with actual outcome

Some issues and questions (cont'd)

- How to pursue unique opportunities (intentional, unintentional) that come up relatively quickly
  - Opportunities at national, regional, local levels
  - Identify and publicize opportunities
- How can accountability studies provide stronger tests of causal relations and contribute to scientific research on health effects of specific sources?
  - Steel mill closure was unplanned but provided important evidence regarding possible causality

HEI studies: Shorter-term actions

Actions to improve fuels & combustion technologies

1. Curtis Noonan: Wood stove change-out program in Montana (draft report due summer 2010)
2. Chit-Ming Wong: Reducing sulfur in fuel in Hong Kong (completed and under review)

Actions to reduce vehicular traffic

3. Frank Kelly: Congestion charging scheme in London (in press)
4. Jennifer Peel: Traffic measures during the 1996 Olympic Games in Atlanta (in press)

Multiple actions

5. Jim Zhang: Air quality improvements during the 2008 Olympic Games in Beijing (draft report due summer 2010)

Medium- to long-term actions

Actions to reduce the impact of mobile, area, or stationary sources

6. Doug Dockery: Coal bans in Irish cities (draft report imminent)
7. Frank Kelly: London low emission zone baseline study (in press)

8. Multiple actions

8. Dick Morgenstern: Air quality improvement under Title IV of the 1990 Clean Air Act Amendments (draft report due summer 2010)
9. Annette Peters: Air quality improvement after German reunification: (HEI Research Report 137, June 2009)

Cleaner wood stoves (Montana)

PI: Curtis Noonan, University of Montana

- community intervention project by Montana DEQ & others
- change-out of 1200 uncertified wood stoves during two winters (2005 and 2006)
- assess $PM_{2.5}$ levels outdoors, in schools, and in some homes before, during and after wood stove replacement

Libby, Montana web cam (June 26, 2007)

- relate air quality to children's respiratory symptoms, infections, and illness-related school absences

Woodstove change-out – preliminary findings

- air quality improvement inside homes
  - $PM_{2.5}$ 50 → 15 µg/m³, peak levels 435 → 100 µg/m³
  - levoglucosan (woodsmoke marker) reduced
- improved ambient $PM_{2.5}$ concentrations (25% lower)
- health studies still ongoing, preliminary data:
  - school absences not affected
  - respiratory symptoms somewhat reduced in children grades 1-8

Challenges

- delays in wood stove change-out
  - more gradual change in air quality
- variation in stove usage and operation
- other wood smoke markers not reduced
- possible reporting bias by parents

Fuel sulfur content (Hong Kong)

PI: Chit-Ming Wong, University of Hong Kong

- effect of 1990 regulation to reduce sulfur in fuel on AQ in Hong Kong
  - affecting both power plants and vehicles
  - shown to reduce SO_2 and mortality (Hedley et al, Lancet 2002)

- develop methodologies for assessing change in life expectancy and years of life gained
- focus on PM composition
- relation between short-term and long-term benefits

Hong Kong fuel sulfur content (Hedley et al 2002)

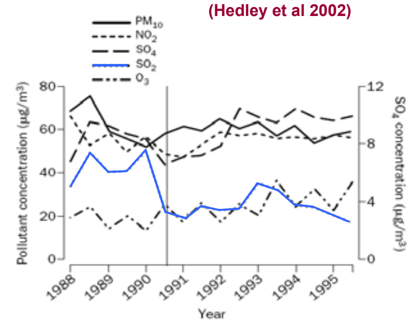


Figure 1: **Average of pollutant concentrations at five monitoring stations**
Vertical line represents date of introduction of fuel regulation.

Sulfur ban – preliminary findings

- changes in PM composition: decreased Ni and V
- reduced PM_{10} and SO_2 associated with reduced nonaccidental mortality
- reduced respiratory mortality associated with Ni and V
- life expectancy changes

Challenges

- complications due to other long-term trends
- sulfur was not the only compound affected
- would benefit from further evaluation of changes in sources, especially regarding Ni and V

Congestion charging scheme (London)

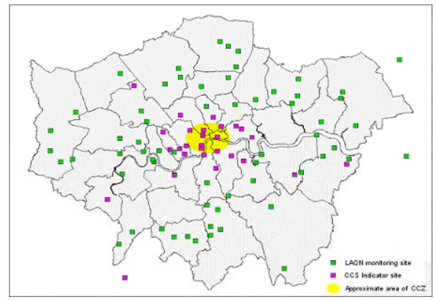
PI: Frank Kelly, King's College London

- implemented in February 2003 to reduce traffic congestion in London's inner city (charge was £5/day, now £8)
  - concomitant increase in public transportation
  - show that traffic reduction has led to pollution reduction
  - also looking at potential changes in pollutant composition
- oxidative properties of PM collected on filters before and after implementation (*in vitro*)
- if pollution reduction evident, follow up with health study:
  - mortality & hospital admissions
  - respiratory and cardiovascular conditions in children and elderly obtained from primary care records

London inner city: original CCZ and western extension

Changes in traffic entering the CCZ during charging hours on a representative selection of major entry points. *Source: Transport for London -- www.cclondon.com*

Greater London air quality monitoring network



Location of long-term continuous pollution monitoring sites within Greater London

London Congestion Charging – findings

- air quality changes very small: PM_{10} and CO levels may have slightly decreased in the zone
- NO_x levels not changed, but NO_2 levels may have slightly increased within the zone
- oxidative potential variable; highest at roadsides, possibly related to brake and tire wear

Challenges

- CCS not designed to reduce pollution
- offset in part by taxi and bus trips
- few data monitoring stations inside the zone; missing data; weather inversion in February 2003
- power to detect changes in health outcomes deemed too low

- calculated potential benefits (based on modeled AQ changes) are presented in Tonne et al. 2008

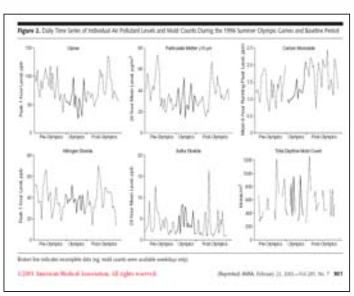
1996 Olympic Games (Atlanta)

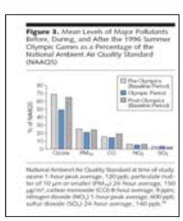
PI: Jennifer Peel, Colorado State University

- efforts to reduce traffic in downtown Atlanta during the Olympic Games
- earlier study showed a decrease in ozone and childhood asthma (Friedman et al, JAMA 2001)
- evaluate emergency department visits for cardio-vascular and respiratory outcomes; also arrhythmic events in patients with ICDs

Atlanta Olympics –

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





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

Atlanta Olympics – some observations

- importance of the time window studied
  - evaluate same period in previous and subsequent years
- importance of looking at a broader geographic area
  - regional weather & air quality
- difficult to study outcomes with small numbers of events and short, temporary intervention
  - ICD data

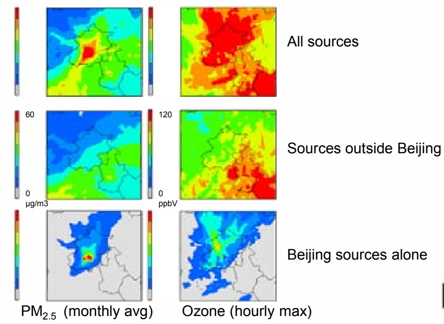
2008 Olympic Games (Beijing)

PI: Jim Zhang, University of Medicine and Dentistry of New Jersey

- reduce emissions from traffic and industrial sources in period leading up to and during Olympic Games
  - changes already started, targeting industry in Beijing area
  - two-tiered approach during the Olympics:
    - (1) keep highly emitting vehicles off the road and restrict operation of high emitting industries (July 25 – September 17)
    - (2) restrict additional vehicles and factories during actual competition (August 8–24)
- follow medical students before, during, and after Olympics to measure blood coagulation and systemic inflammation

Modeled Air Quality in Beijing –
David Streets et al, Atmospheric Environment 41 (2007) 480-492

CMAQ model simulations of $PM_{2.5}$ and ozone concentrations for Beijing, July 2001



Beijing Olympic Games – preliminary findings

- reductions in $PM_{2.5}$, SO_2, and CO, but not O_3
- ~450 deaths and ~7,500 ER visits avoided
- changes in biomarkers of oxidative stress
  - decreased exhaled nitric oxide
- improved vascular function in healthy young people

Challenges

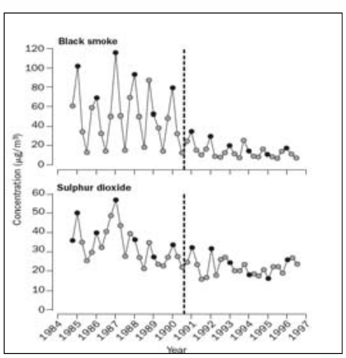
- complicated regional and local actions that started up to a year earlier
- favorable weather, thus unclear to what extent the AQ actions contributed

Coal ban in Irish Cities

PI: Douglas Dockery, Harvard School of Public Health

- based on earlier study showing reduction in black smoke and mortality after a 1990 coal ban in Dublin (Clancy et al, Lancet 2002)
- include 11 other cities: Cork (1995 ban) and 10 other major cities (1998 ban)
- quantify the effect of the ban on coal sales on black smoke and sulfur oxide levels
- total and cause-specific mortality, and cardiovascular and respiratory hospital admissions

Dublin 1990 coal ban (Clancy et al 2002)



Coal ban – preliminary findings

- clear black smoke reductions in Dublin and elsewhere
- reduction of peak concentrations in winter
- SO_2 less affected, some decreases and one increase

Challenges

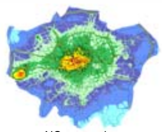
- smaller populations in the additional cities → statistical power issues
- relatively smaller cumulative AQ improvements
- long-term mortality and AQ trends

Low emission zone (London)

PI: Frank Kelly, King's College London

- reduce pollution levels by excluding high emitters, several stages starting February 4, 2008 through 2012
- affects much larger area (Greater London)
- much higher charges
- prospective study: **baseline** assessment
  - pollution levels
  - collect filters for oxidative properties
  - obtain access to primary care data
- improved monitoring network
  - in collaboration with Transport for London

  (http://www.tfl.gov.uk/roadusers/lez/default.aspx)



NO_2 scenario

LEZ implementation plan

Heavier HGV > 12 tonnes	February 2008 January 2012	Euro III for PM Euro IV for PM
Lighter HGV 3.5 – 12 tonnes	July 2008 January 2012	Euro III for PM Euro IV for PM
Buses and coaches > 8 seats and > 5 tonnes	July 2008 January 2012	Euro III for PM Euro IV for PM
Heavier LGV 1.205 – 3.5 tonnes	October 2010 *Postponed until 2012*	Euro III for PM
Minibuses > 8 seats and < 5 tonnes	October 2010 *Postponed until 2012*	Euro III for PM
Private cars, small vans motorcycles	Not included	

HGV = heavy goods vehicles; LGV = light goods vehicles

London Low Emission Zone – findings

- additional monitoring put in place
- access to primary care health data could be worked out
- large variability in oxidative potential of filter samples across London
- filters from roadside locations possibly more toxic; linked to coarse PM / metals (tire and brake wear)

Challenges

- gradual fleet changes in anticipation of the 2008 rule
- less improvement expected with subsequent stages
- uncertainties in AQ modeling at zip code level

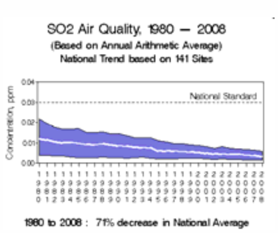
HEI: need air quality data for several more years before designing a health study

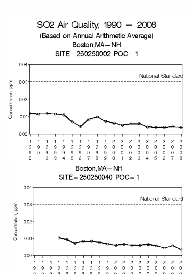
SO_2 from power plants (eastern US)

PI: Richard Morgenstern, Resources for the Future

- reduction of SO_2 emissions from power plants under Title IV of the 1990 Clean Air Act Amendments
  - two phases, targeting largest, dirtiest plants first
- source-by-source analysis of to determine where and when reductions occurred
  - using EPA emissions inventories and transaction data
- source-receptor models to establish relationship between emissions reduction and air quality improvement
  - estimate pollution levels in absence of policies
- study on health effects to be finalized

SO_2 air quality trends (EPA)





source: http://www.epa.gov/air/airtrends/sulfur.html

Morgenstern study – challenges

- complex, multistage modeling
- difficulties collecting data
- estimating impact of missing data:
  - had to relax requirement for inclusion of monitors
- final analyses pending

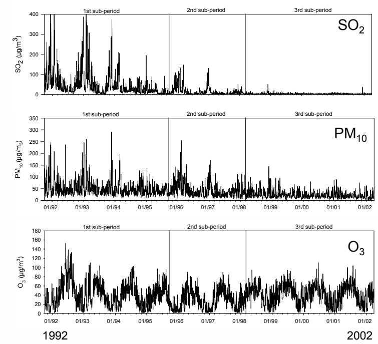
German reunification

PI: Annette Peters, GSF-National Research Center for Environment and Health (HEI Report No. 137)

- conversion from brown coal to natural gas in homes, factories, and power plants
- conversion of cars with two-cycle engines to cars equipped with catalytic converters
  - general increase in traffic, including diesel cars & trucks
- track daily cause-specific mortality in Erfurt at various lagged times with levels of pollutants of interest
- develop methods to track dynamic changes in health risks over time during interventions or source changes (1991–2002)

Time series of air pollutants in Erfurt (1992–2002)

(Peters et al, 2009)



German reunification – findings

- gradual decrease in PM_{10}, $PM_{2.5}$, SO_2, CO
- smaller decreases in NO_2, O_3, ultrafine PM (UFP)
- associations between UFP and mortality, CO and mortality (3 or 4 day lag)
- association between O_3 and mortality (2 day lag)
- time varying coefficient model showed that relative risks were lowest near the end of the study period

Challenges

- small population in Erfurt (200,000 people)
- socioeconomic and demographic changes
- effects of UFP but not PM_{10} / $PM_{2.5}$ unexplained

HEI comment: need to look at distributed lags

(→ Breitner et al, EHP 2009)

Summary and conclusions

- Important to establish AQ improvement before starting a study of health benefits
  - need sufficient exposure contrast
- Flexibility needed to take advantage of new opportunities for prospective studies
  - expand AQ monitoring, if possible
- Influence of weather patterns and other variables
  - sensitivity analyses: time windows, geographic areas
- Even if AQ improvement cannot be tied directly to action, evidence of improved health is still important
- Studies of long-term actions remain underrepresented

Data Sources and Access

A Street Level View From a City Health Department

Tom Matte
HEI Accountability Workshop
December 17, 2009

Overview

- Standardized data
  - Hospital discharge
  - Vital statistics
  - Surveys for covariates
- Near-real-time 'syndromic' surveillance
- Other non-traditional data
- Data access – no simple answers – barriers and levers
- Environmental Public Health Tracking Network

What's available?

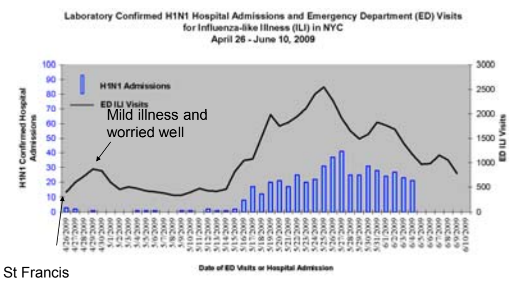
- Geographically resolved rates for prospective accountability studies
  - Available, accessible, and improving.
  - May improve prospective RIA
- Record level health events for retrospective studies – available. Accessibility is a work in progress.

Apr 27, 2009 6:01 am US/Eastern

CONFIRMED: Swine Flu Outbreak At Queens School

Department Of Health Tests Students At St. Francis Prep In Queens, Examine Travel Histories

http://wcbstv.com/health/swine.flu.nyc.2.994071.html



When the public needs to know, data sharing becomes a priority.

Public use data available

Researchers apply for access or data

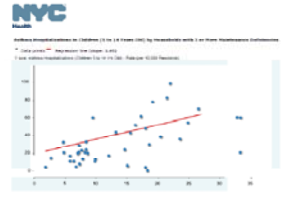
Select an EpiQuery Module:

- Community Health Survey 2008 NEW 2007 2006 2005 2004 UPDATE 2003 2002
- Communicable Disease Surveillance System (CDSS), 2000-2006 UPDATE
- NYC Health and Nutrition Examination Survey, 2004 (NYCHANES)
- Youth Risk Behavior Survey (Odd years from 1997 to 2007) UPDATE
- Vital Statistics Birth Data (2000-2007) UPDATE
- Vital Statistics Death/Mortality Data (2000-2007)
- Vital Statistics Death/Mortality Trend Data (1994-2007) NEW
- World Trade Center Health Registry Baseline Survey (2003-2004)

nyc.gov/health/mycommunityshealth

Environmental Public Health Tracking Program

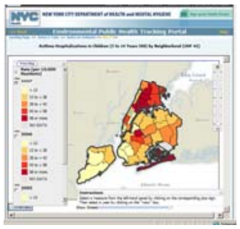
- CDC funded –22 state and one city
- Data linkage
- Public portals
- Common health data
  - Hospital admissions (AMI, Asthma, CO poisoning)
  - Cancer incidence
  - Birth outcomes
  - Childhood lead poisoning
- States, city provide minimally aggregated data for national portal with approval of stewards



Hospital Discharge Records
(NYS added ED in 2005)

- Two data use agreements
  - ‘Identifiable’ –
    - date, xy, EUPIN
    - Can’t be shared outside DUA users and institution
    - Students, fellows, academic investigators can be credentialed as paid or volunteer consultants
  - ‘Non-identifying’ ~ safe harbor:
    - Used for our public portal
    - DUR permits sharing aggregated data with CDC for national portal
  - Similar to SID/SEDD HCUP

Population susceptibility varies.
What about burdens and benefits?



http://nyc.gov/html/doh/html/tracking/tracking.shtml

Confidentiality Criteria Vary

- NYC Vital Statistics query is evaluated using K-anonymity and L-diversity criteria
- NYS hospital discharge data requires < 6 cell suppression
- Data stewards are busy

http://privacy.cs.cmu.edu/people/sweeney/kanonymity.html

http://www.cs.cornell.edu/~mvnak/pubs/ldiversity-icde06.pdf

“The public needs to know”

- 10/06 – provisional data
- 40 hyperthermia deaths (OCME)
- ~100 excess natural cause (OVS)

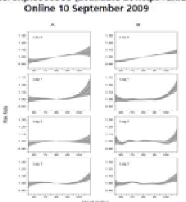
“We need to do a study”

- IRB and DUR 1997-2006 data
- Application process (~9mos) (same as outside request)
- Credentialed academic co-investigator

Summer Heat and Mortality in New York City: How Hot is Too Hot?

Kristina B. Metzger, Kaz Ito, and Thomas D. Matte

doi: 10.1289/ehp.0900906 (available at http://dx.doi.org/) Online 10 September 2009



EPHT secure portal concept for accessing identifiable data

- Central registration and credentialing process
- Provide secure and restricted access via CDC Secure Data Network (same as for State HD’s to provide data to CDC)
- Online analysis, visualization, and reporting tools.
- Collaboration and knowledge management functions
- Intermediary for data requests to participating state and local agencies for approval

Concepts for Shared Data Access

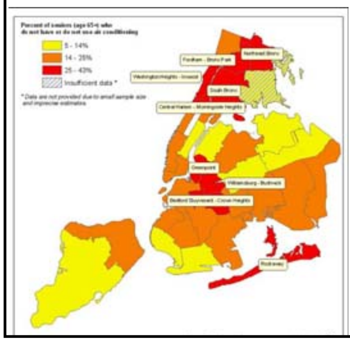
- Central broker (e.g. secure portal, HCUP)
- Investigator works within authorized data user environment (e.g. NCHS, DOHMH)
- State/local standardization of data for remote query by investigators
- Fellow model (e.g. CDC PHP, Informatics fellows)
- State/local health agency role in communication to stakeholders

Behavioral Risk Factor Surveillance System

- **State level**
- **350k adults/yr**
- **Selected MSAs**
- **Core and state added quest**
- **Covariates - Health status and behaviors**

http://www.cdc.gov/brfss/

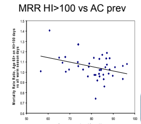
New York City Community Health Survey – 'NYC BRFSS'



- RDD telephone survey, started in 2002
- ~10,000 adults (18+)
- Estimates for UHF neighborhoods, zip with multi-year

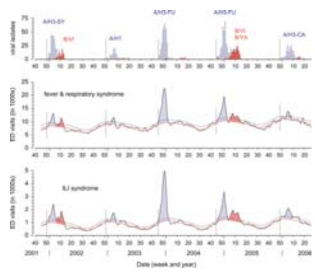
http://nyc.gov/html/doh/html/survey/survey.shtml

MRR HI>100 vs AC prev

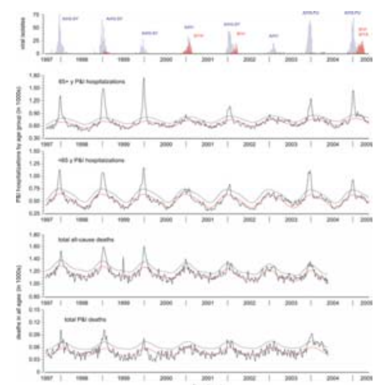


"Syndromic" surveillance: ED visits

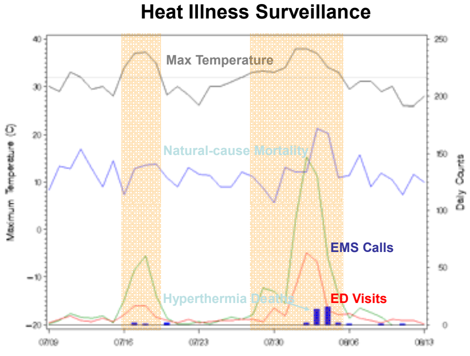
- After 9/11/01, CDC deployed dozens of epidemiologists for 24/7 data collection in selected NYC EDs
- November 2001 – ED logs by fax, email
- Data entry, scanning, text processing
- Syndrome coding algorithms refined
- Now – all electronic reporting, automated analysis, electronic delivery of results (<12h lag)
- Mostly used to track communicable diseases
- Researchers can apply – no public use data



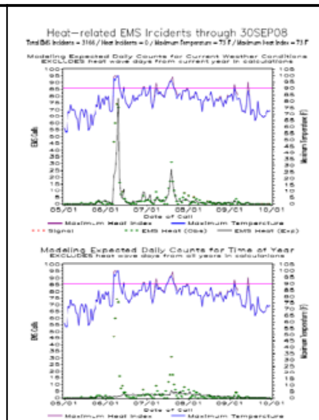
Olson DR, Heffernan RT, Paladini M, Konty K, Weiss D, et al. 2007 Monitoring the Impact of Influenza by Age: Emergency Department Fever and Respiratory Complaint Surveillance in New York City. PLoS Med 4(8): e247. doi:10.1371/journal.pmed.0040247



Heat Illness Surveillance



Summer 2006



Asthma ED syndrome tracks asthma hospital admissions

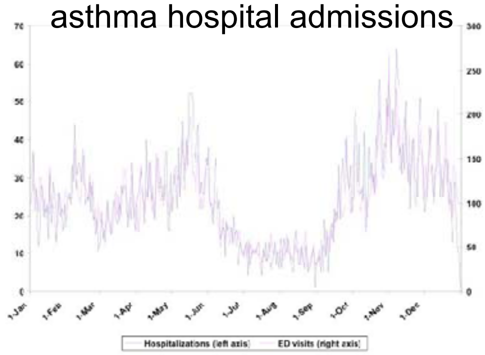
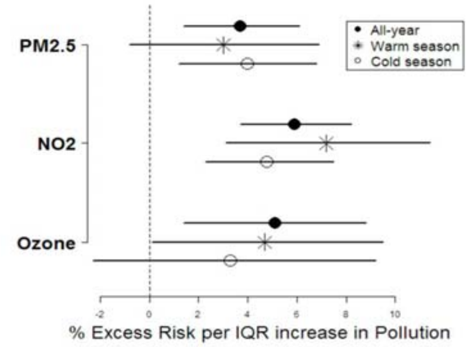
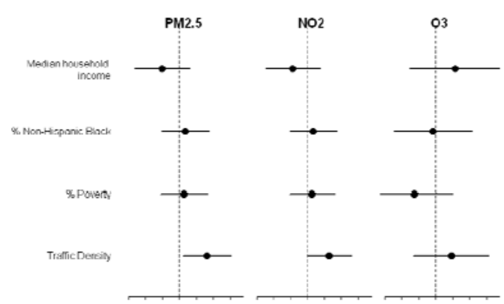


Figure 2. ED asthma syndrome visits and asthma hospitalizations in 2005

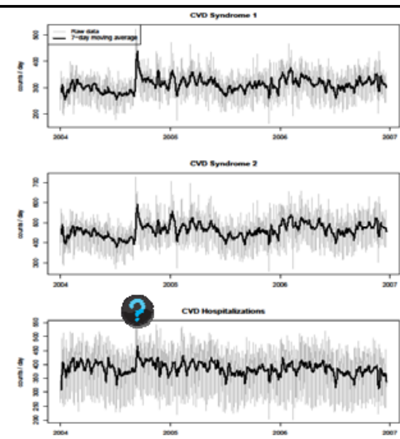
Percent Excess Risk for Citywide Asthma ED Syndromic Illness Counts for Age 5 to 17



Source: Ito et al. ISEE 2009

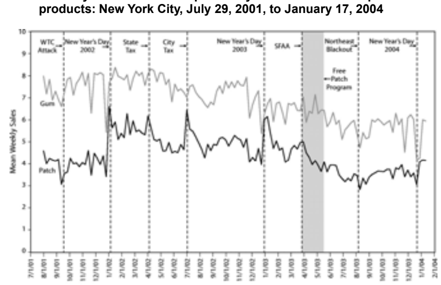


Change in % Excess Risk per 1 S.D. of Effect Modifier
In the second stage regression model of air pollution risk estimates from 115 zip-code areas, estimated traffic intensity was a significant effect modifier for PM2.5 and NO2.

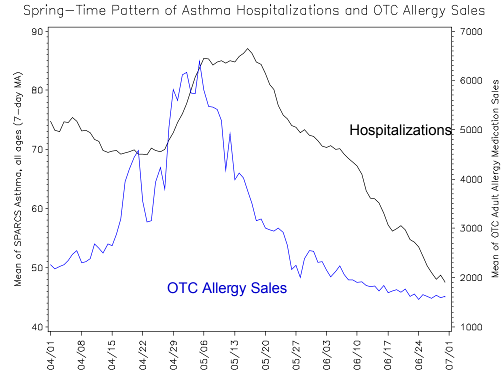


Pharmacy Sales

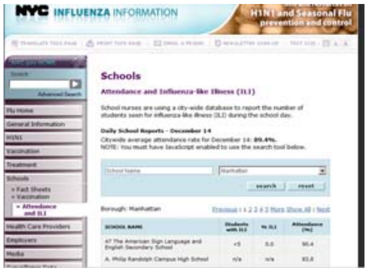
FIGURE 2-- Mean weekly over-the-counter pharmacy sales of nicotine replacement therapy products: New York City, July 29, 2001, to January 17, 2004

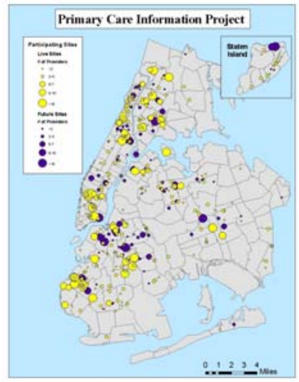


Metzger, K. B. et al. Am J Public Health 2005;95:1050-1055



School attendance and school nurse visits





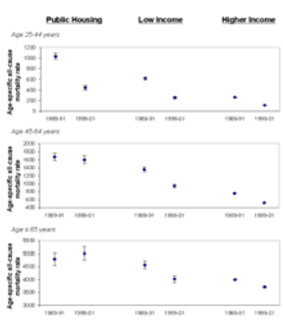
Data for future accountability studies?

DOHMH

Near Real Time Surveillance ↑ E H R ↓ Decision support

Providers

Secular Changes in Mortality Disparities in New York City: A Reexamination



- During 1990s, mortality fell, life expectancy increased
- Gap narrowed between low and higher income neighborhoods
- ?gentrification or healthy migrant
- Improvement not seen in public housing population

Althoff et al. Journal of Urban Health 2009;86:729-44

Conclusions

- One stop access to identifiable traditional data sources (vital statistics, hospital admissions) is still a work in progress
- These may help:
  - Show that the public has a stake
  - Feedback locally-relevant information
  - High level leadership
- State and local data sources are rapidly evolving
- Near-real time surveillance for non-communicable conditions shows some promise

Accountability studies: exposure contrasts

Bert Brunekreef, PhD
Institute for Risk Assessment Sciences
University of Utrecht, Netherlands

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The HEI solution to vehicular pollution

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HEI's Research Program on the Impact of Actions to Improve Air Quality: Interim Evaluation and Future Directions

Annemoon M. van Erp and Aaron J. Cohen

ing on such challenging research. Any intervention that does not produce a sizeable change—of at least a factor of 1.5 to 2—in air pollutant concentrations can hardly be expected to show evidence of improved health outcomes. Such exposure contrasts are usually taken into consideration when deciding whether epidemiologic research of air pollution and health is worth the effort; these kinds of considerations should be equally applied to accountability research.

HEI Communication 14 — SEPTEMBER 2009 — HEALTH EFFECTS INSTITUTE

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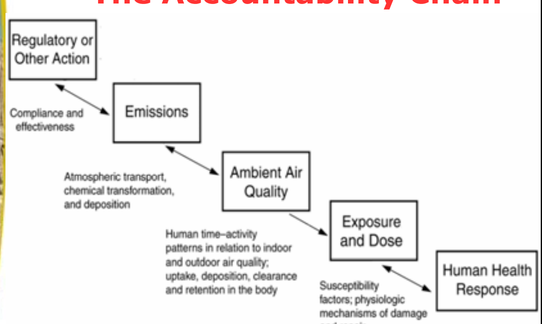
The Accountability Chain



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An evaluation of the indoor air quality in bars before and after a smoking ban in Austin, Texas

MICHAEL S. WARING AND JEFFREY A. SIEGEL

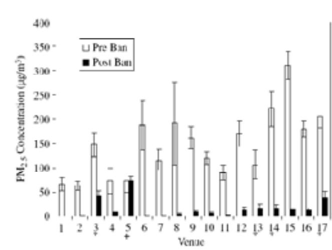

Figure 1. Best estimate pre- and post-ban $PM_{2.5}$ concentrations for all venues: *indicates occupant non-compliance and +indicates venues exempt from the ordinance.

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The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Smoke-free Legislation and Hospitalizations for Acute Coronary Syndrome

Jill P. Pell, M.D., Sally Haw, B.Sc., Stuart Cobbe, M.D., David E. Newby, Ph.D., Alastair C.H. Pell, M.D., Colin Fischbacher, M.B., Ch.B., Alex McConnachie, Ph.D., Stuart Pringle, M.D., David Murdoch, M.B., Ch.B., Frank Dunn, M.D., Keith Oldroyd, M.D., Paul MacIntyre, M.D., Brian O'Rourke, M.D., and William Borland, B.Sc.

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SMOKE-FREE LEGISLATION AND HOSPITALIZATIONS FOR ACUTE CORONARY SYNDROME

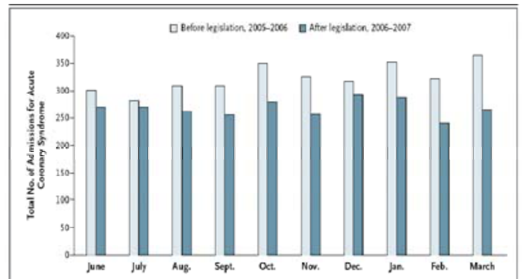

Figure 1. Admissions for Acute Coronary Syndrome According to Month before and after Smoke-free Legislation.

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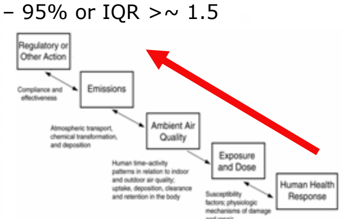
Reversing the chain…

- Epidemiological studies need power
- Power comes from study size *& exposure contrast*
- Typically, range in concentrations factor >~ 2, range in 5 – 95% or IQR >~ 1.5



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What was found? (1)

- Noonan: 70-75% decrease in indoor PM2.5 (woodstoves)
- Wong: ~50% decrease in SO2 but not PM (Hong Kong fuel sulfur)
- Kelly: very small changes in NOx, PM, CO, oxidative potential (London CCZ)
- Peel: ozone reductions not associated with Olympic traffic measures (Atlanta)

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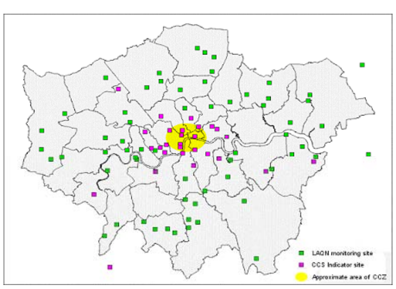
Greater London air quality monitoring network



Location of long-term continuous pollution monitoring sites within Greater London

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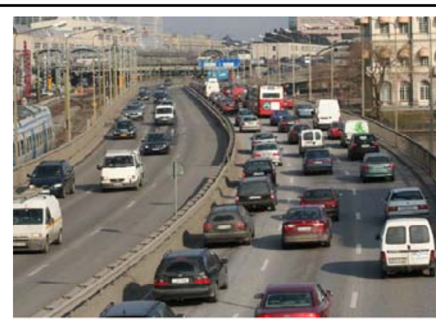

Facts and results from the Stockholm Trials

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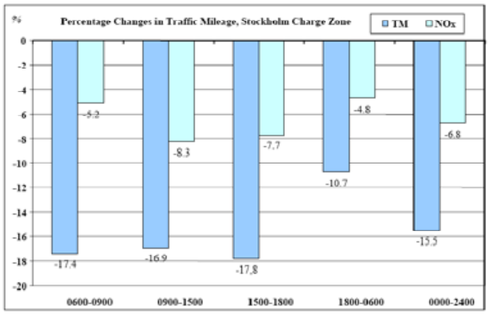

Figure S2 Percentage changes in NO_x emissions compared with changes in traffic.

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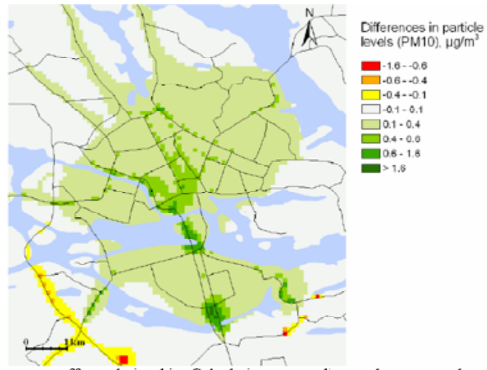

higher cause-effect relationship. Calculations, according to these research findings, demonstrate that up to 25-30 premature deaths can be prevented per year. This corresponds to about 300 life years.

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What was found? (2)

- Zhang: 40-60% decreases in AP during Beijing Olympics, not yet clear to what extent due to policy measures
- Dockery: 45-70% reductions in BS (Irish coal ban studies)
- Kelly: 3 µg/m³ decrease in NO_2, 0.75 µg/m³ decrease in PM10 predicted (LEZ)
- Morgenstern: changes in ambient PM2.5 due to 1990 clean air act
- Peters: large SO_2 reduction, 50% PM reduction (German Reunification)

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Science of the Total Environment

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

Yi Li[a], Wen Wang[b], Haidong Kan[c,*], Xiaohui Xu[d], Bingheng Chen[c]

Periods[b]	Asthma events (/day)	$PM_{2.5}$ ($\mu g/m^3$)	O_3 (ppb)
Baseline period	12.5	78.8	65.8
Pre-Olympic period	16.5	72.3	74.6
Olympic period	7.3	46.7	61.0

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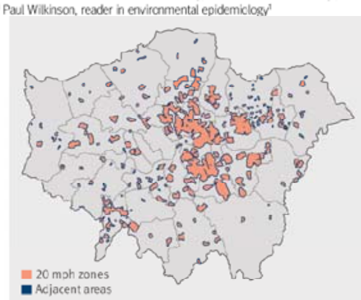
Effect of 20 mph traffic speed zones on road injuries in London, 1986-2006: controlled interrupted time series analysis

Chris Grundy, lecturer in geographical information systems,[1] Rebecca Steinbach, research fellow,[1] Phil Edwards, senior lecturer in statistics,[2] Judith Green, reader in sociology of health,[1] Ben Armstrong, professor of epidemiological statistics,[1] Paul Wilkinson, reader in environmental epidemiology[1]

BMJ 2009



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Chris Grundy, lecturer in geographical information systems,[1] Rebecca Steinbach, research fellow,[1] Phil Edwards, senior lecturer in statistics,[2] Judith Green, reader in sociology of health,[1] Ben Armstrong, professor of epidemiological statistics,[1] Paul Wilkinson, reader in environmental epidemiology[1]

	Per cent reduction (95% CI) after introduction of 20 mph zones	
	In 20 mph zones	Adjacent areas
Casualties:		
All casualties	41.9 (36.0 to 47.8)	8.0 (4.4 to 11.5)
All casualties (0-15 years)	48.5 (41.9 to 55.0)	9.7 (4.5 to 14.9)
KSI*	46.3 (38.6 to 54.1)	7.9 (2.2 to 13.5)
KSI* (0-15 years)	50.2 (37.2 to 63.2)	5.4 (−8.1 to 18.8)

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Effect of Air Pollution Control on Mortality in County Cork, Ireland

David Q. Rich,[1] Prethibha George,[1] Patrick G. Goodman,[2] Pamela Ohman-Strickland,[1] Luke Clancy,[3] Tania Kotlov,[4] Douglas W. Dockery[4]

Ban Year - City	Black Smoke (ug/m³) Pre Mean	Post Mean	Reduction	(%)
1990				
Dublin	50.4	15.0	-35.1	(-70%)
1995				
Cork	33.7	17.2	-21.6	(-49%)
1998				
Arklow	40.0	18.4	-21.6	(-54%)
Wexford	37.7			
Limerick	27.1	12.5	-14.6	(-54%)
Dundalk	23.0	11.9	-11.1	(-48%)
Drogheda	24.0	9.3	-14.8	(-61%)

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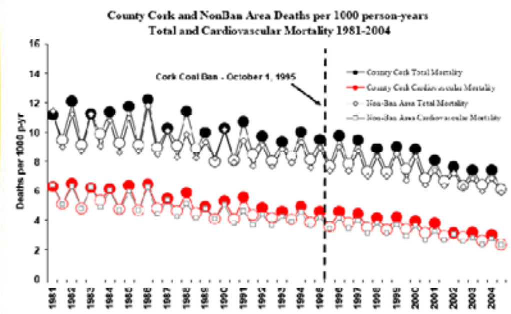

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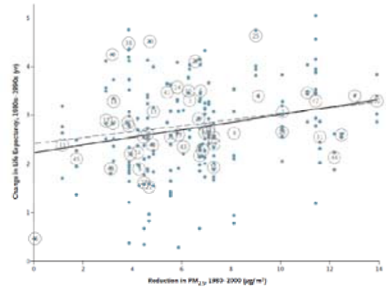
Life expectancy increases in the US are associated with decreases in air pollution



NEJM 2009

Figure 4. Changes in Life Expectancy for the 1980s–1990s, Plotted against Reductions in $PM_{2.5}$ Concentrations for 1980–2000.

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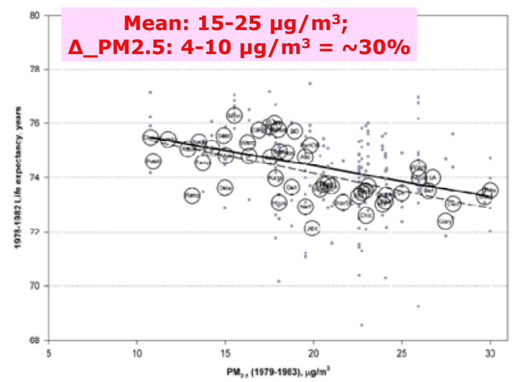
Mean: 15-25 μg/m³;
Δ_PM2.5: 4-10 μg/m³ = ~30%



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RESEARCH REPORT

The Influence of Improved Air Quality on Mortality Risks in Erfurt, Germany

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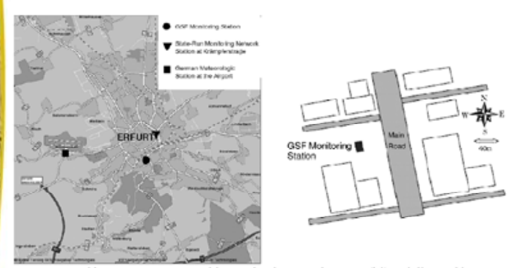

Figure 2. Locations of the two air monitoring stations and the meteorological station in Erfurt, Germany (left). Detail of location of the GSF monitoring station (right).

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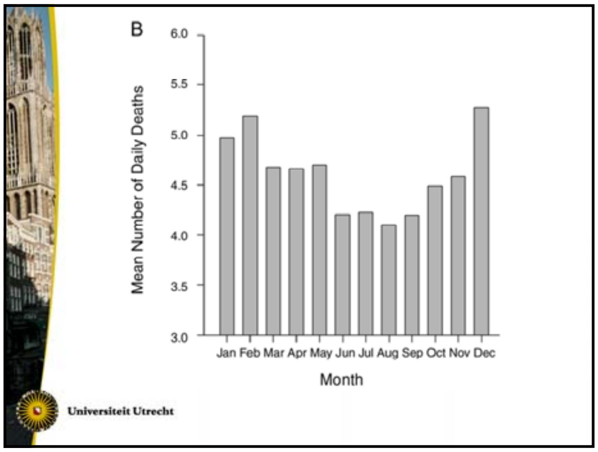
B
Mean Number of Daily Deaths
6.0
5.5
5.0
4.5
4.0
3.5
3.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
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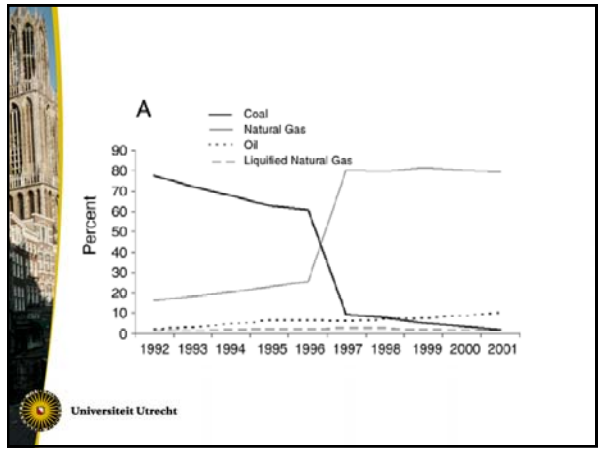
A
Coal
Natural Gas
Oil
Liquified Natural Gas
Percent
90
80
70
60
50
40
30
20
10
0
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
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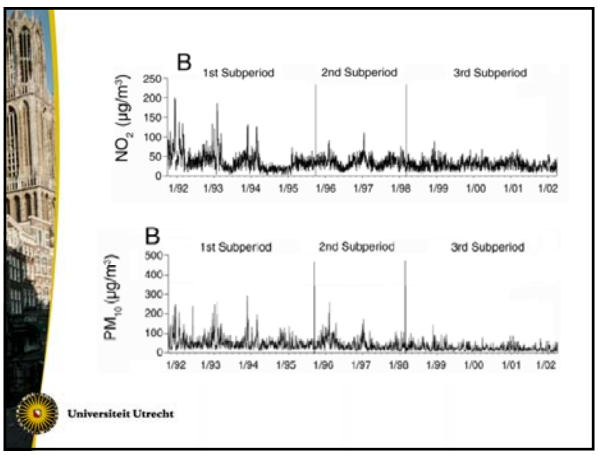
B
1st Subperiod
2nd Subperiod
3rd Subperiod
NO_2 (µg/m³)
250
200
150
100
50
0
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01 1/02
B
1st Subperiod
2nd Subperiod
3rd Subperiod
PM_{10} (µg/m³)
500
400
300
200
100
0
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01 1/02
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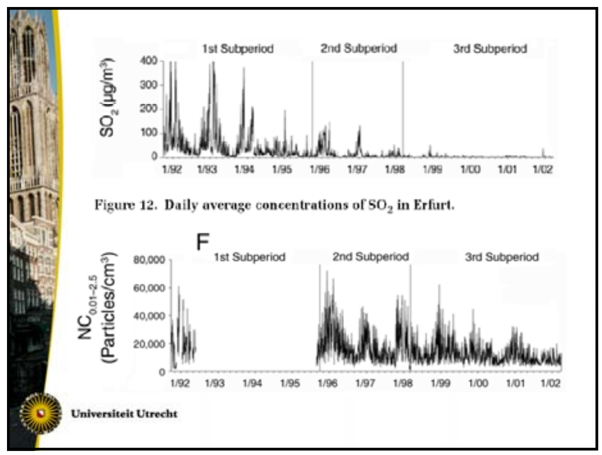
1st Subperiod
2nd Subperiod
3rd Subperiod
SO_2 (µg/m³)
400
300
200
100
0
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01 1/02
Figure 12. Daily average concentrations of SO_2 in Erfurt.
F
1st Subperiod
2nd Subperiod
3rd Subperiod
$NC_{0.01-2.5}$ (Particles/cm³)
80,000
60,000
40,000
20,000
0
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01 1/02
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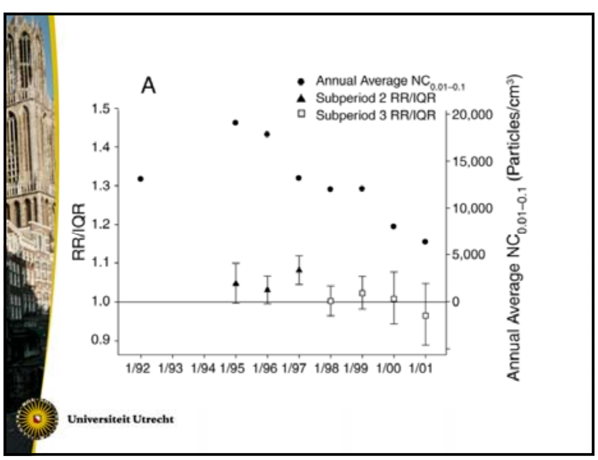
A
Annual Average $NC_{0.01-0.1}$
Subperiod 2 RR/IQR
Subperiod 3 RR/IQR
RR/IQR
1.5
1.4
1.3
1.2
1.1
1.0
0.9
20,000
15,000
10,000
5,000
0
Annual Average $NC_{0.01-0.1}$ (Particles/cm³)
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01
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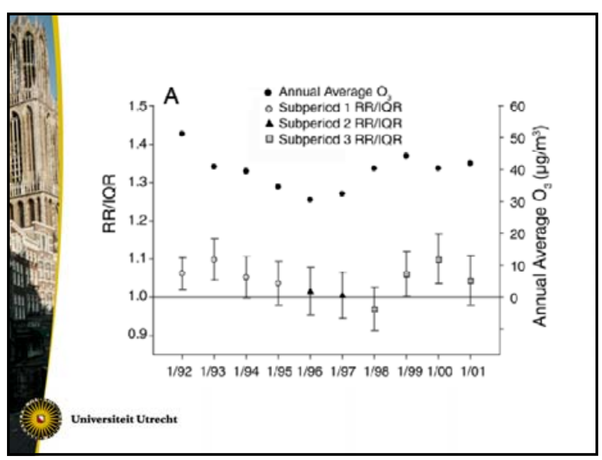
A
Annual Average O_3
Subperiod 1 RR/IQR
Subperiod 2 RR/IQR
Subperiod 3 RR/IQR
RR/IQR
1.5
1.4
1.3
1.2
1.1
1.0
0.9
60
50
40
30
20
10
0
Annual Average O_3 (µg/m³)
1/92 1/93 1/94 1/95 1/96 1/97 1/98 1/99 1/00 1/01
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Table 29. Summary of Key Findings

Pollutant	More Than Twofold Decrease[a]	Overall Effect on Mortality	Subperiod with Effects on Mortality[b]
NO_2[c]	No	At lag day 3 to 4	Transition period, 1995–1997
CO	Yes	At lag day 3 to 4	Transition period, 1995–1997
Ultrafine particles	No	At lag day 3 to 4	Transition period, 1995–1997
$PM_{2.5}$	Yes	No	Transition period, 1995–1997
PM_{10}	Yes	No	Transition period, 1995–1997
SO_2	Yes	No	Transition period, 1995–1997
O_3	No	At lag day 2	Subperiods 1 and 3

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Dutch Accountability studies (1)

- Busy roads in Amsterdam, The Hague, Utrecht, Tilburg, The Hague
- Background locations in same city/region
- Traffic measures planned to comply with EU regulations for PM10
- Health measurements in subjects living at street & background locations before & after implementation (symptom questionnaire, spirometry, eNO)

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Dutch Accountability studies (2)

Location	Participants
Amsterdam road 1	66
Amsterdam road 2	36
Bussum background	50
Tilburg road	94
Den Bosch road 1	31
Den Bosch road 2	60
Oisterwijk background	96
Den Haag road 1	37
Den Haag road 2	15
Voorschoten background	54
Utrecht road 1	70
Utrecht road 2	14
Bilthoven background	124
TOTAL	747

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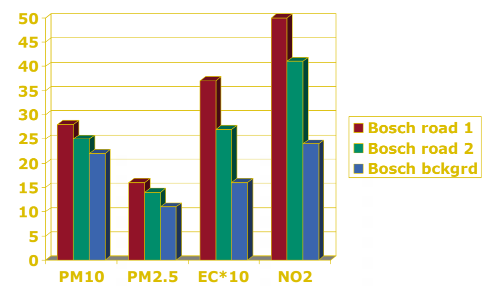
Dutch Accountability studies (3)



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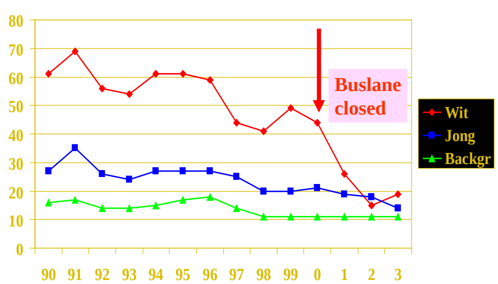
Black Smoke in Utrecht



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Observations (1)

- Pollution reductions *as result of regulatory actions* in HEI accountability studies range from very small to well over 50%
- Not surprising some studies have difficulty documenting health benefits
- Traffic studies (e.g., CCS, LEZ) may need other metrics than PM, NOx and other than area-wide health studies
- Studies from other domains (e.g., smoking bans) lend support to expecting public health benefits from regulatory action to reduce air pollution

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Observations (2)

- Great potential for supporting causality esp. in studies of temporary changes (Olympics, factory closings etc.)
- Health effects of large-scale pollution reductions only observable in large populations over long periods of time: potential for confounding by secular trends
- Lack of power $\neq$ lack of effect!

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Accountability Assessment of Long-Term Regulatory Action Warm Season O_3 and Cardiac Mortality

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Mark van der Laan, Ph.D.; Division of Biostatistics

A Pilot Study to Quantify the Health Benefits of Incremental Improvements in Air Quality—*CARB, 2002 RFA*

- CARB issues an RFA to evaluate health effects of improved air pollution in Southern CA
- Investigate the feasibility of relating health changes in residents to air quality improvements in the South Coast Air Basin (SoCAB)
- Issues for Design
  - Biggest concern was temporal trends
    - Air pollutants
    - Demography
    - Changes in health care practices
    - Changes in smoking

Thoughts About "Long-Term" In the Context of Time and Study Design for Accountability Studies

Study Design	Level of Design	"Long-term"
1. Time series	Ecologic	Change in or departure from expected trend
2. Cohort	Individual	Hazard, YLL, CI
3. Cross-sectional across populations	Ecologic Individual	Cumulative exposure
4. *Cross-sectional serial w/in populations*	Ecologic Individual	Combination of 1 & 3 above

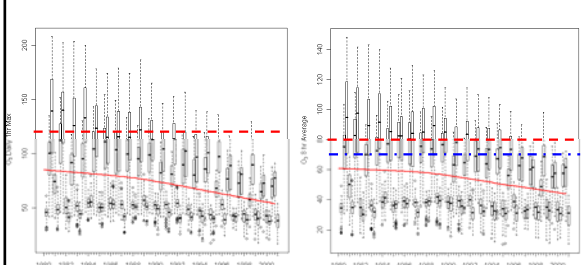
Concerns That Time Poses for "Long-Term" Accountability Studies

Study Design	Level of Design	Confounders Other
1. Time series	Ecologic	weather (w), trend ((t)-health outcomes, care, habits, environ. demography)
2. Cohort	Individual	w, t, individual, censor
3. Cross-sectional across populations	Ecologic Individual	"Survival", non-exchangeability of people and exposure
4. Cross-sectional serial w/in Pop.	Ecologic Individual	Combination of 1 & 3 above

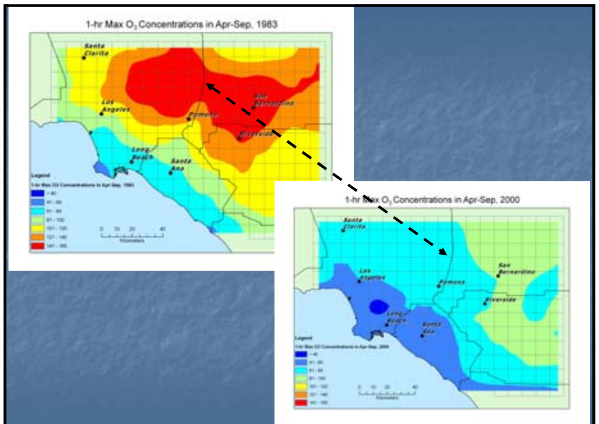
Focus on South Coast Air Basin

- 195 of 200 10x10 km grids used

Time Trends for Ozone by Quarter from 1980 - 2001



Same trends seen for CO and NO_2



Processing of Data

- Air pollutants
  - Monthly averages → quarterly averages
    - Initially chose 1-hr maximum O_3, since it was the standard for most years of the study period
      - Correlation with 8-maximum = 0.99
  - Assigned to grids by inverse distance weighting to grid centroid based on 4 nearest monitors within 50 km
    - 86% <25 km; 13% with monitor in grid
    - Results similar to those based on kreiging

Categories of the Grid and Quarter-Specific 54 Covariates

- Demographic
  - Race
  - Education
  - Income
  - Employment
  - % time at current residence in past 5 years
  - Country of birth (state, if U.S.)
  - Number of persons/household
  - % above poverty
  - Previous quarter proportion of cardiac deaths

Categories of the Grid and Quarter-Specific 54 Covariates

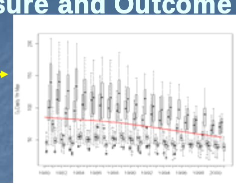
- Air Pollutants
  - Previous year 24-hour average CO, NO_2, PM_{10}, SO_2
- Meteorologic
  - Relative humidity
    - Quarterly average and previous year annual average
  - Temperature
    - Quarterly average and previous year annual average
- Time
  - Quarter number
  - Year

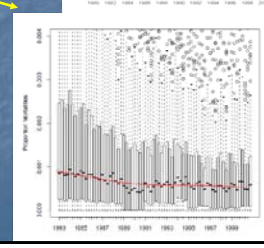
Selected Demographic Variables, Ages >55 years, 1983-2000

Variables	Grid Med (IQR)
Total Population (N)	
Males (46.8%, 38.1-100.0)	989,000 (938,000-1,049,000)
Females (53.2%, 0.0 – 61.9)	1,285,000 (1,229,000-1,350,000)
Race (%)	
Hispanic	15.3 (9.6-24.7)
White	74.6 (60.3-83.2)
African American	2 (1-5)
Asian	3 (1-7)
Born in California (%)	51 (46-57)
Foreign Born (%)	34 (29-40)
Residence in Same House 5 Years Prior (%)	44 (37-50)
Below Poverty Level (%)	10 (6-13)

Specification of Exposure and Outcome

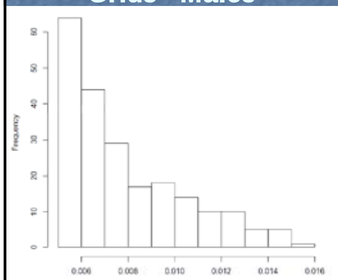
- Grid-specific quarterly mean O_3 for months April-June (q 2) and July-Sept. (q3)
- Male Mortality expressed as grid-specific % of eligible population
  - Progressive decline over time as expected



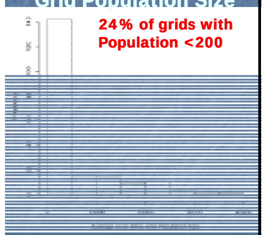


Number of Males/Qtr
Median 968,879
IQR 914,688 – 1,039,471
Range 864,740 – 1,101,659

Population Proportion of Cardiac Mortality By Grids--Males



Distribution of Average Grid Population Size



Statistical Analysis

- How data structured

$$O = \overline{W}(71), \overline{A}(71), \overline{Y}(72)$$

- Where:
  - *W bar* = history of confounders
  - *A bar* = history of O_3 exposure
  - *Y bar* = history of cardiac mortality over the 36 quarters of time
- Time Ordering
  - Investigate A(t-1) on Y(t), but both measured in same quarter
    - We assume that a given exposure precedes outcome
      - Use of monthly means to maximize the assumption
      - Use of previous quarter creates exposure problems
    - Assume most of O_3 population effect would be over a single quarter

Statistical Analysis

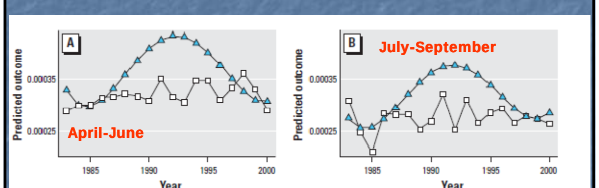
- Assumption about spatial correlations between grids
  - Assumption that each spatial unit is a random variable, O_i – (i =1, ... 195), each with distribution, P_i
    - Thus, we do not assume that each unit was sampled from one common distribution
      - –i.e., assume each unit sampled from *n* distinct distributions, P_i, that may be similar for units close spatially
    - Therefore, model observed data with average distribution

$$P = \frac{1}{n}\sum_{i=1}^{n} P_i$$

Statistical Analysis

- Methods
  - Traditional regression—gives conditional effect estimate (i.e., stratum-specific)
  - History restricted marginal structural models—gives population effect estimate
    - Permits specification of time interval over which the history of exposure is considered
    - Has a causal interpretation
  - Flexible model fitting with deletion-substitution-addition algorithm (DSA)
    - Based on multiple cross-validation and minimization between observed minus expected values for proportion cardiac mortality based on model

Control for Temporal Confounding Asthma Hospital Discharges
Moore, *et al.* EHP 2008



Predicted Proportions of Quarterly Hospital Discharges for Population 0-19 Year With Asthma

△ Model with only time (up to 3rd order polynomial)

☐ Model with time and demographic variables

Some Results

- Conventional regression with adjustment for confounders and repeated measures showed only + association between quarterly 1-hr max [O_3] and ↑ cardiac mortality
  - Included multiple interaction terms with race, temperature, relative humidity
  - Due to interactions, marginal estimates not obtained

History Restricted MSM Based on Continuous O_3

Model with Interaction	Gcomp (p-value)
Intercept	6.41e-04 (0.022)
a(t-1)	6.99e-06 (0.004)
t	-3.52e-06 (0.141)
a(t-1)*t	-5.93e-08 (5e-04)

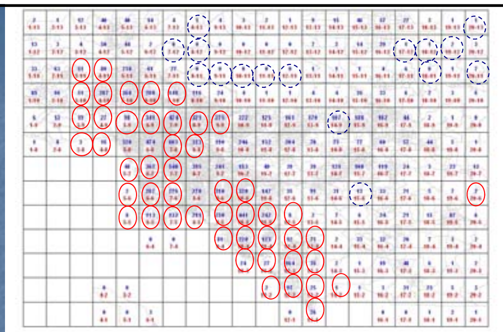
From MSM With Continuous Ozone

Estimated Effect On O_3-*Related* Mortality Reduction If, Contrary to Fact, All Grids Had a 1 ppb Decrease in O_3

Quarter 1 ≅ 6.9 deaths/10^6 population

Quarter 35 ≅ 4.9 deaths/10^6 population

Quarter 70 ≅ 2.8 deaths/10^6 population



2000 Gridded Block Group Population (thousands) with Grid X-Y values

DISTRIBUTION OF GRIDS HAVING:

- ≤50% probability of quarterly 1-hour max $[O_3]$ > 80 ppb (red circles)
- less than 70 ppb (blue circles)

Statistical Analysis "Realistic MSM"

- When the experimental treatment assignment assumption (ETA) is violated, "usual" MSMs cannot be estimated reliably
  - Neither can estimates from other regression techniques
  - I.E., we cannot learn anything from a unit of observation that cannot experience a hypothetical intervention based on the characteristics of that unit
    - i.e., the intervention is "unrealistic"
- Dichotomize the exposure distribution
  - In our case, we use:
    - Current maximum 8-hr ozone standard (80 ppb)
    - Proposed EPA standard (75 ppb)
    - Standard proposed by CASAC (70 ppb)

Statistical Analysis "Realistic MSM"--Solution

- Treatment Rules
  - Set intervention being above the standard, if $P(O_3 > std \mid grid\ covariates) > \alpha(0.1) = 1$; otherwise = 0
  - Set being below the standard if $P(O_3 < std \mid grid\ covariates) > \alpha(0.1) = 1$; otherwise = 0
- Where α is a probability above which the intervention is considered "realistic" based on the covariate pattern of each spatial unit
  - No formalism as yet for choice of α
    - Trade off between bias and variance
- Estimation includes units that cannot receive either intervention in estimation of mean and variance
  - Shrinks estimate of the mean and accounts for variance

Distribution of Grids that Have a Very Low Probability to Move from "High" O_3 Concentrations to "Low" Concentrations Based on Various Quarterly Average 1-hour O_3 Concentration Cut-points

	Proposed Cut-Point	
	90 ppb	110 ppb
Number (%) of grids > cut-point ("high")	3319 (47)	1178 (26)
75th %tile for grids below cut-point ("low")	89.9 ppb	92.5 ppb
% of grids above cut-points that have a $p(O_3$ < the 75th %tile of "low" grids, given covariates) $<\alpha=0.1$	65	61

More Results: 1-Hr Max. Warm Season Maximum O_3-Male Mortality 1983-2000

- Due to violation of the ETA with continuous O_3, used HRMSM and realistic model with cut-points

MSM Model	Coefficients (SE) 75 ppb Cut-point
HRMSM	
Intercept	$5.5*10^{-4}$ ($6.0*10^{-4}$)
1. Quarter (t-1) 1-hr max O_3	$1.1*10^{-3}$ ($6.2*10^{-4}$)
2. Quarter Number	$1.8*10^{-6}$ ($1.2*10^{-5}$)
Interaction 1 & 2	$-1.7*10^{-5}$ ($1.2*10^{-5}$)
"Realistic"	
Intercept	$1.6*10^{-3}$ ($2.4*10^{-4}$)
1. Quarter (t-1) 1-hr max O_3	$-9.0*10^{-7}$ ($2.1*10^{-4}$)
2. Quarter Number	$-1.7*10^{-5}$ ($3.7*10^{-6}$)
Interaction 1 & 2	$2.2*10^{-6}$ ($3.6*10^{-6}$)

More Results: 8-Hr Max Warm Season Maximum O_3-Male Mortality 1991-2000

MSM Model	Coefficients (SE) 75 ppb Cut-point
HRMSM	
Intercept	$8.5*10^{-4}$ ($1.8*10^{-4}$)
1. Quarter (t-1) 1-hr max O_3	*$9.7*10^{-4}$ ($2.8*10^{-3}$)*
2. Quarter Number	$-2.0*10^{-6}$ ($3.2*10^{-6}$)
Interaction 1 & 2	*$-1.5*10^{-5}$ ($5.6*10^{-6}$)*
"Realistic"	
Intercept	$8.7*10^{-4}$ ($1.8*10^{-4}$)
1. Quarter (t-1) 1-hr max O_3	*$1.0*10^{-3}$ ($3.1*10^{-4}$)*
2. Quarter Number	$-2.4*10^{-6}$ ($3.1*10^{-6}$)
Interaction 1 & 2	*$-1.7*10^{-5}$ ($5.3*10^{-6}$)*

Estimated Percentage Reduction in Male Cardiac Mortality Based on 8-Hr Max O_3 Concentrations, 1991-2000 Selected Quarters—75 ppb Cut-point

Year/Qtr	% of Grids with low Probability of Going Below 75 ppb	% ↓ Mortality If All Grids Could Be Set Below 75 ppp	Attributable Population Mortality (%) – PIM
1991 / 2	4.6	37.7	10.5
1991 / 3	3.1	36.8	28.8
1994 / 2	28.7	26.5	11.5
1994 / 3	12.8	25.4	15.8
1998 / 2	90.3	1.1	0.0
1998 / 3	32.8	-1.3	0.0
2000 / 2	74.4	--**	0.0
2000 / 3	61.5	--**	0.0

Summary and Conclusions

- Estimates of population-level effects of 1- and 8-hour maximum ozone on cardiac mortality are decreased over time
  - Results very sensitive to choice of model and metric of population exposure
- Population estimates based on continuous data and "traditional" regression methods not:
  - Estimable due to multiple interactions between ozone and other variables
  - Valid due to violation of the experimental treatment assignment (positivity) assumption

Summary and Conclusions

- Estimates of changes in population burden need to take into account how likely it is for a given spatial unit to achieve a target concentration of pollutant over some fixed period of time
  - Typical measures of attributable risk over-estimate burden due to—
    - Inclusion of areas/populations that cannot achieve target level
    - Failure to account for accelerated outcomes that would have occurred at later time, if intervention would not have taken place
      - Is not the same as harvesting in short-term time-series studies

Statistical Methods for Accountability Research

Francesca Dominici

December 17 2009

Accountability Assessment of Long Long-Regulatory Action Warm Season O3 and Cardiac Mortality (Tager et al)

- Estimated time trend for ozone (1983-2001) for every grid cell (195 cells of 10x10 km)
- Estimated time trend for several demographic variables (54 variables) for every grid cell (use linear interpolation)
- Exposure: previous year average CO, NO_2, PM_{10}, SO_2
- Regression modeling: estimating the effect of historic exposure to ozone on the history of cardiac mortality (main assumption: all areas could experience all levels of ozone)
- Marginal Structural Models for estimating the effect of population-level intervention (counterfactual arguments)
- Data-adaptive algorithm to identify exposures and confounders

Challenges

- Why doing the analysis by grids?
  - 24% of the grids have population smaller than 200
  - Instability in the estimated trends by grid
  - Instability in the estimation of the mortality rates
  - Instability in the estimated trends of the confounders
- How about restricting the analysis to the most highly populated areas surrounding the monitoring stations (approx 40 monitoring stations)
- Temporal confounding is always an issue, results are highly sensitive to temporal confounding
- MSM as an elegant way of evaluating the assumptions about counterfactuals
- However results are model and metric dependent, conventional regression methods give biased results

Scientific Questions in Accountability Research

- **Are short-term effects of PM on mortality from time series studies declining over time?**
- **Are recent declines in air pollution concentrations leading to improved life expectancy in the United States?**

Assessing the Public Health Impact of the Air Quality Regulations

American Journal of Epidemiology
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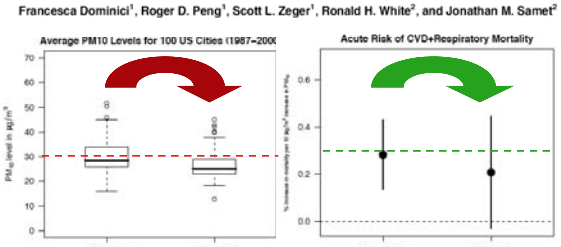
Original Contribution

Particulate Air Pollution and Mortality in the United States: Did the Risks Change from 1987 to 2000?

Francesca Dominici[1], Roger D. Peng[1], Scott L. Zeger[1], Ronald H. White[2], and Jonathan M. Samet[2]



Estimate local and national long-term trends in air pollution

- **Hierarchical spatial time series model for ambient air pollution concentrations**

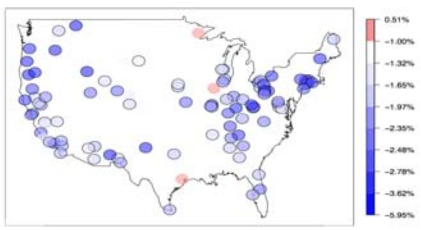
$$x_t^{cm} = \mu_t + \delta_t^c + \varepsilon_t^{cm}$$

(average) national trend → μ_t

Observed air pollution level on day "t" in monitor "m" within county "c" → x_t^{cm}

County specific trend → δ_t^c

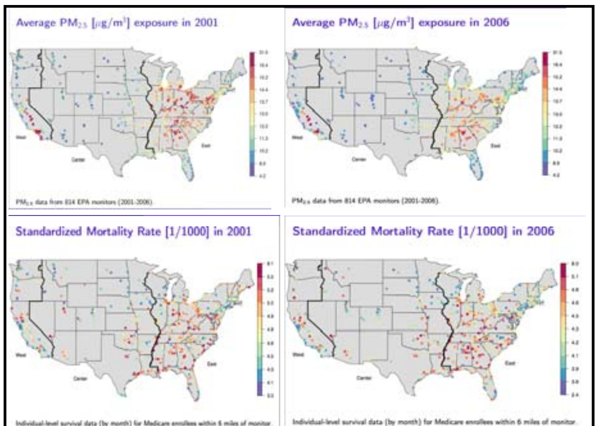
Map of 100 US counties: The color scale is proportional to the yearly percentage change in PM_{10} levels during the period 1987-2007. The bold outlines denote declines that are statistically significant.



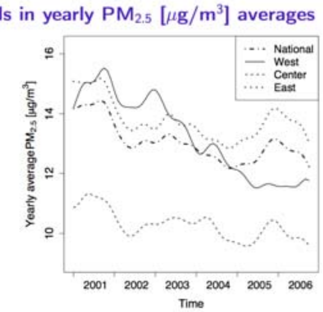
On average across the 100 counties, PM_{10} decreases yearly by 2.2%. The PM_{10} has been decreasing in 97 of the 100 counties studied

Question:
Are recent declines in air pollution concentrations leading to improved life expectancy in the United States?

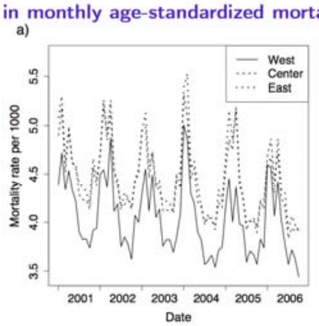
Confounding:
When assessing the association, how best to avoid common sources of confounding in air pollution studies?



Trends in yearly $PM_{2.5}$ [$\mu g/m^3$] averages



Trends in monthly age-standardized mortality rates



Spatio-Temporal Information and Confounding

Decompose the evidence (Janes, Dominici & Zeger, Epidemiology, 2007):

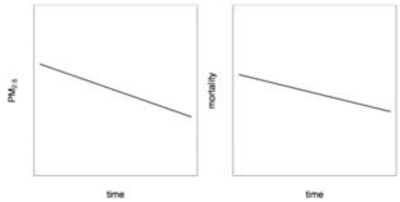
$$\log E(Y^c_{at}) = \log(N^c_{at}) + \log(h^c(a)) + \overline{PM_t}\beta_1 + (PM^c_t - \overline{PM_t})\beta_2,$$

with $\overline{PM_t}$ the national average $PM_{2.5}$ at time t (from complete time series).

This approach

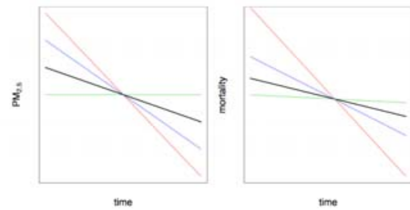
- Does not use purely spatial information: differences in $PM_{2.5}$ levels between locations absorbed by location intercept → no cross-sectional confounding.
- Decomposes remaining information into purely temporal (β_1) and residual spatio-temporal (β_2) → might be differently affected by confounding.

Interpretation of β_1 - National Trends



Are $PM_{2.5}$ and mortality declining in parallel nationally?

Interpretation of β_2 - Local Deviations



Is the decrease in mortality steeper where the $PM_{2.5}$ decline is faster than the national average?

Summary

- Methods for causal inferences can be very valuable in accountability research
- Estimation of air pollution trends can be challenging
- National data are useful because we can compare results across areas that have experienced very different changes in air quality
- It is of critical importance to look at association between “global” and “local” trends

Accountability Studies: Evaluating shorter-term and small scale actions

Jennifer L. Peel, PhD, MPH
Colorado State University
HEI Accountability Workshop
December 17, 2009

Short-term / small scale accountability studies

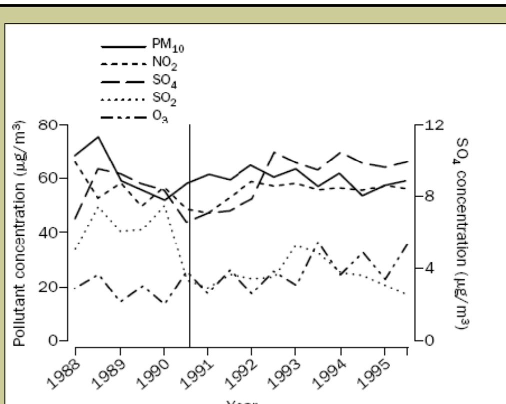
- Examples
  - Fuel sulfur reductions on Hong Kong
  - London congestion charging scheme
  - 1996 Atlanta Summer Olympics
- Challenges
- Considerations for studies

Types of short-term / small scale actions

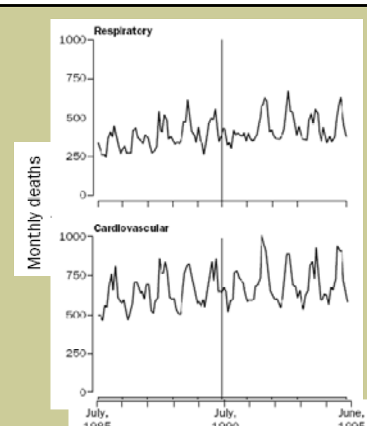
- Small scale, permanent
  - Potential for both short-term and longer-term impacts
- Short-term, reversible
  - Likely small in scale
  - Focus on short-term, reversible health endpoints

Sulfur reduction in fuels

- Hong Kong (Hedley et al. Lancet 2002)
- Restriction on sulfur content of fuel July 1990
- Immediate reduction of SO_2 (45% over 5 years)
- Short-term reduction of sulfate (2 years), then levels increased again
- Immediate reduction in cool season mortality (first year); increase the 2nd year
- Decline in average annual mortality trend; 20-41 days per year gained in life expectancy per year at lower pollution levels



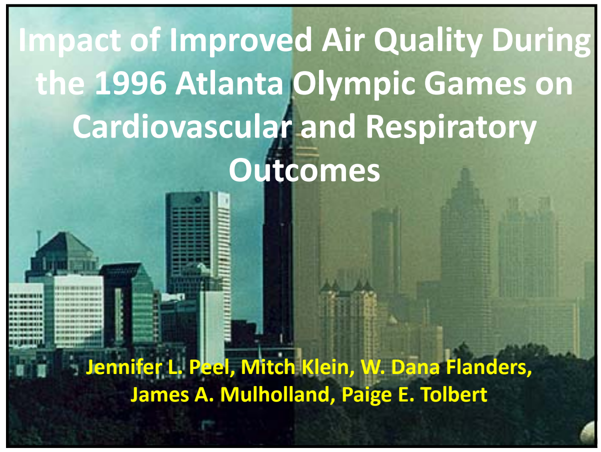
Hedley et al. Lancet 2002



Hedley et al. Lancet 2002

London Congestion Charging Scheme

- Tonne et al. 2008
- Feb 2003 – Feb 2007; drivers charged to drive in designated zone in Central London
- Impacted areas had 200,000 of 7 million London residents
- Modeled NO_2 and PM_{10} (assumed meteorology and fleet remained constant)
- Small reductions in annual NO_2
- Small increased in modeled life expectancy (based on other cohort studies)



Study Motivation

- Efforts to reduce traffic during the 1996 Summer Olympics in Atlanta
  - Reduced traffic
  - Reduced levels of air pollutants

December 17, 2009

Study Motivation

- Previously published study reported decreases in pediatric Medicaid asthma ED and hospitalization claims during the Olympic time period compared to 4 weeks before and after (Friedman et al., JAMA 2001) (RR=0.48; 95% CI 0.44, 0.86)
  - Smaller reductions in pediatric asthma ED visits (RR=0.93; 95% 0.71, 1.22)
  - Reductions attributed to reduced traffic
  - Questions about confounding by time trends and behavioral changes during the Olympics

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Methods – Emergency Department Visits

- Billing records from all Atlanta EDs
- Atlanta residents only
- Multiple cardiovascular and respiratory case groups defined based on primary ICD-9 codes
  - Pediatric and all ages
  - 1993 – 2004: 41 hospitals, 20 counties
  - 1996: 12 hospitals, 5 counties

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Methods – Air Quality Data

- EPA AQS networks, 1993 - 2004
  - Ozone: 2 sites
  - PM_{10}: 1 site
  - CO: 2 sites
  - NO_2: 2 sites
  - SO_2: 2 sites
- Hourly traffic counts, 18 sites
- Meteorologic data

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Methods

- Poisson time-series models, 1995-2004 summers
  - Adjusted for day of week, holidays, temp, dewpoint, day of summer, indicator for 1996 vs. other years, interaction term for 1996 x exposure
  - Offset = log (total non-accidental, non-case ED visits)
  - Exposure = Olympic time period (yes/no) in 1996
  - 12 hospitals (all ages)
  - 2 pediatric hospitals (pediatric visits)

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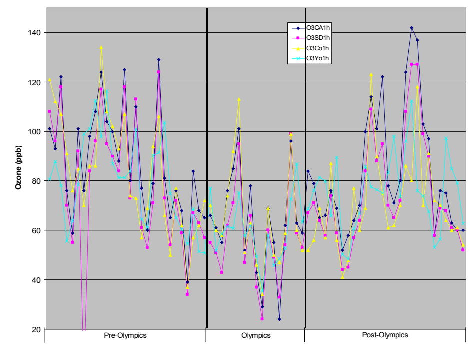
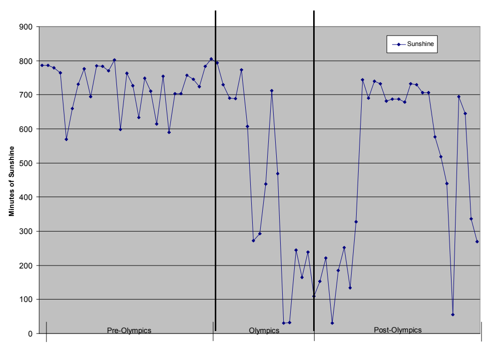
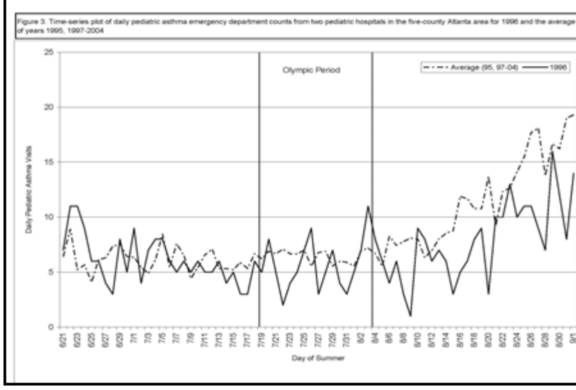
Results – Ozone (1-hour max)



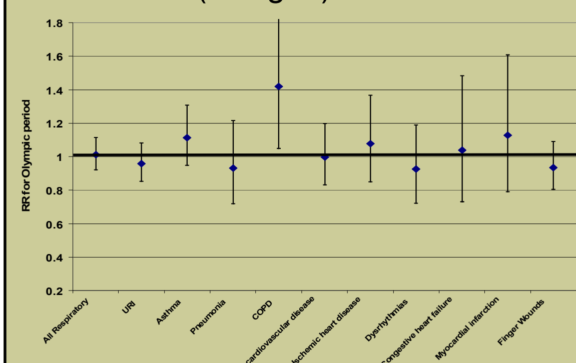
Results - Sunshine



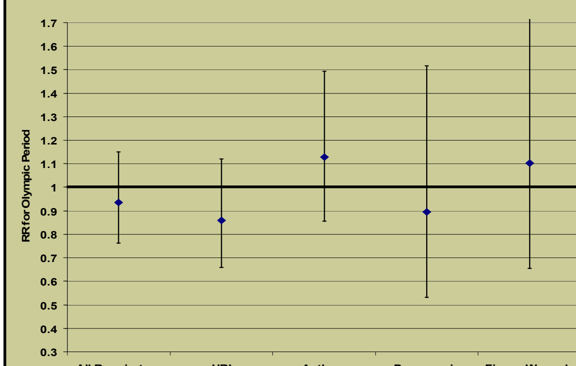
Results – Pediatric Asthma Visits



ED Visits (all ages)



Pediatric ED Visits



Additional Results

- Observed similar reductions in ozone throughout Southeastern US
- Proportions of age groups, gender, payment, racial groups similar during the Olympics
- No difference when restricted to Medicaid visits
- Estimates were sensitive to control for temporal trends and choice of model

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Summary

- Ozone levels ~30% lower during Olympics compared to 4 weeks before and after
  - PM_{10}, NO_2, CO also slightly lower
- 1-hour max (morning rush hour) traffic counts reduced ~10-15%
- Observed similar reductions in ozone at various sites throughout the Southeast
  - Not impacted by traffic intervention

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Summary

- Both the intervention and prevailing meteorology likely played a role in reduced ozone
  - Regional evidence suggests meteorology
  - Role of traffic unclear
- Observed little or no evidence of reductions in emergency department visits

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Limitations

- Behavioral changes may have contributed to reductions in ED usage
  - URI
- Entirely retrospective
- Limited time period of intervention (17 days)
- Limited monitoring sites for pollutants, traffic
- Intervention likely not sustainable

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Considerations: Intervention

- Designed to reduce pollution?
- Area affected
- Length of time
- Multiple pollutants affected? Increase or decrease?

Considerations: Pollutant Measure

- What to measure?
  - Multiple pollutants? Components?
  - Peak? Average?
- Where to measure?
  - Relevant locations
  - Near road, background, residences
  - How many sites?
- Other sources?
- Vehicle counts, fleet composition, speed/flow, age

Considerations: Other

- Baseline pollution level and expected reduction
- Assuming linearity at all levels?
- Subtle effects per IQR increase in pollutants
  - What effect do we expect to see?
- What else is changing in population
  - Unintended side effects
    - E.g., reduce vehicle use, increase bike use
- What is the objective?
  - Evaluate intervention method
  - Strengthen evidence

Colorado State University
Knowledge to Go Places

EMORY ROLLINS SCHOOL OF PUBLIC HEALTH

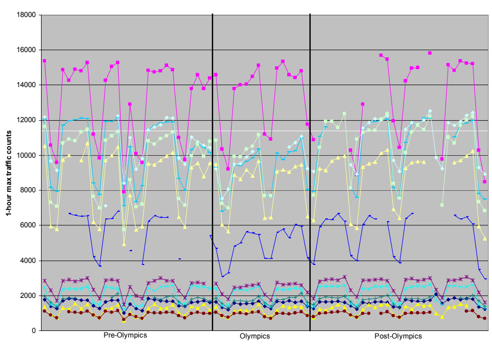
Colorado State University
- Jennifer Peel

Georgia Tech
- Jim Mulholland

Emory
- Paige Tolbert
- Mitch Klein
- Dana Flanders

Funded by Health Effects Institute (Research Agreement #4740-RFA04-4/06-1), the U.S. Environmental Protection Agency (R82921301-0), the National Institute of Environmental Health Sciences (R01ES11294), and the Electric Power Research Institute (W03253-07).

Results – Traffic Counts



Considerations: Health Outcome

- Available data
  - Mortality, hospital admission
  - Small numbers
  - Capture affected population?
- Panel study design
  - Limited power
  - Healthy? Underlying respiratory or cardiovascular disease?
- Short or long term
- Reversible?

Objective

- Assess impact of reduced air pollution levels during the 1996 Olympics on multiple cardiovascular and respiratory outcomes
  - ED visits (pediatric and other age groups)
  - Various control for time trends

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Evaluating Shorter-Term and Small Scale Actions

Douglas W. Dockery
Harvard School of Public Health

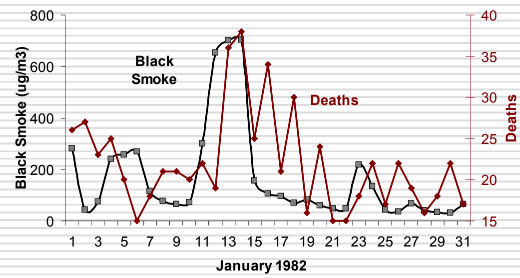
Experience in Dublin

- Oil crisis in late 1970's led to programs to encourage use of solid fuels, primarily coal
- 1980's - switch from oil to coal
- Dominant source of air pollution in Dublin was smoke from domestic fires

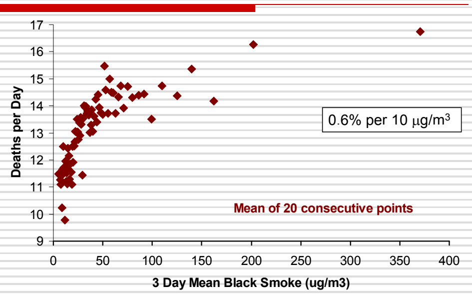
Deterioration in air quality after switch to coal
(Flanagan, 1986)

During winters of 1980's, Dublin experienced number of severe air pollution episodes.

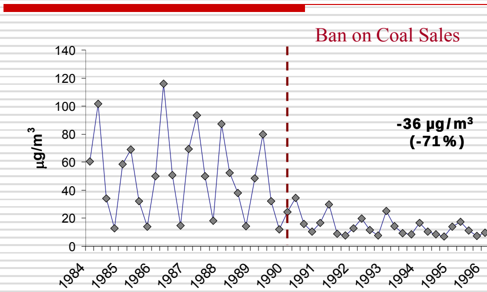
Dublin County Borough



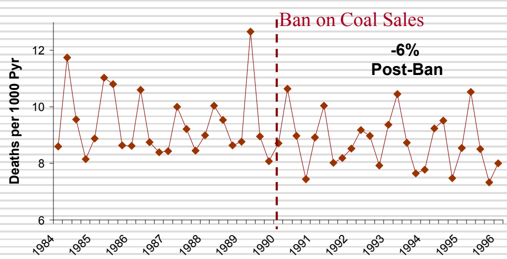
Dublin 1980-1990



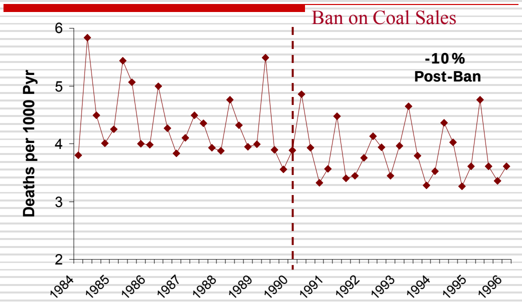
Dublin Black Smoke



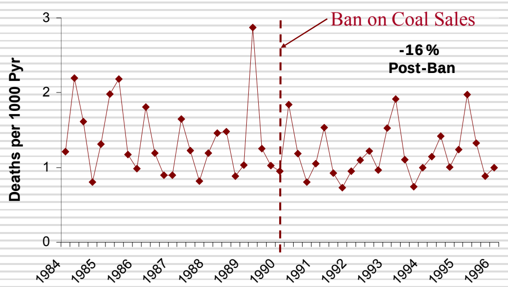
Dublin Total Mortality



Dublin Cardiovascular



Dublin Respiratory Deaths



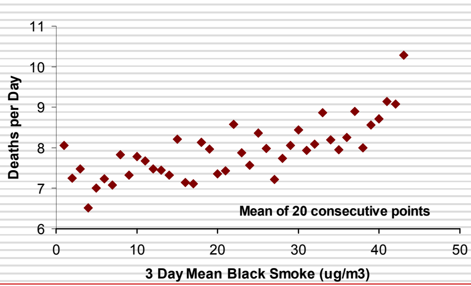
Effect of Air Pollution Control on Mortality in Dublin

Clancy et al, Lancet 2002

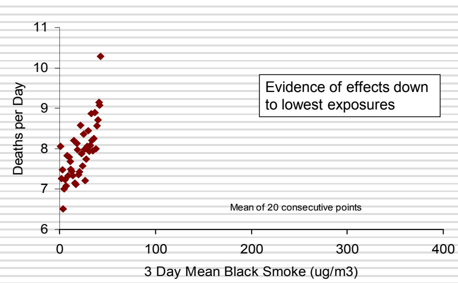
- Effect of ban on sale of coal on air pollution in Dublin
  - 36 μg/m³ BS (-71%)
  - 11 μg/m³ SO_2 (-34%)
- Effect on mortality
  - -7% Total Mortality *-2%*
  - -13% Cardiovascular *-2%*
  - -16% Respiratory *-6%*
  - -3% Other *0%*

Estimated improvements from time series studies

Dublin 1990-1996: Cardio-Respiratory Deaths



Dublin 1990-1996 Cardio-Respiratory Deaths



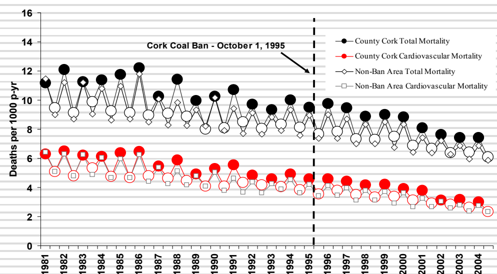
COAL SALE BANS

- **Sept 1, 1990**
  - \- Dublin
- **Oct 1, 1995**
  - \- Cork
- **Oct 1, 1998**
  - Limerick
  - Dundalk
  - Drogheda
  - Wexford
  - Arklow

Effect of sequential coal bans in BS

Ban Year - City	Black Smoke (ug/m^3) Pre Mean	Post Mean	Reduction	(%)
1990				
Dublin	50.4	15.0	-35.1	(-70%)
1995				
Cork	33.7	17.2	-21.6	(-49%)
1998				
Arklow	40.0	18.4	-21.6	(-54%)
Wexford	37.7			
Limerick	27.1	12.5	-14.6	(-54%)
Dundalk	23.0	11.9	-11.1	(-48%)
Drogheda	24.0	9.3	-14.8	(-61%)

Detecting effect of step change on long term background trends?



CORK

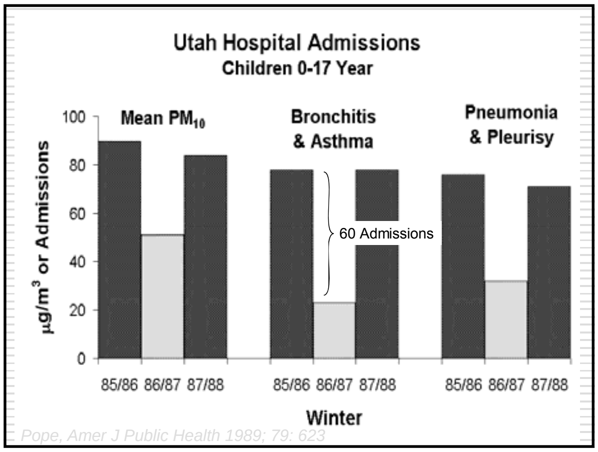
Percent change in mortality rate in the Post-ban period, compared to the Pre-ban period. All Ages; 1981-2004

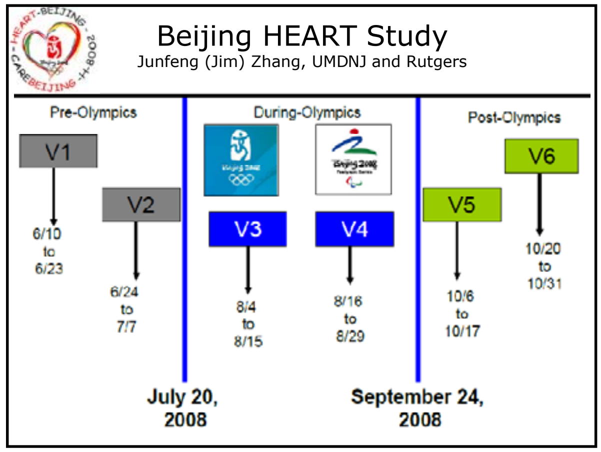
Disease Group	ICD-9	Deaths/1,000 per-yrs Pre-Ban	Post-Ban	% Change
TOTAL, NON-TRAUMA	**All (<800)**	**9.71**	**7.70**	**-7%**
CARDIOVASCULAR	**390-459**	**5.01**	**3.44**	**-13%**
Ischemic Heart Disease	410-414	2.65	1.83	-18%
Cerebrovascular	430-438	1.08	0.66	-23%
RESPIRATORY	**460-519**	**1.35**	**1.15**	**-8%**
Pneumonia	480-487	0.65	0.57	-7%
Chronic Obstructive Pulmonary Disease	490-496	0.59	0.44	-12%
CANCER	**140-239**	**2.16**	**2.05**	**-6%**
Lung Cancer	160-165	0.46	0.38	-17%
DIGESTIVE	**520-579**	**0.26**	**0.24**	**-8%**
NON CARDIO /RESPIRATORY	**<390, >519**	**3.36**	**3.11**	**-7%**

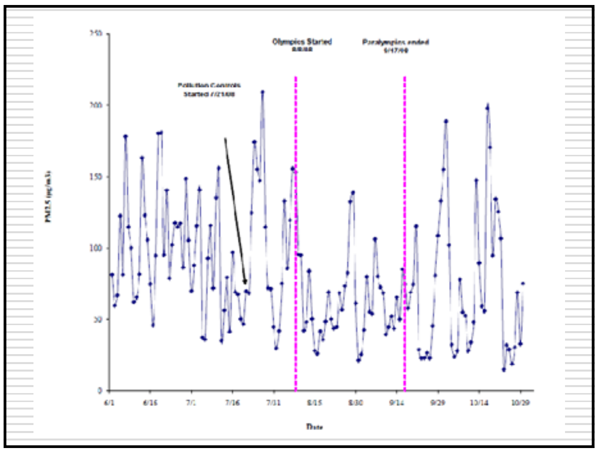
Percent change in mortality rate in the Post-ban period compared to the Pre-ban period Pooled and county specific estimates for each of the 1998 counties

Disease Group	Pooled estimate	95% CI	County Louth (Drogheda & Dundalk)	County Wexford (Wexford City)	County Wicklow (Arklow)	County Limerick (Limerick City)
TOTAL, NON-TRAUMA	**-7%**	**-8%, -5%**	**-7%**	**-8%**	**-6%**	**-5%**
CARDIOVASCULAR	**-14%**	**-16%, -11%**	**-12%**	**-14%**	**-11%**	**-17%**
Ischemic Heart Disease	-20%	-24%, -17%	-18%	-14%	-24%	-25%
Cerebrovascular	-25%	-29%, -19%	-26%	-25%	-19%	-27%
RESPIRATORY	**-7%**	**-11%, -3%**	**-12%**	**-15%**	**-5%**	**1%**
Pneumonia	2%	-4%, 9%	-19%	-16%	7%	26%
COPD	-27%	-32%, -21%	-21%	-25%	-30%	-30%
CANCER	**-7%**	**-10%, -4%**	**-8%**	**-5%**	**-11%**	**-5%**
Lung Cancer	-9%	-15%, -3%	-16%	-4%	-22%	-2%
DIGESTIVE	**-8%**	**-16%, 0%**	**-22%**	**1%**	**-2%**	**-10%**
NON CARDIO/RESPIR	**-4%**	**-6%, -1%**	**-6%**	**0%**	**-6%**	**-4%**

Contrast to reversible interventions







Air Pollution Concentrations and % Change

Pollutant	Pre-Olympic (Jun. 1 - Aug. 7)	During-Olympic (Aug. 8 - Sep. 17)	Post-Olympic (Sep. 18 - Oct. 31)	(dur-pre)/pre%
$PM_{2.5}$(μg/m³)	98.2±42.1	64.1±30.0	72.4±49.8	-34.7
SO_2(ppb)	11.5±12.6	4.6±2.5	6.8±3.2	-60.0
NO_2(ppb)	21. 2±7.2	20.2±8.6	37.8±16.1	-4.7
NO_x(ppb)	24.6±8.9	23.2±10.8	59.8±29.4	-5.7
CO(ppm)	1.0±0.4	0.6±0.2	0.7±0.6	-40.0
O_3(ppb)	36.0±15.6	35.9±14.4	15.8±6.2	-0.3
EC	3.2±1.0	1.8±0.7	4.8±2.3	-43.8

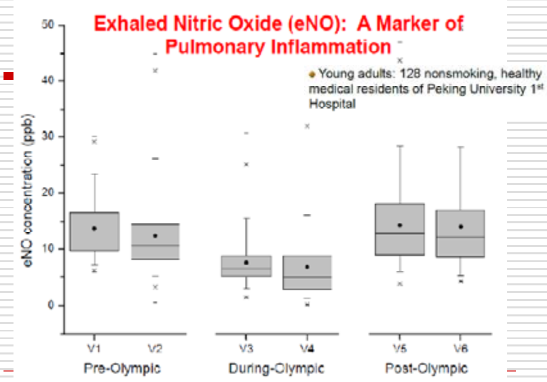
Lives Saved during the Olympic Air Pollution Controlled Period in Beijing

- ~ 300 deaths per day
- 1% reduction per 20 μg/m³ reduction in PM_{10}.
- On average PM_{10} reduction of 50 μg/m³ for 60 days.
- Death count reduction: ~450 ⇒ 7.5 deaths per day

Reduction in Emergency Room Visit during the Olympic Air Pollution Controlled Period in Beijing

- ~ 2500 cardio-respiratory visits per day -
- 1% reduction per 10 μg/m³ reduction in PM_{10}.
- On average PM_{10} reduction of 50 μg/m³ for 60 days.
- ER visits reduction: ~7,500

⇒ 125 ER visits per day



Issues for short-term small scale studies

- Permanent short-term step changes
  - Depends on surveillance data
    - Large numbers, but low sensitivity/specificity
  - Detecting in presence of long term trends
    - Competing explanations
- Reversible short-term step changes
  - Surveillance data
    - Short changes ⇒ small number of events
  - Prospective studies
    - Sensitive/specific markers
  - Competing explanations
    - Behavioral, economic, weather, … changes