Is more health research needed to cope with air pollution?

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Annual mean PM$_{2.5}$ concentrations, 2014

PM$_{2.5}$ annual mean Limit Value = 25 µg/m$^3$

WHO AQG = 10 µg/m$^3$

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EEA 2016
Annual mean NO₂ concentrations, 2014

NO₂ annual mean
Limit Value = 40 µg/m³

WHO AQG = 40 µg/m³

EEA 2016
Maximum daily 8-h \(O_3\) concentrations, 2014

\(O_3\) Target Value: 120 \(\mu g/m^3\) not to be exceeded for more than 25 days/yr (3 yr. average)

WHO AQG=100 \(\mu g/m^3\)
Strength of evidence on health effects of PM$_{2.5}$, NO$_2$ and O$_3$

Systematic reviews:
- for PM: US EPA 2009
- for NO$_2$: US EPA 2016 / HC 2016
- for O$_3$: US EPA 2013

C – causal
L – likely causal
S – suggestive for causal

<table>
<thead>
<tr>
<th>Outcome</th>
<th>PM2.5</th>
<th>NO2</th>
<th>O3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Total mortality</td>
<td>C</td>
<td>C</td>
<td>S / S</td>
</tr>
<tr>
<td>CV mortality</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Respiratory mortality</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Lung cancer</td>
<td>- / C$^1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory effects</td>
<td>L</td>
<td>L</td>
<td>L / L</td>
</tr>
<tr>
<td>CV effects</td>
<td></td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ IARC 2013 (Group 1)
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Number of deaths attributable to PM$_{2.5}$ in selected countries of Europe, 1990-2015

EEA: > 400,000 premature deaths / year attributed to PM exposure in the EU28 (2013)

https://www.stateofglobalair.org/data
Air Pollution and Mortality in the Medicare Population

Qian Di, M.S., Yan Wang, M.S., Antonella Zanobetti, Ph.D., Yun Wang, Ph.D., Petros Koutrakis, Ph.D., Christine Choirat, Ph.D., Francesca Dominici, Ph.D., and Joel D. Schwartz, Ph.D.

NEJM 29 June 2017

60,925,443 persons (age 65+) followed 2000-2012; PM$_{2.5}$ and O$_3$ long term exposure estimated for the ZIP of residence

HR for all-cause mortality in two-pollutants model:

HR = 1.073 (1.071 – 1.075) per 10 µg/m$^3$ PM$_{2.5}$
HR = 1.011 (1.010 – 1.012) per 10 ppb ozone
National Emission Ceiling directive 2016/2284/EU

Objective: cut the health impacts of air pollution by half compared with 2005
Source contributions to ambient PM2.5 at urban traffic stations in UK and Poland, in the base year 2009 and for 2030 assuming adoption of the EU Clean Air Policy Package

**United Kingdom**

A. 2009

B. 2030 Commission Proposal

**Poland**

A. 2009

B. 2030 Commission Proposal

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IIASA 2014
Is more health research needed to cope with air pollution?

✓ Causality of exposure
✓ Burden of disease / risk assessment

ACT NOW!!! The evidence is sufficient!

Diagram:
- Driving forces (economy)
- Pressures (emissions)
- State (concentrations)
- Exposure
- Effects

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Evidence: sufficient ≠ complete
Demand for local evidence on health effects of air pollution

Arguments for local studies:

• Local exposure or health conditions differ from that in other settings (e.g. desert dust in Middle East);

• Need to convince local authorities and the public about the scale of air pollution problem with local data.

Arguments against:

• Insufficient power /quality of local study;

• Time, costs, expertise…

• Delay in coping with the problem.

Response to Environmental Pollution
More Research May Not Be Needed

David A. Savitz  Epidemiology 2016

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Risk assessment
Research to improve exposure – response functions

- Further studies in Europe and N. America: increase precision of health risk assessment, especially in low exposure levels (e.g.: MEDICARE cohort; ESCAPE+);
- Studies in low/medium income regions:
  - increase confidence in HRA results in medium – high exposures;
  - confirm applicability of ERF in local conditions;
- Identification of the role of PM components and sources (e.g. coal combustion, traffic, desert dust) – focus on the most effective strategy to cope with pollution;
- Studies examining effects of multiple pollutants: enable consideration of possible confounding or synergistic effects of various pollutants.

Multi-disciplinary collaboration!
PM$_{2.5}$ (10 $\mu$g/m$^3$ increase) and Non-accidental Mortality

Study | HR (95% CI) | Weight
--- | --- | ---
Harvard six cities (Dockery, 1993) | 1.14 (1.07, 1.22) | 5.70
ACS study (Krewski, 2009) | 1.06 (1.02, 1.11) | 6.52
ACS LA sub-cohort study (Jerrett, 2005) | 1.17 (1.05, 1.30) | 4.22
Netherlands Cohort Study (Beelen, 2008) | 1.06 (0.97, 1.16) | 4.82
Nurses’ Health Study (Puett, 2009) | 1.26 (1.03, 1.55) | 1.97
Medicare national cohort (Zeger, 2008) | 1.04 (1.03, 1.06) | 7.16
Health professionals f-up study (Puett, 2011) | 0.86 (0.72, 1.02) | 2.49
US trucking industry cohort (Hart, 2011) | 1.10 (1.03, 1.18) | 5.61
California teachers study (Lipsett, 2011) | 1.01 (0.94, 1.08) | 5.59
Rome longitudinal study (Cesaroni, 2013) | 1.04 (1.03, 1.05) | 7.21
ACS California subcohort (Jerrett, 2013) | 1.06 (1.00, 1.12) | 6.09
National English cohort (Carey, 2013) | 1.11 (0.98, 1.26) | 3.56
Escape (Beelen, 2015) | 1.14 (1.03, 1.27) | 4.36
Canadian Nat Breast Screening Study (Villeneuve, 2015) | 1.12 (1.05, 1.20) | 5.64
Canadian national cohort (Crouse, 2015) | 1.07 (1.06, 1.08) | 7.19
The Dutch Study (DUELS) (Fischer, 2015) | 1.13 (1.12, 1.15) | 7.17
Canada Community Cohort (Pinault, 2016) | 1.26 (1.19, 1.34) | 5.93
French national electricity cohort (Bentayeb, 2016) | 1.14 (0.90, 1.44) | 1.62
Medicare (65+) (Wang, 2016) | 1.23 (1.21, 1.25) | 7.15
D-L Overall (I-squared=96.2%, p=0.000) | 1.10 (1.06, 1.14) | 100.00

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Courtesy of F. Forastiere
Non-linearity of the PM2.5 effect

Effects per 10 μg/m³ (and 95% CI, vertical bars) according to the long-term average PM2.5 exposure levels.

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## Table 2. Risk of Death Associated with an Increase of 10 µg per Cubic Meter in PM$_{2.5}$ or an Increase of 10 ppb in Ozone Concentration.*

<table>
<thead>
<tr>
<th>Model</th>
<th>PM$_{2.5}$</th>
<th>Ozone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>hazard ratio (95% CI)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-pollutant analysis</td>
<td></td>
<td></td>
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<tr>
<td>Main analysis</td>
<td>1.073 (1.071–1.075)</td>
<td>1.011 (1.010–1.012)</td>
</tr>
<tr>
<td>Low-exposure analysis#</td>
<td>1.136 (1.131–1.141)</td>
<td>1.010 (1.009–1.011)</td>
</tr>
<tr>
<td>Analysis based on data from nearest</td>
<td>1.061 (1.059–1.063)</td>
<td>1.001 (1.000–1.002)</td>
</tr>
<tr>
<td>monitoring site (nearest-monitor analysis)†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-pollutant analysis‡</td>
<td>1.084 (1.081–1.086)</td>
<td>1.023 (1.022–1.024)</td>
</tr>
</tbody>
</table>

* Within 50 km

# Below 12 µg/m³ for PM$_{2.5}$ and below 50 ppb for O$_3$

† Within 50 km
Health effects of NO2

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

STATEMENT ON THE EVIDENCE FOR THE EFFECTS OF NITROGEN DIOXIDE ON HEALTH

Summary

1. Studies have shown associations of nitrogen dioxide (NO₂) in outdoor air with adverse effects on health, including reduced life expectancy. It has been unclear whether these effects are caused by NO₂ itself or by other pollutants emitted by the same sources (such as traffic). Evidence associating NO₂ with health effects has strengthened substantially in recent years and we now think that, on the balance of probability, NO₂ itself is responsible for some of the health impact found to be associated with it in epidemiological studies.
Health effects of NO$_2$

Issues:

• Effects seen well below WHO AQG and EU LV;
• Potentially – burden of disease in cities: the same order of magnitude as that due to PM;
• Measures to reduce PM may increase NO$_x$ emissions.

Research questions:

• Specific role of NO$_2$ in (urban / traffic related) air pollution mixture;
• Local vs. regional exposures (see Crouse et al, JESEE 2015);
• Inclusion of NO$_2$ in HRA of air pollution: RR, $C_0$, overlap with other pollutants…
• …
Studies on “novel” health outcomes affected by air pollution

- Emerging fields: child development, cognitive effects, renal function…;
- Identify (new) susceptible / vulnerable groups;
- Complete burden of disease assessment (years lived with disability, productivity / wellbeing);
- Provide additional arguments for coping with pollution.

Review article

Exposure to air pollution and cognitive functioning across the life course – A systematic literature review

Angela Clifford, Linda Lang, Ruoling Chen, Kaarin J. Anstey, Anthony Seaton

Environ Res 2016

Living near major roads and the incidence of dementia, Parkinson’s disease, and multiple sclerosis: a population-based cohort study

Hong Chen, Jeffrey C Kwong, Ray Copes, Karen Tu, Paul J Villeneuve, Aaron van Donkelaar, Perry Hystad, Randall V Martin, Brian J Murray, Barry Jessiman, Andrew S Wilton, Alexander Kopp, Richard T Burnett

January 4, 2017

www.thelancet.com

Long-Term Exposure to Ambient Fine Particulate Matter and Renal Function in Older Men: The Veterans Administration Normative Aging Study

Amar J. Mehta, Antonella Zanobetti, Marie-Abele C. Bind, Itai Kloog, Petros Koutrakis, David Sparrow, Pantel S. Vokonas, and Joel D. Schwartz
Studies to explain biological mechanisms of effects

- Epi studies of early indications of disease conditions, e.g.
  - CV indicators;
  - Epigenetics?
  - Changes in brain?
  - ...
- Epi studies of vulnerable groups (CVD, COPD patients, diabetics);
- Clinical controlled exposure studies;
- Exposome (including metabolic factors, hormones, oxidative stress, ...)?

Understanding of disease causation;
Improvement of disease prevention.
Accountability research

• Monitoring of effects of intervention (changes in emissions, AQ, exposure and health);
• Use of randomized control design (when feasible);
• Novel statistical approaches (causal inference, …);
• Identification of conditions of effective interventions (including social and environmental characteristics of the target population);
• Optimization of interventions from public health point of view;
• Information / communication / policy support for effective intervention.

Multi-disciplinary collaboration!
Is more health research needed to cope with air pollution? My conclusions:

**NO:** The evidence to justify the reduction of population exposure to PM$_{2.5}$, NO$_2$ and O$_3$ is sufficient. Such reduction will bring significant health benefits in most populations.

**YES:** Further health studies will strengthen the arguments for the actions:
- Local evidence on health effects of air pollution;
- Improvement of CR functions to increase reliability and precision of health burden estimates of various components of pollution mix;
- Identification, understanding and quantification of air pollution “novel” health effects – potential impact on burden of disease estimates;
- Identification of the most feasible, socially acceptable and effective approaches to air pollution reduction to comply with current legislation and beyond.

Thank you, what do YOU think?