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  June 9, 2021
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.

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

Thurston et al. ERJ 2017
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

all available at www.healtheffects.org
Several recent reviews

Interventions to reduce ambient air pollution and their effects on health: An abridged Cochrane systematic review
J. Burns, H. Boogaard, S. Polus, L.M. Pfadenhauer, A.C. Rohwer, A.M. van Erp, R. Turley, E.A. Rehfuess

Review of interventions to improve outdoor air quality and public health

Health Benefits of Air Pollution Reduction
Dean E. Schraufnagel, John R. Balmes, Sara De Matteis, Barbara Hoffman, Wook Jin Kim, Rogelio Perez-Padilla, Mary Rice, Aksray Sood, Aneesa Vanker, and Donald J. Wuebbles on behalf of the Forum of International Respiratory Societies Environmental Committee

Accountability Studies on Air Pollution and Health: the HEI Experience
Hanna Boogaard, Anneleen M. van Erp, Katherine D. Walker, Rashid Shakh
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.
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.
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%).

-36 µg/m³ (-71%)

-11 µg/m³ (-34%)

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 of residents of the Midland counties where coal ban was not instituted.

Dockery et al. 2013. HEI report 176
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).

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.

<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting at week 1</td>
<td>Irish indoor smoking ban (population): 13% all-cause mortality: 26% reduction in ischemic heart disease, 32% reduction in stroke, 38% in COPD (29)</td>
</tr>
<tr>
<td>17 days</td>
<td>Olympic games: decreased clinic, emergency department visits and hospitalizations for childhood asthma (40)</td>
</tr>
<tr>
<td>Weeks</td>
<td>Steel mill closure: decreased respiratory symptoms (65), school absenteeism (36), daily mortality (37), premature births (38)</td>
</tr>
<tr>
<td>4 weeks</td>
<td>Home heater change: asthmatic symptoms improved (64)</td>
</tr>
<tr>
<td>1 month</td>
<td>Irish smoking ban (workers): decreased wheeze, dyspnea, cough, phlegm, itilating eyes, painful throat, nasal itch, runny nose and sneeze (35)</td>
</tr>
<tr>
<td>9 months</td>
<td>Olympics: improved lung function (healthy and asthmatic adults), lower asthma-related physician visits (44); less cardiovascular mortality (49)</td>
</tr>
<tr>
<td>8.5 months</td>
<td>Smellers strike: decrease in mortality by 2.5% (39)</td>
</tr>
<tr>
<td>Pregnancy term</td>
<td>Clean cook stoves: higher birthweights, gestational age at delivery, less perinatal mortality (60)</td>
</tr>
<tr>
<td>6 years</td>
<td>Swiss air pollution decrease: Respiratory deaths decrease by 15.5%; cardiac deaths by 10% (18)</td>
</tr>
<tr>
<td>7 years</td>
<td>USA pollution tracking: life expectancy increase 0.56 years for each 10 μg/m³ reduction of PM2.5 (19)</td>
</tr>
<tr>
<td>10 years</td>
<td>Accounting for fine particle change: life expectancy gain 7 months (9)</td>
</tr>
<tr>
<td>15 years</td>
<td>Harvard 6 cities study; decrease in fine particles reduced the risk of death by 27% (13)</td>
</tr>
<tr>
<td>25 years</td>
<td>US EPA estimates: Health benefits exceed cost by 32.1 (8)</td>
</tr>
</tbody>
</table>

References and location

Clancy 2002; Dockery 2013; Stallings-Smith, 2013 Ireland
Friedman, 2001; Peel 2013 Atlanta
Pope 1989; Ransom 1992; Pope 1992; Parker 2008 US
Pilotto 2004 Australia
Menzies 2006 Ireland
Li 2010; Su 2015; Zhang 2013 Beijing
Pope 2007 US
Alexander 2018 Nigeria
Downs 2007 Switzerland
Correia 2013 US
Pope 2009 US ACS study
Lepeule 2012 US Harvard Six city study

Schraufnagel 2019