

Evaluating the Benefits of Air Pollution Interventions

Hanna Boogaard

Principal Scientist, Health Effects Institute, co-chair ISEE Europe

Workshop on Air Pollution and Health in Southeast Europe

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Air pollution is responsible for up to one in five premature deaths in 19 Western Balkan cities

- Air pollution causes nearly 5,000 premature deaths in group of cities.
- On average, people living in the Western Balkan cities studied lose up to 1.3 years of life to air pollution.
- The main sources of particulate matter emissions are thermal power plants that use lignite coal and household heating.

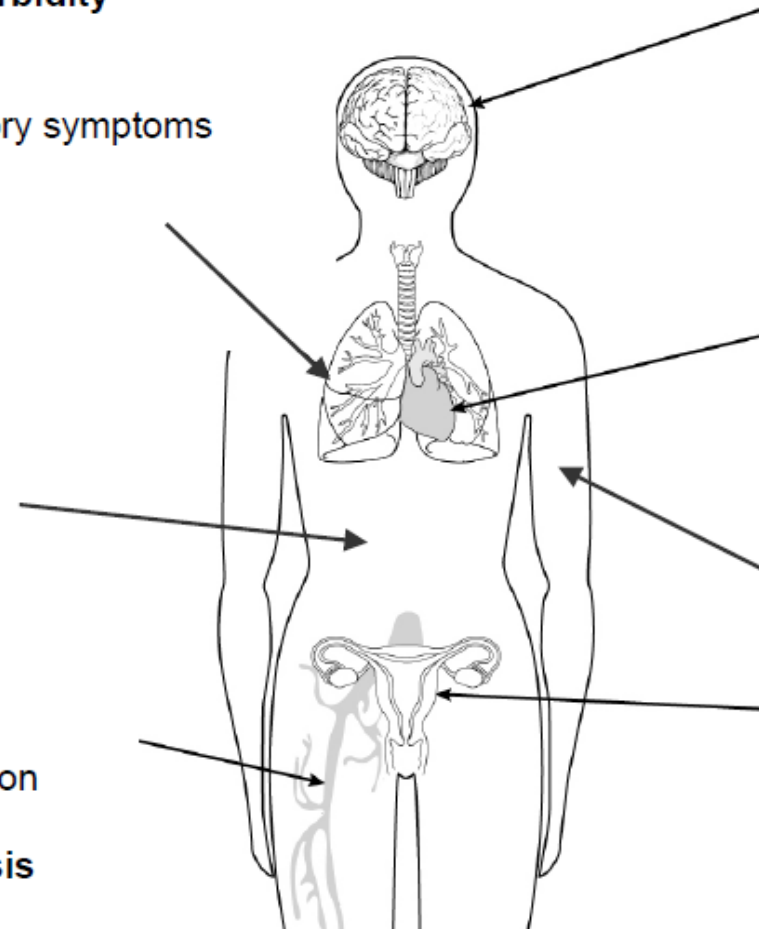
<https://www.unep.org/news-and-stories/press-release/air-pollution-responsible-one-five-premature-deaths-19-western>

Systemic Health Effects of Particulate Air Pollution

- **Respiratory Disease Mortality**
- **Respiratory Disease Morbidity**
- **Lung Cancer**
- **Pneumonia**
- Upper and lower respiratory symptoms
- Airway inflammation
- Decreased lung function
- Decreased lung growth

- Insulin Resistance
- **Type 2 diabetes**
- **Type 1 diabetes**
- Bone metabolism

- **High blood pressure**
- Endothelial dysfunction
- Increased blood coagulation
- Systemic inflammation
- **Deep Venous Thrombosis**



- **Stroke**
- Neurological development
- Mental Health
- **Neurodegenerative diseases**

- **Cardiovascular Disease Mortality**
- **Cardiovascular Disease Morbidity**
- **Myocardial Infarction**
- **Arrhythmia**
- **Congestive Heart Failure**
- Changes in Heart Rate Variability
- ST-Segment Depression

- Skin Aging

- **Premature Birth**
- **Decreased Birth Weight**
- Decreased foetal growth
- In uterine growth retardation
- Decreased sperm quality
- Preclampsia

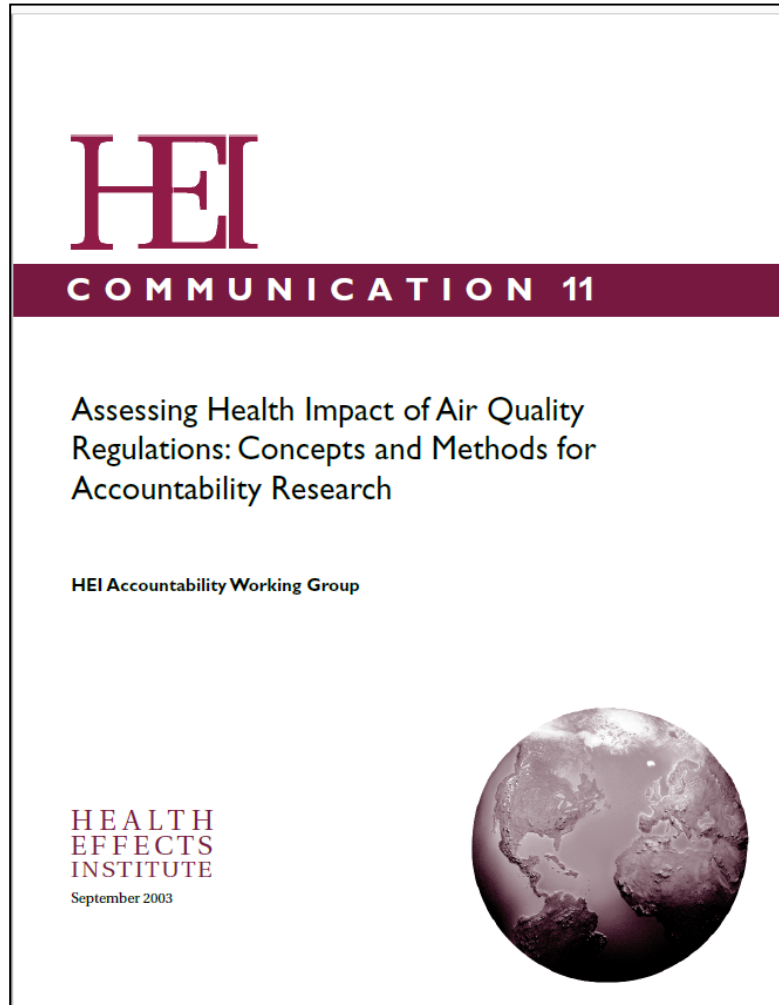
Why assess health effects of air quality actions?

While air quality has improved substantially, further improvements are becoming more costly.

Check that projected calculations of benefits have actually happened.

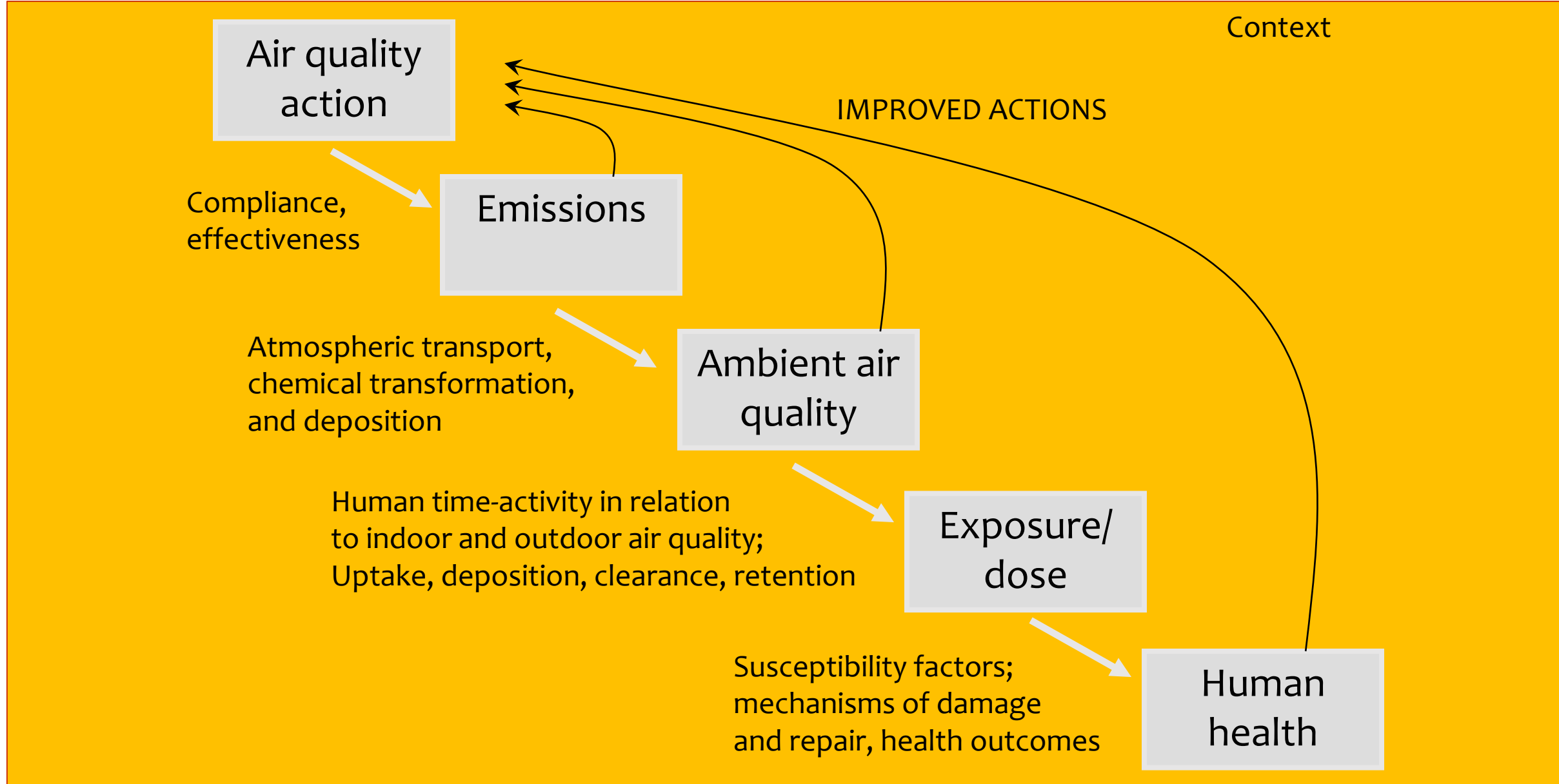
Intervention studies may provide strong evidence for ‘causal’ effects; though note that the determination of causality draw on various lines of evidence including epidemiology, toxicology and human clinical studies.

Intervention research



How do we know that air quality regulations and actions “work”?

- Testing the extent to which air quality actions improve public health.
- Assessments of past environmental policies—termed accountability studies—contribute important information to the decision-making process used to review the efficacy of past policies, and subsequently aid in the development of effective new policies.
- HEI has a long track-record of comprehensive research and reviews.



The Chain of Accountability

Showing relationship of air quality action to health effects of air pollution

Overview of intervention studies funded by HEI

Traffic measures

Sara Adar: School bus retrofit and replacement US wide (ongoing)

Perry Hystad: Traffic and congestion measures in Texas (ongoing)

Frank Kelly: Congestion charging scheme in London

Frank Kelly: London low emission zone baseline study

Jennifer Peel: Traffic measures during the 1996 Olympic Games in Atlanta

Fuel changes

Doug Dockery: Coal bans in Irish cities

Sam Harper, Jill Baumgartner: Coal ban and heat pump subsidy in Beijing, China (ongoing)

Curtis Noonan: Wood stove change-out program in Montana

Chit-Ming Wong: Reducing sulfur in fuel in Hong Kong

Multiple sources

Frank Gilliland: Policy-driven air quality improvements on children's health

Patrick Kinney: Major national regulatory policies in China (ongoing)

Dick Morgenstern: Air quality improvement 1990 Clean Air Act Amendments

Annette Peters: Air quality improvement after German reunification

Ted Russell: Impacts of air quality regulations in Atlanta

Jim Zhang: Air quality improvements 2008 Olympic Games in Beijing

Ports

Ying-Ying Meng: Goods Movement Actions in Los Angeles. **NEW**

Statistical Methods

Cory Zigler: Causal inference methods for estimating long-term health effects of air quality regulations

Several recent reviews

Environment International 135 (2020) 105400



Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Interventions to reduce ambient air pollution and their effects on health: An abridged Cochrane systematic review

J. Burns^{a,b,*}, H. Boogaard^c, S. Polus^{a,b}, L.M. Pfadenhauer^{a,b}, A.C. Rohwer^d, A.M. van Erp^c, R. Turley^e, E.A. Rehfuss^{a,b}



Public Health England 2019

Protecting and improving the nation's health

Review of interventions to improve outdoor air quality and public health

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



REVIEW PAPER

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

Lucas R.F. Henneman^a, Cong Liu^b, James A. Mulholland^a, and Armistead G. Russell^a

Curr Envir Health Rpt
DOI 10.1007/s40572-017-0161-0



AIR POLLUTION AND HEALTH (S ADAR AND B HOFFMANN, SECTION EDITORS)

Accountability Studies on Air Pollution and Health: the HEI Experience

Hanna Boogaard¹ · Annemoon M. van Erp¹ · Katherine D. Walker¹ · Rashid Shaikh¹

Current Environmental Health Reports (2020) 7:424–440
<https://doi.org/10.1007/s40572-020-00296-z>

AIR POLLUTION AND HEALTH (S ADAR AND B HOFFMANN, SECTION EDITORS)

2020

Individual- and Household-Level Interventions to Reduce Air Pollution Exposures and Health Risks: a Review of the Recent Literature

Ryan W. Allen¹ · Prabjit Bam²

Health Benefits of Air Pollution Reduction

Dean E. Schraufnager¹, John R. Balmes², Sara De Matteis³, Barbara Hoffman⁴, Woo Jin Kim⁵, Rogelio Perez-Padilla⁶, Mary Rice^{7*}, Akshay Sood⁸, Aneesa Vanker^{9,10}, and Donald J. Wuebbles¹¹; on behalf of the Forum of International Respiratory Societies Environmental Committee

AnnalsATS Volume 16 Number 12 | December 2019

Environment International 100 (2017) 62–78



Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review article

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

David Q. Rich^{*}



Key observations

Most intervention studies to date have focused on effects of relatively short-term, local-scale, and sometimes temporary interventions.

Only a few recent intervention studies have sought to investigate large-scale, multiyear regulatory programs.

Most intervention studies come from Western Europe and North America.



42 studies with 38 unique interventions from 19 different countries. Majority of them were targeting vehicular sources (Burns 2020 Cochrane systematic review)

Industrial sources

- Cap and trade program
- Industry standards
- Smelter closure
- Factory closure
- Power plant fuel conversion

Residential sources

- Coal ban
- Stove exchange
- Ban on wood burning
- Clean fuel usage

Vehicular sources

- Fuel standards
- Vehicle standards
- Even-odd vehicle restriction
- Clean fuel usage
- Road construction and redesign
- Public transportation restructuring
- Road closure
- Low emission zone
- Speed limit change
- Diesel vehicle ban
- Vehicle charging scheme
- Road washing/sweeping
- Road paving
- Public bicycle sharing
- Urban green belt

Multiple sources

- Tailored selection of most appropriate measures
- Comprehensive measures surrounding short-term events (e.g. 2008 Beijing Olympics; 2014 APEC Beijing; 2010 Asian Games; 2004 US Democratic National Convention)
- Coordinated measures during high pollution episodes

Lack of intervention studies in Southeast Europe

One study published in 2007 in Calarasi, Romania where they investigated the influence the closing of an iron, steel and coke factory on the incidence of wheezing in children living near the factory.

One study published in 2015 where they analyzed the effect of a street closure on air quality in Ljubljana, Slovenia.

Both studies report improvements, but also highlight some challenges

European Journal of General Practice. 2007; 13: 135–143

informa
healthcare

ORIGINAL ARTICLES

Industrial air pollution and children's respiratory health: A natural experiment in Călărași

ALEXANDRA CARMEN CĂRA¹, FRANK BUNTINX^{2,3}, MARJAN VAN DEN AKKER²,
GEERT-JAN DINANT² & CARMEN MANOLOVICI⁴



ELSEVIER

Atmospheric Environment 114 (2015) 19–31

Contents lists available at [ScienceDirect](#)

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Evaluation of the impact of transportation changes on air quality

G. Titos ^{a,b,*}, H. Lyamani ^{a,b}, L. Drinovec ^c, F.J. Olmo ^{a,b}, G. Močnik ^c,
L. Alados-Arboledas ^{a,b}

Key observations

Wide range of interventions, contexts, outcomes and study methods, making any overall conclusions difficult.

Intervention research provide weak evidence that AQ and health improvements over last few decades can be assigned to AQ policies -

It doesn't mean that policies haven't helped, but rather reflects methodological difficulties in linking regulations/specific policies causally to the effect.

Key challenges

Lack of data

Lack of air quality and health data and opportunities for intervention research in many regions across the globe.

Complexity of the system

Multiple interventions are implemented within the same time frame, and at multiple levels, range of other factors affecting air quality and health (e.g., economic activity, access to health care).

Methodological challenges of included studies

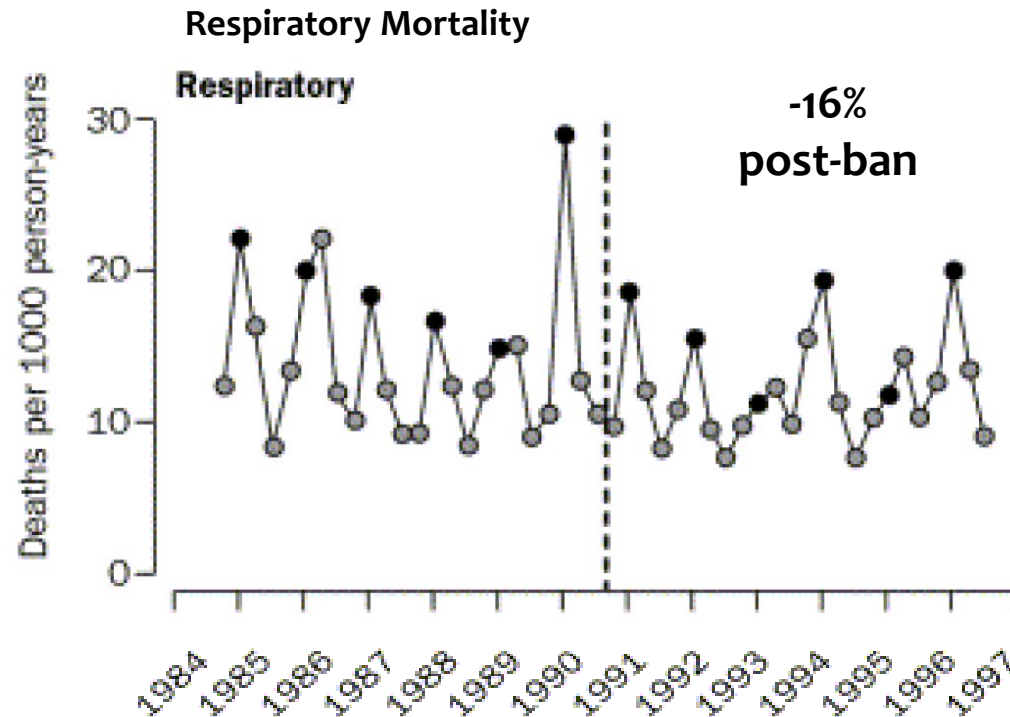
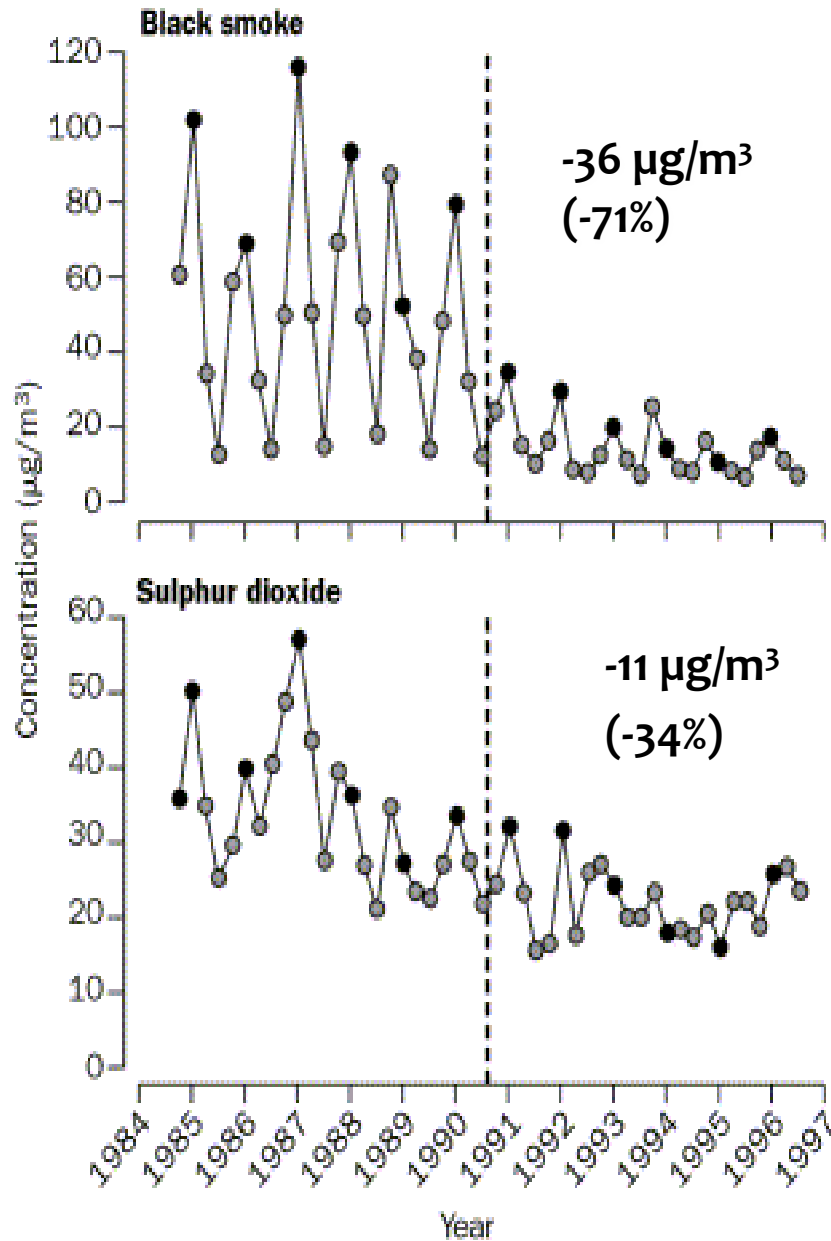
Study design and analysis aspects including lack of statistical power, selection of appropriate control populations, accounting for underlying time trends, and accounting for other important confounders.

A key element of intervention studies:

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

Coal ban in Dublin. September 1, 1990 - Irish gov't banned marketing, sale, and distribution of coal in Dublin

Immediate reduction in ambient air pollution and respiratory (-16%), cardiovascular (-10%) and total mortality (-6%).



Clancy
2002
Lancet

Dublin re-analyses

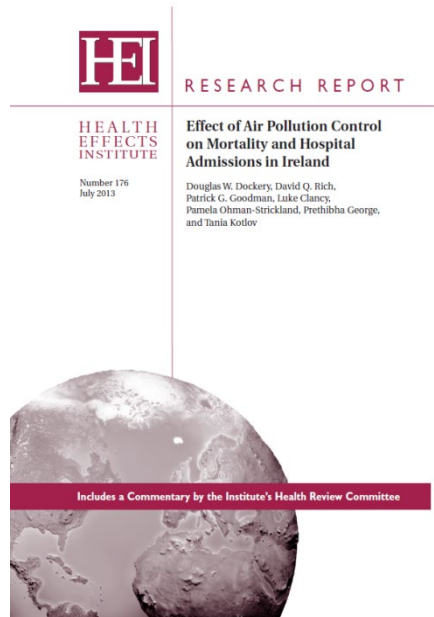
Clancy et al. focused on changes in Dublin only

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;

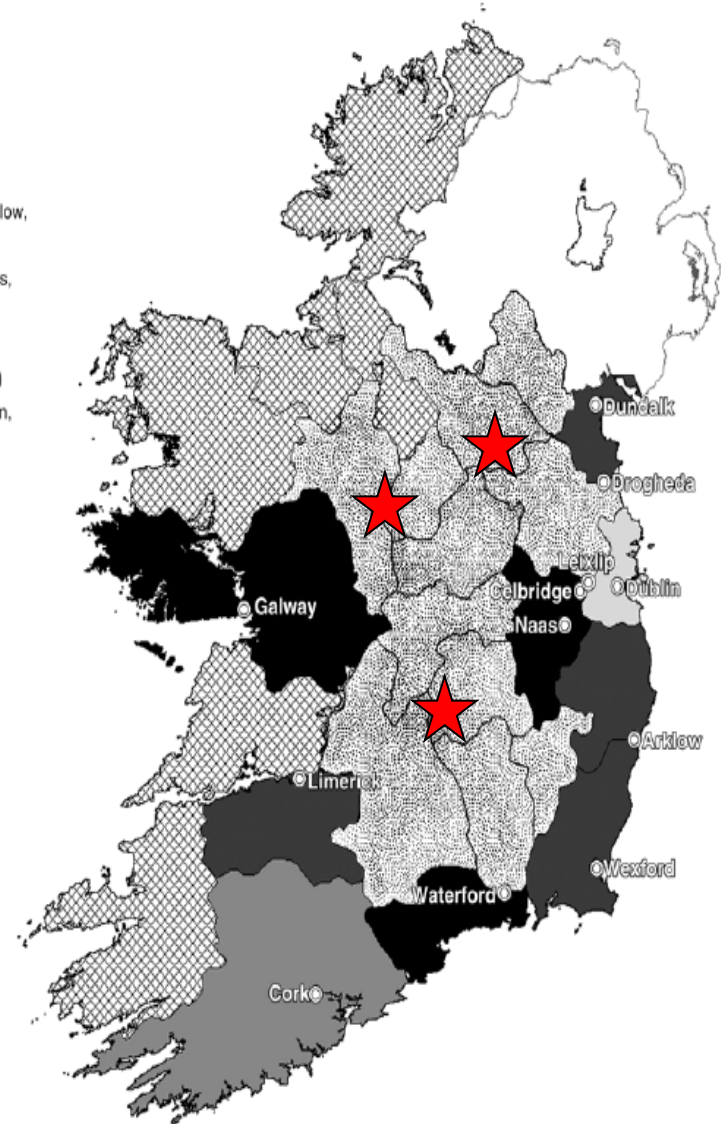
Added a “comparison” population★ residents of the Midland counties where coal ban was **not** instituted.

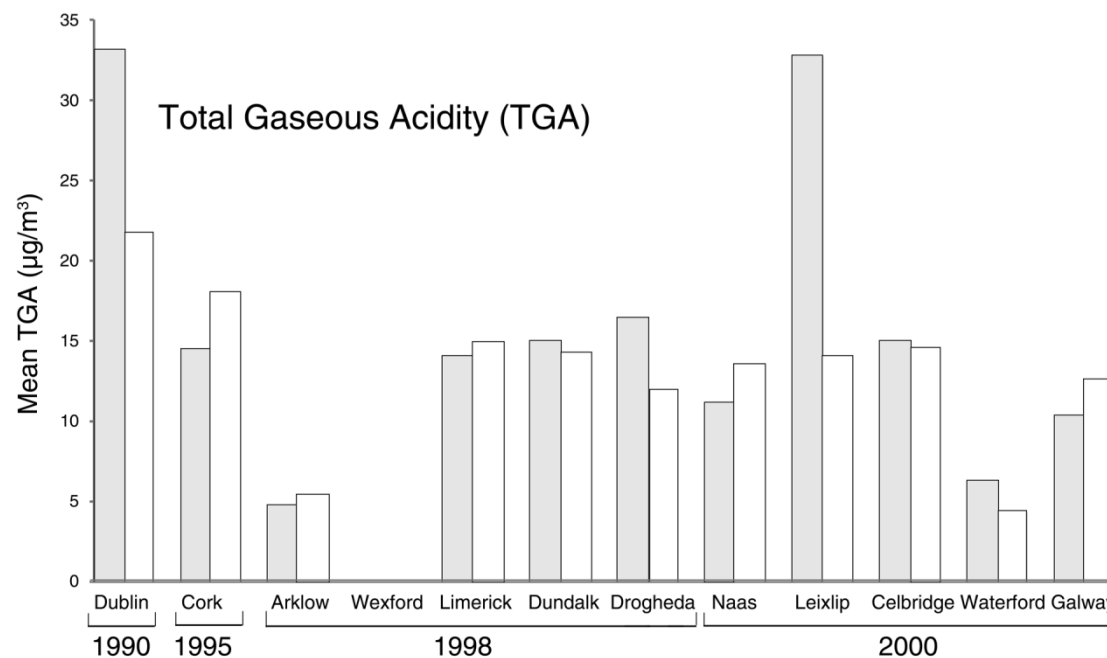
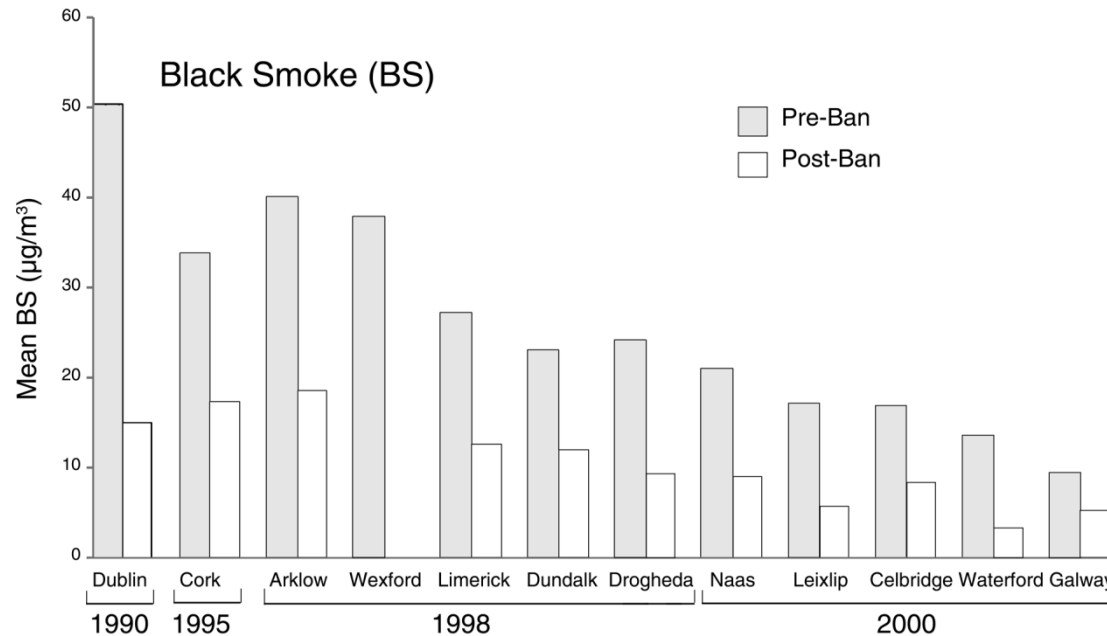


Dockery et al. 2013. HEI report 176

- 1990 Ban in Dublin
- 1995 Ban in Cork County Borough
- 1998 Ban in Dundalk, Drogheda, Arklow, Wexford, Limerick
- 2000 Ban in Galway, Waterford, Naas, Leixlip, Celbridge
- Coastal counties (Clare, Donegal, Kerry, Leitrim, Mayo, and Sligo)
- ★ Midlands counties (Cavan, Monaghan, Meath, Laois, Longford, Offaly, Westmeath, Tipperary [North and South], Carlow, Kilkenny, and Roscommon)
- Northern Ireland

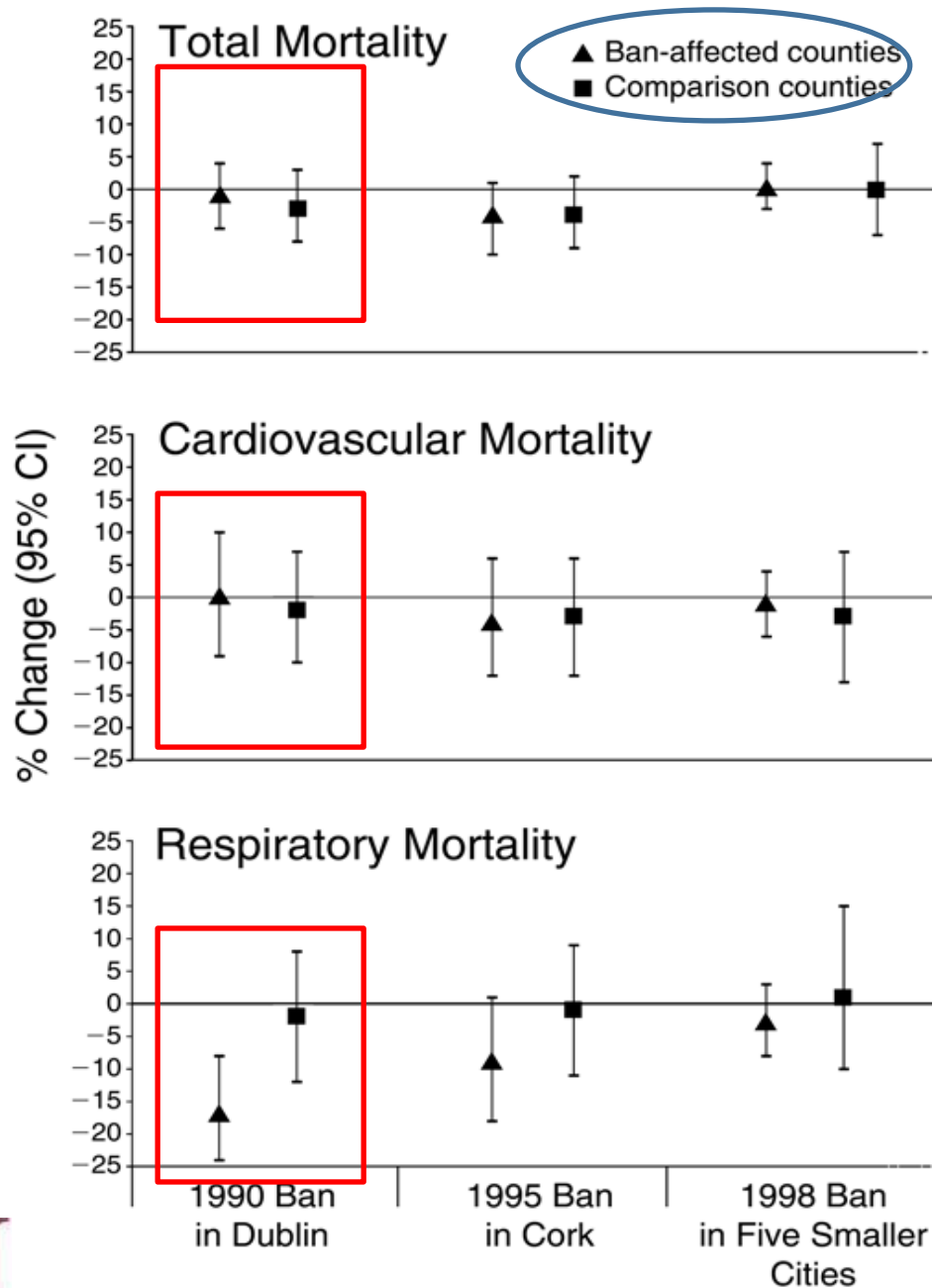
0 25 50 Miles





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

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



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

Key result: Comparison counties saw **same** changes in cardiovascular and total mortality as those in ban-affected counties that had reduced air pollution (likely because of improving heart health overall)

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

So what do intervention studies add?

They offer real world opportunities to test whether changes in air pollution result in changes in health.

If well-designed – control populations, well-defined health outcomes, etc. – they can offer significant insight on cause and effect.

You need to find the “sweet spot” where an action has caused a significant change in air quality; coincident with a good health data set.

More to be done!

Potential opportunities in Southeast Europe?

Stove replacement programs

Replacement of solid fuels for domestic heating

Scrubber technologies on emissions from coal-fired power plants

Low emission zones in city centers

Public transport measures

???

Thank you

Questions? Contact:

Hanna Boogaard

jboogaard@healtheffects.org



Los Angeles Then and Now

Source: New York Times

Additional slides

Timeline of benefits after stopping the air pollution source

Reducing air pollution can result in prompt and substantial health gains.

Pollution Reduction

Time	Events	References and location
Starting at week 1	Irish indoor smoking ban (population): 13% all-cause mortality: 26% reduction in ischemic heart disease, 32% reduction in stroke, 38% in COPD (29)	Clancy 2002; Dockery 2013; Stallings-Smith, 2013 Ireland
17 days	Olympic games: decreased clinic, emergency department visits and hospitalizations for childhood asthma (40)	Friedman, 2001; Peel 2013 Atlanta
Weeks	Steel mill closure: decreased respiratory symptoms (35), school absenteeism (36), daily mortality (37), premature births (38)	Pope 1989; Ransom 1992; Pope 1992; Parker 2008 US
4 weeks	Home heater change: asthmatic symptoms improved (64)	Pilotto 2004 Australia
1 month	Irish smoking ban (workers): decreased wheeze, dyspnea, cough, phlegm, irritated eyes, painful throat, nasal itch, runny nose and sneeze (33)	Menzies 2006 Ireland
2 months	Olympics: Improved lung function (healthy and asthmatic adults), fewer asthma-related physician visits (41); less cardiovascular mortality (43)	Li 2010; Su 2015; Zhang 2013 Beijing
8.5 months	Smelters strike: decrease in mortality by 2.5% (39)	Pope 2007 US
Pregnancy term	Clean cook stoves: higher birthweights, gestational age at delivery, less perinatal mortality (60)	Alexander 2018 Nigeria
6 years	Swiss air pollution decrease: Respiratory deaths decrease by 15.5%; cardiac deaths by 10% (18)	Downs 2007 Switzerland
7 years	USA pollution tracking: life expectancy increase 0.35 years for each 10 µg/m reduction of PM _{2.5} (10)	Correia 2013 US
10 years	Accounting for fine particle change: life expectancy gain 7 months (9)	Pope 2009 US ACS study
15 years	Harvard 6 cities study: decrease in fine particles reduced the risk of death by 27% (13).	Lepeule 2012 US Harvard Six city study
25 years	US EPA estimates: Health benefits exceed cost by 32:1 (6)	US EPA 2011. Clean Air Act from 1990 to 2020 US

