KING'S College LONDON

Is more health research needed to cope with air pollution?

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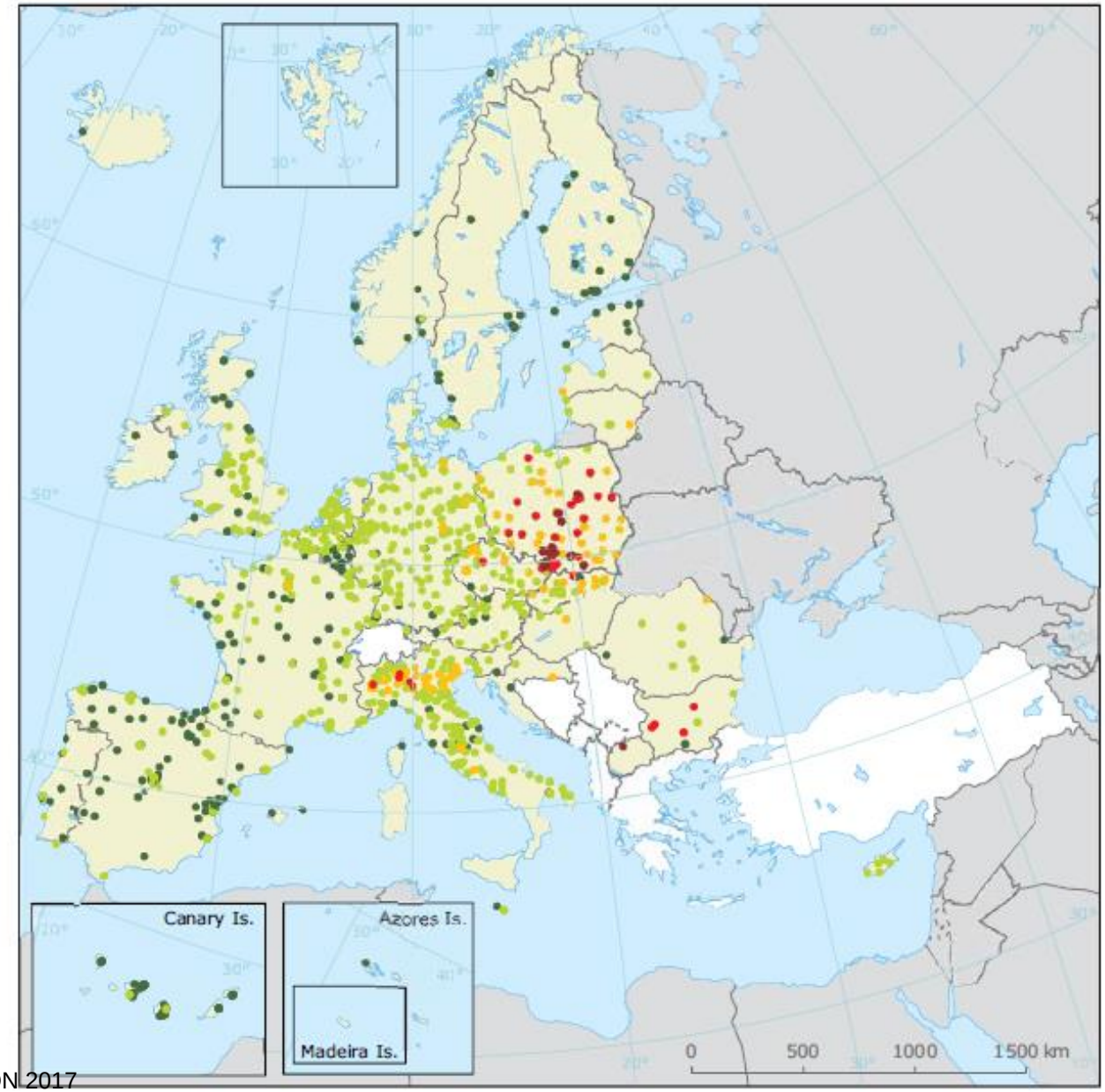
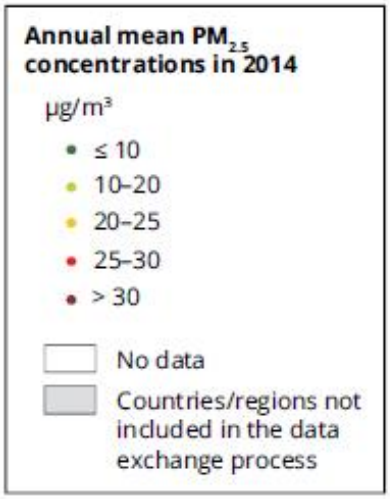
Annual mean $PM_{2.5}$ concentrations, 2014



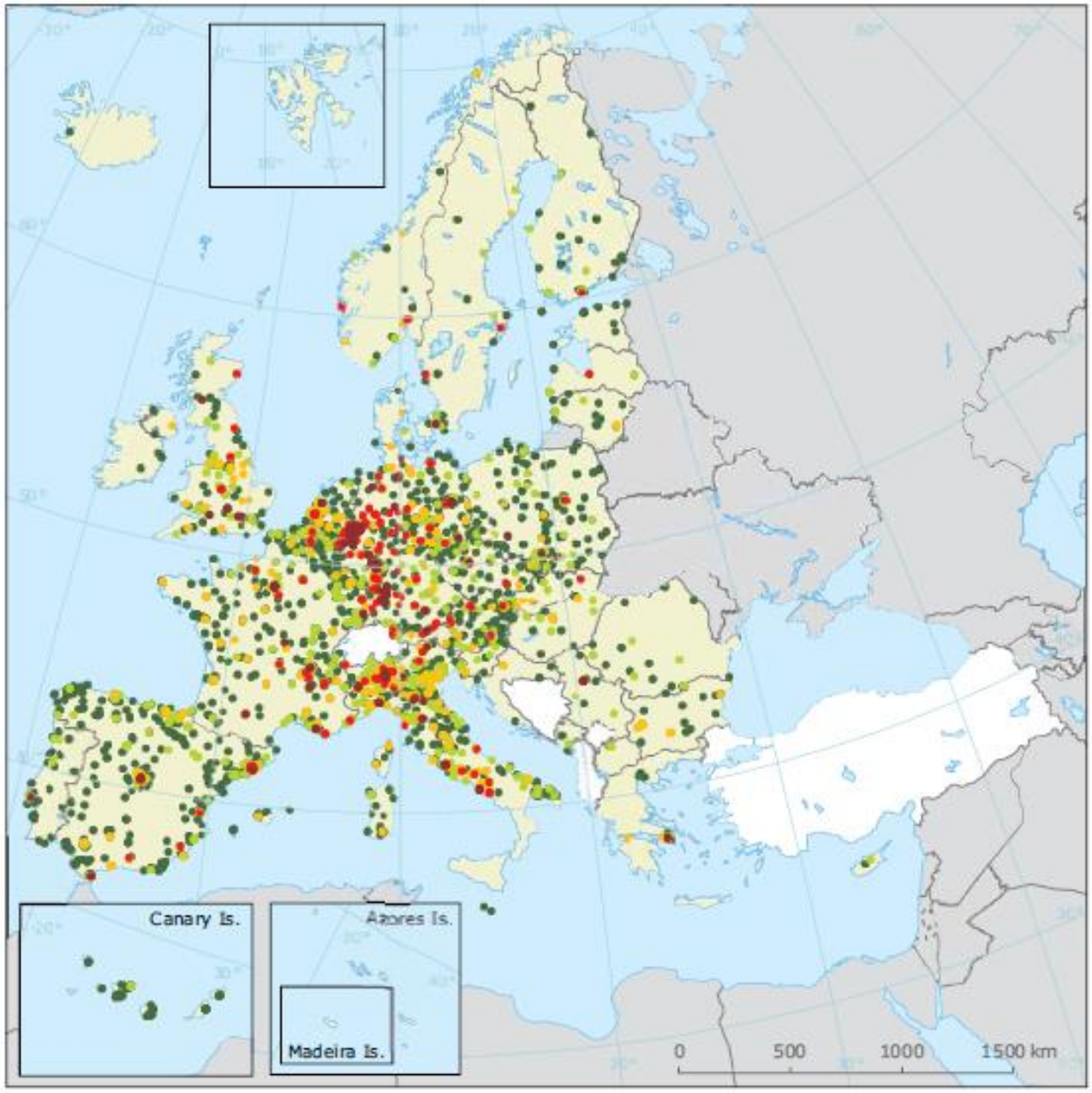


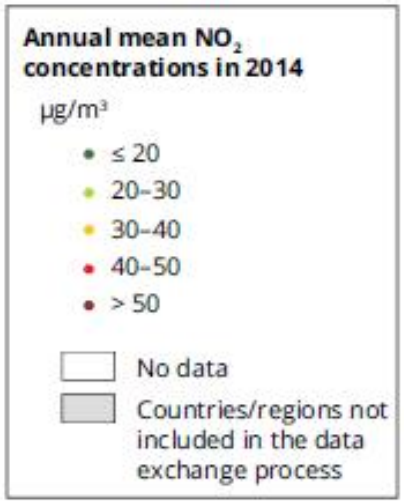
$PM_{2.5}$ annual mean Limit Value = 25 µg/m³

WHO AQG =10 µg/m³

EEA 2016

Annual mean NO_2 concentrations, 2014



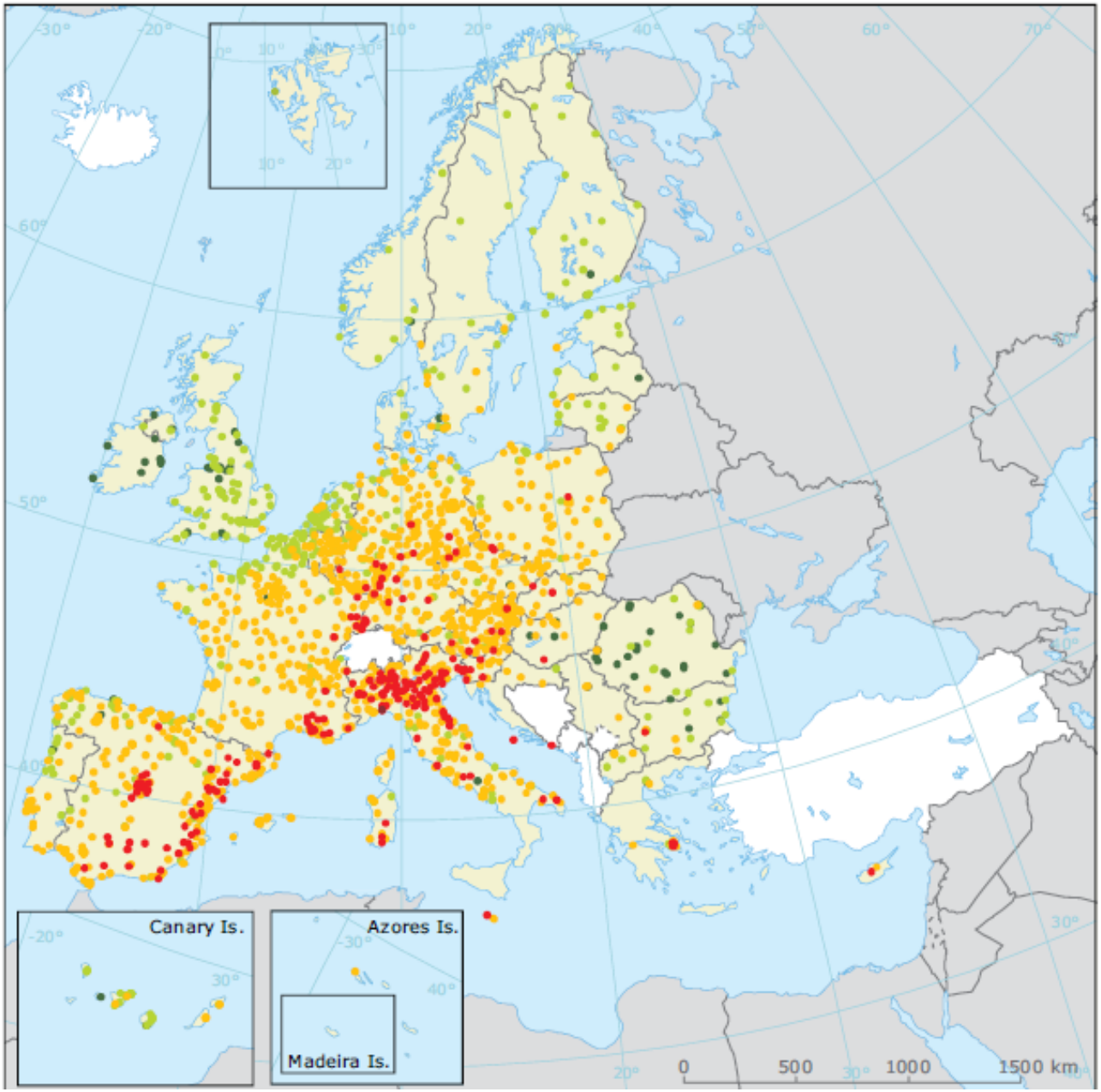


NO_2 annual mean Limit Value = 40 µg/m³

WHO AQG =40 µg/m³

EEA 2016

Maximum daily 8-h O_3 concentrations, 2014



93.2 percentile of O_3 maximum daily 8-hours mean in 2014

µg/m³

- ≤ 80
- 80–100
- 100–120
- 120–140
- > 140

No data

Countries/regions not included in the data exchange process

O_3 Target Value: 120 µg/m³ not to be exceeded for more than 25 days/yr (3 yr. average)

WHO AQG=100 µg/m³

EEA 2016

Strength of evidence on health effects of $PM_{2.5}$, NO_2 and O_3

Systematic reviews:

for PM: US EPA 2009
for NO2: US EPA 2016 / HC 2016
for O3: US EPA 2013

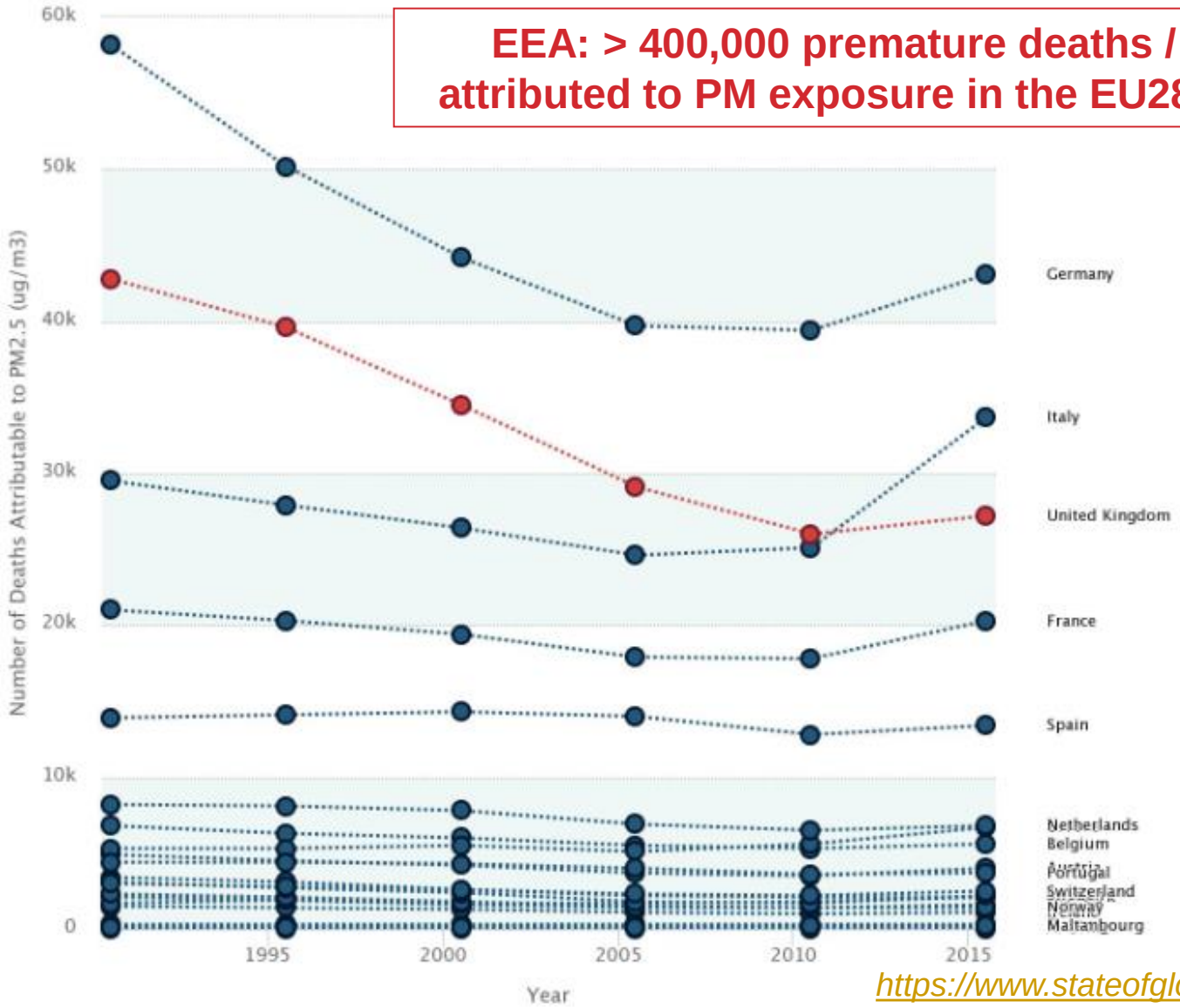
C – causal
L – likely causal
S – suggestive for causal

Outcome	PM2.5		NO2		O3	
	Long	Short	Long	Short	Long	Short
Total mortality	C	C	S / S	S / L	S	L
CV mortality	C	C				
Respiratory mortality	C	C				
Lung cancer	- /C[1]					
Respiratory effects	L	L	L / L	C / C	L	C
CV effects		C				L

[1] IARC 2013 (Group 1)

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.

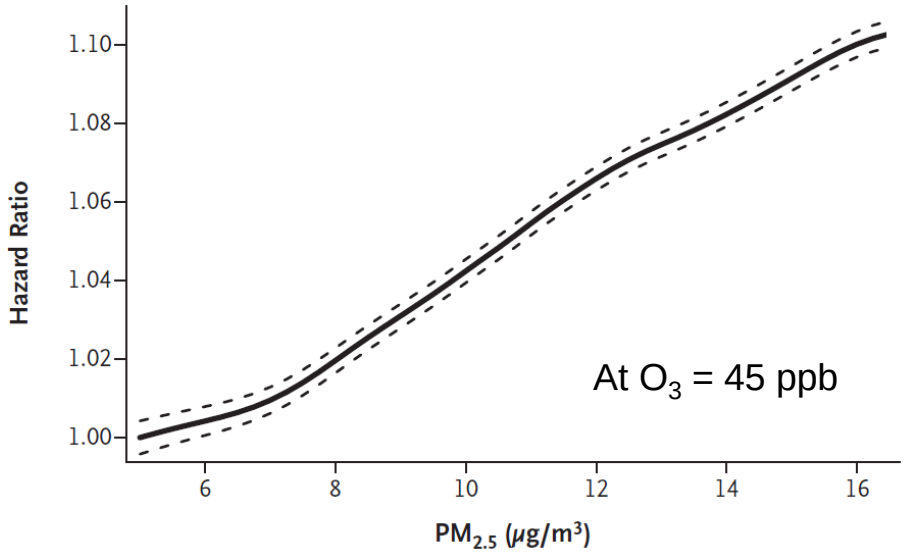
NEJM 29 June 2017

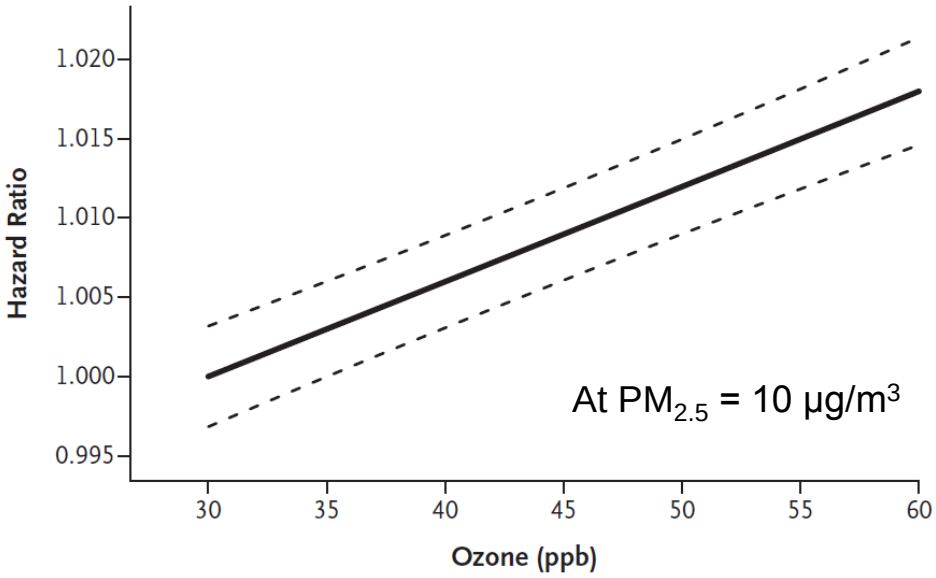
60,925,443 persons (age 65+) followed 2000- 2012; $PM_{2.5}$ and O_3 long term exposure estimated for the ZIP of residence

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

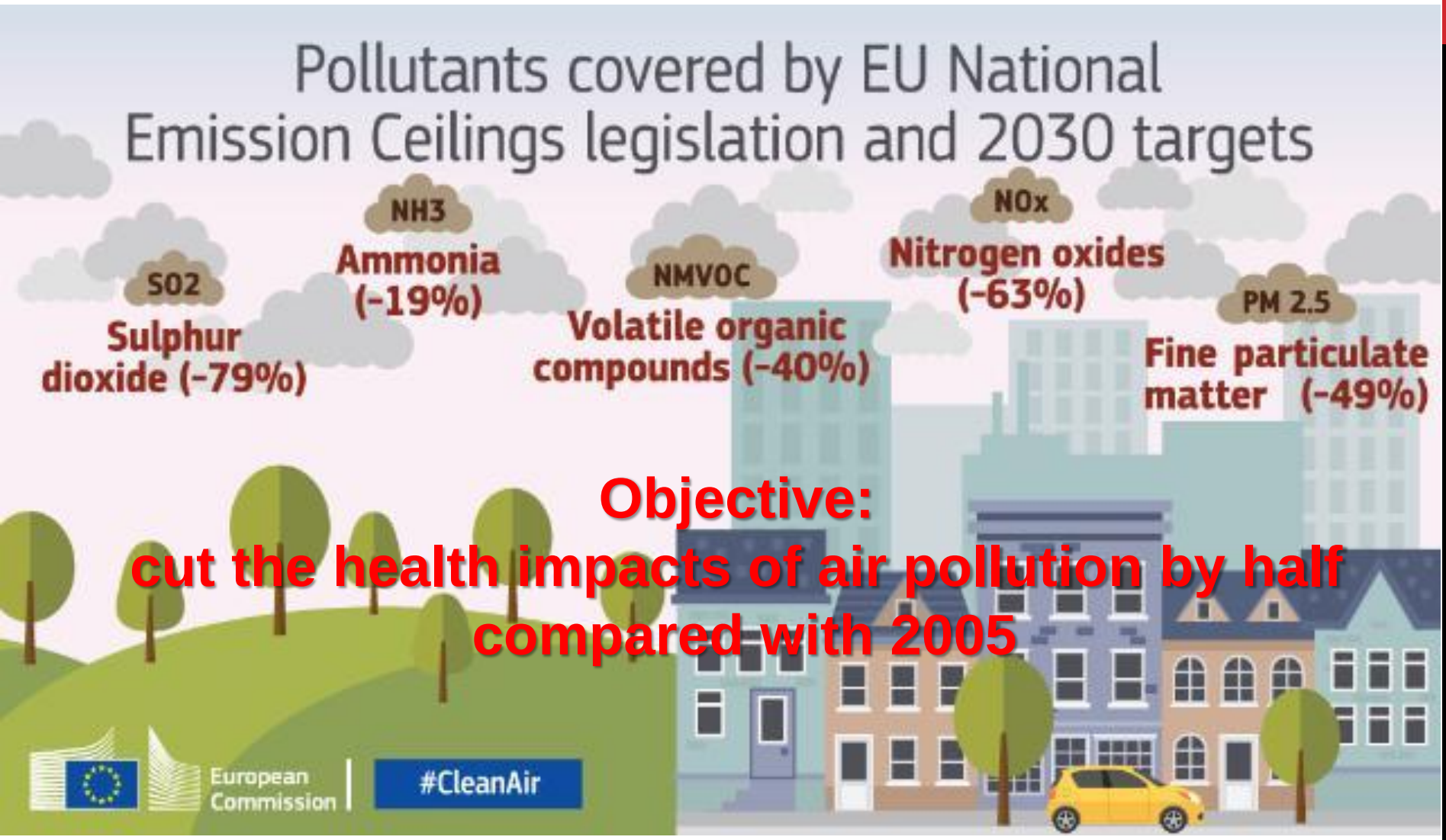
HR = 1.073 (1.071 – 1.075) per 10 μg/m³ $PM_{2.5}$

HR = 1.011 (1.010 – 1.012) per 10 ppb ozone

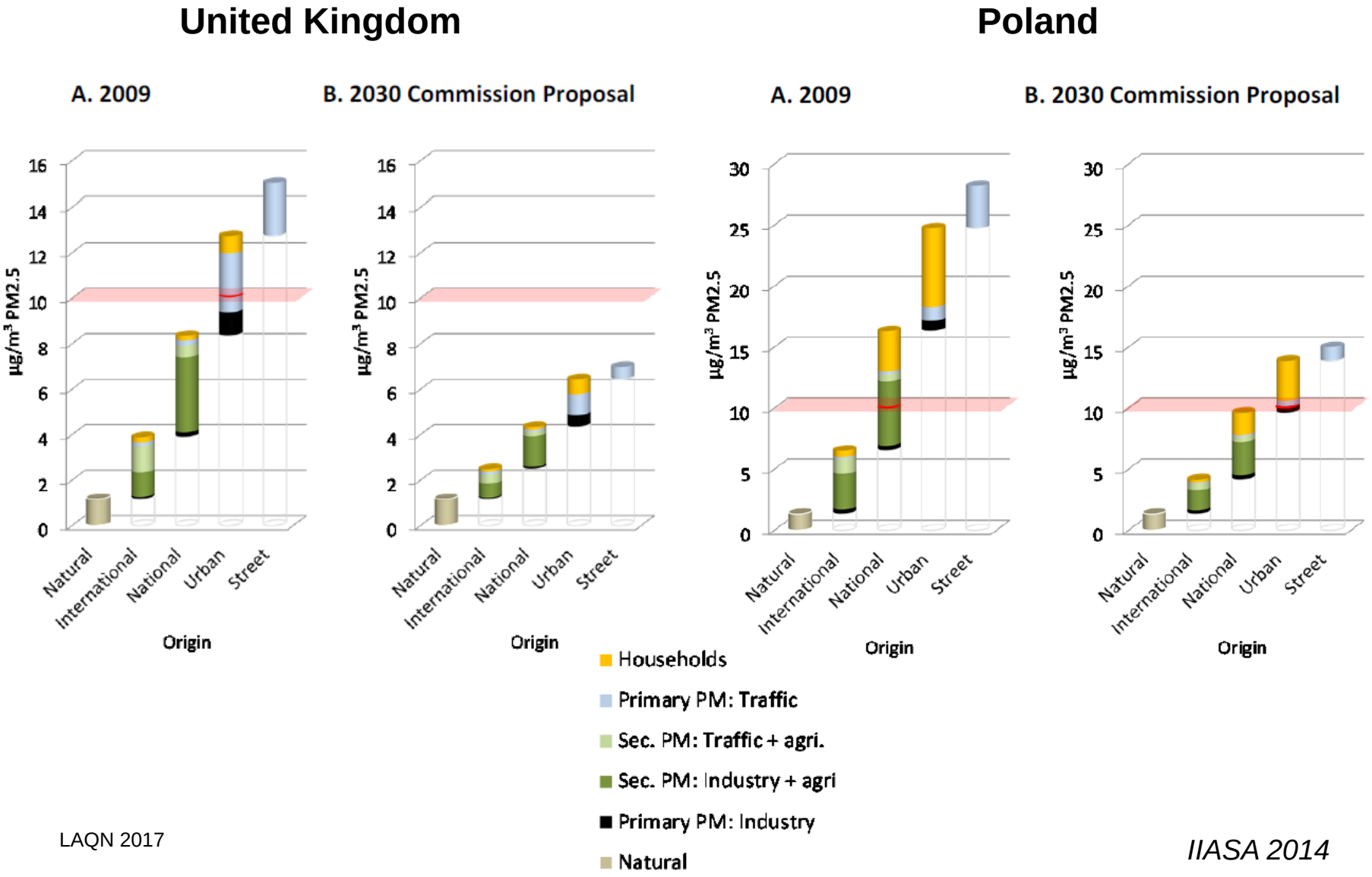




National Emission Ceiling directive 2016/2284/EU



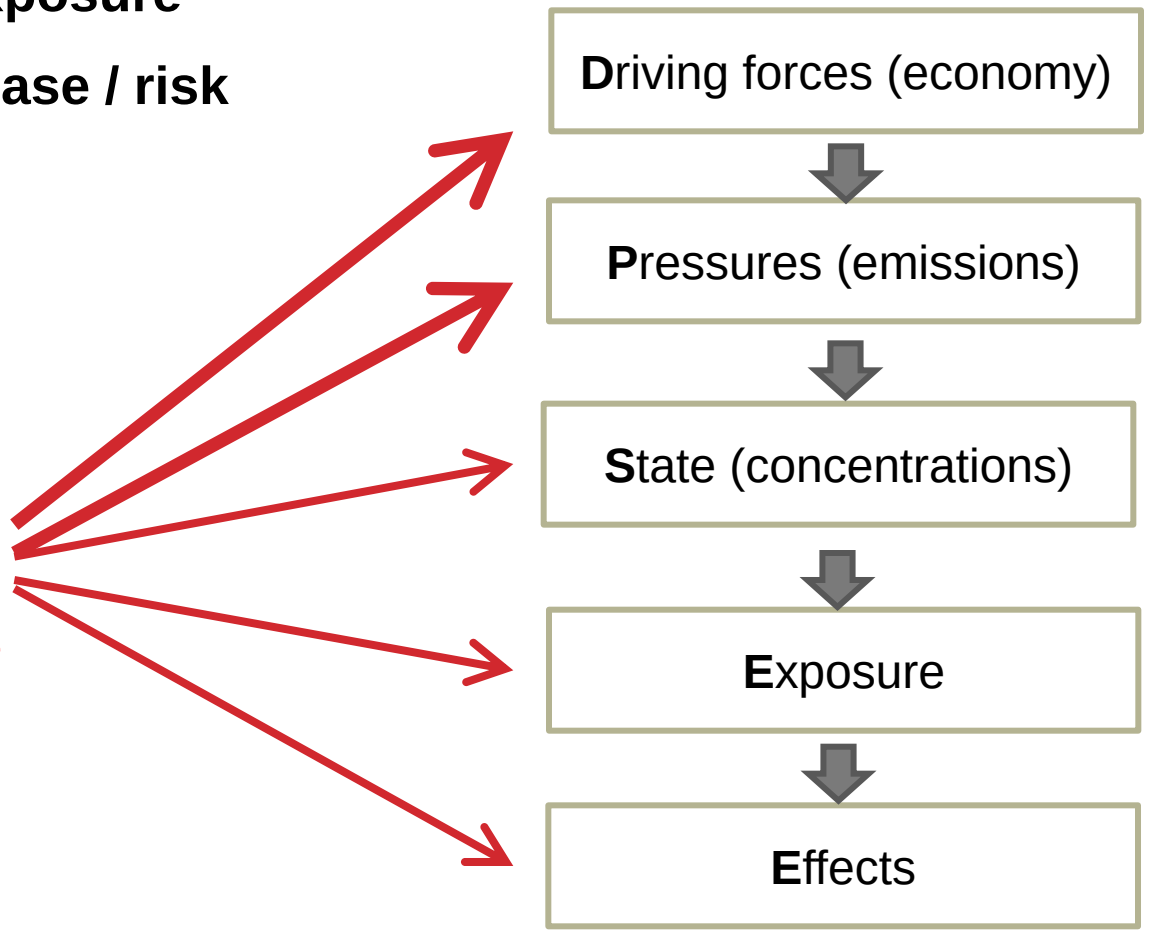
Source contributions to ambient PM2.5 at urban traffic stations in UK and Poland, in the base year 2009 and for 2030 assuming adoption of the EU Clean Air Policy Package



Is more health research needed to cope with air pollution?

- ✓ **Causality of exposure**
- ✓ **Burden of disease / risk assessment**

ACT NOW!!!
The evidence is sufficient!



Knowledge

Action

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

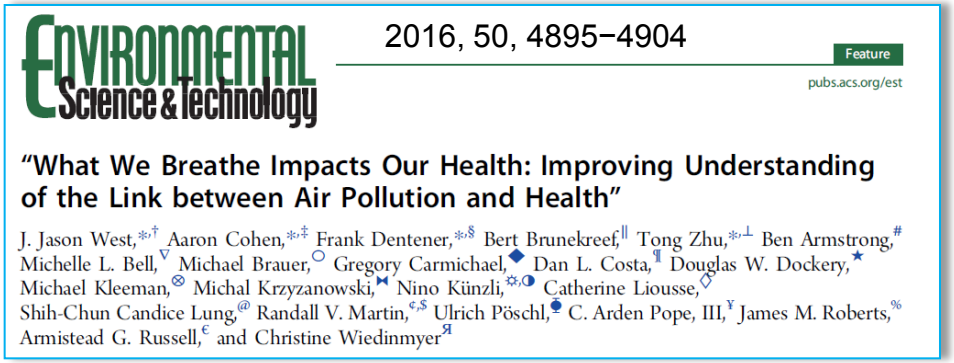
David A. Savitz *Epidemiology 2016*

➡ **Risk assessment**

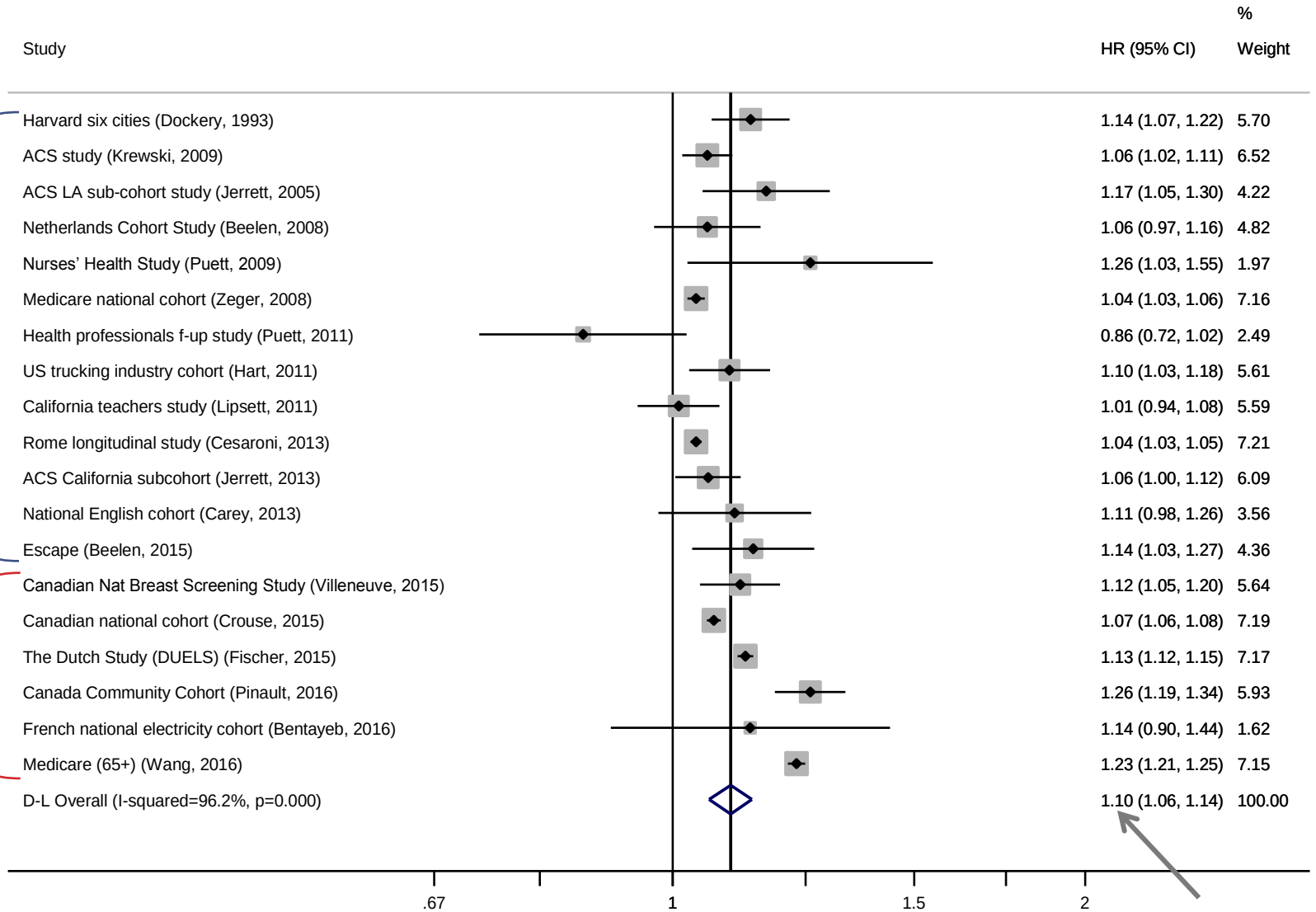
Research to improve exposure – response functions

- **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 μg/m^3 increase) and Non-accidental Mortality



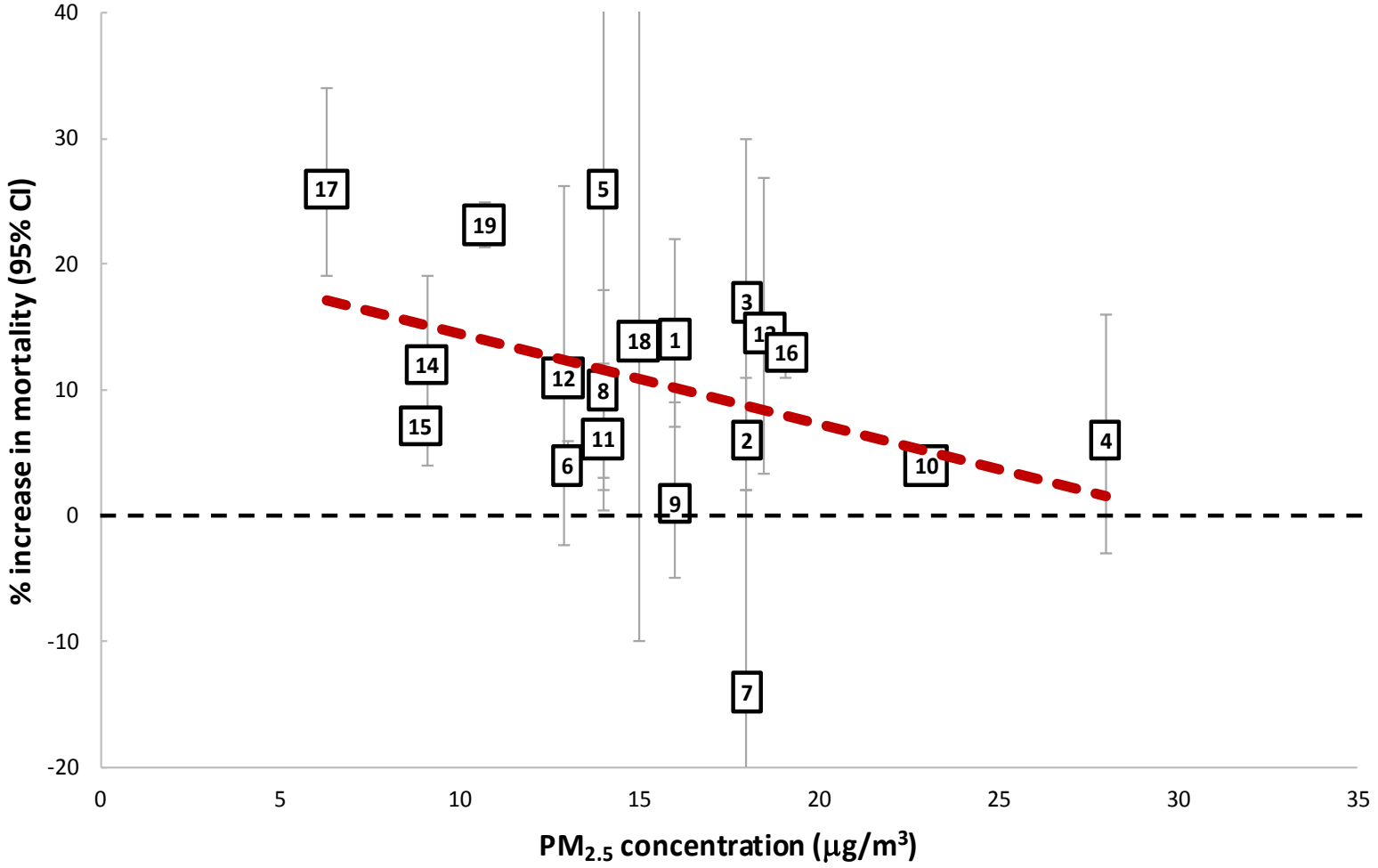
HR=1.07

2015-16

HR= 1.10

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.

LAQN 2017

Forastiere et al, WHO 2017

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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.*

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

Below 12 μg/m³ for $PM_{2.5}$ and below 50 ppb for O_3
† Within 50 km

Health effects of NO2

COMEAP
COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

March 2015

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 (NO_2) in outdoor air with adverse effects on health, including reduced life expectancy. It has been unclear whether these effects are caused by NO_2 itself or by other pollutants emitted by the same sources (such as traffic). Evidence associating NO_2 with health effects has strengthened substantially in recent years and we now think that, on the balance of probability, NO_2 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

Environ Res 2016

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

Angela Clifford [a], Linda Lang [a,b], Ruoling Chen [a,b,*], Kaarin J. Anstey [c], Anthony Seaton [d]

www.thelancet.com **January 4, 2017**

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

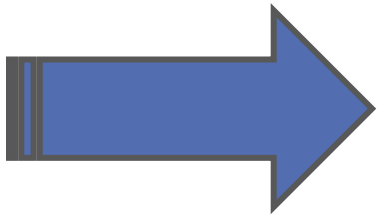
Hong Chen, Jeffrey C Kwong, Ray Copes, Karen Tu, Paul J Villeneuve, Aaron van Donkelaar, Perry Hystad, Randall V Martin, Brian J Murray, Barry Jessiman, Andrew S Wilton, Alexander Kopp, Richard T Burnett

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

Amar J. Mehta,[1] Antonella Zanobetti,[1] Marie-Abele C. Bind,[1] Itai Kloog,[2] Petros Koutrakis,[1] David Sparrow,[3,4,5] Pantel S. Vokonas,[3,5] and Joel D. Schwartz[1,4]

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, …)?**



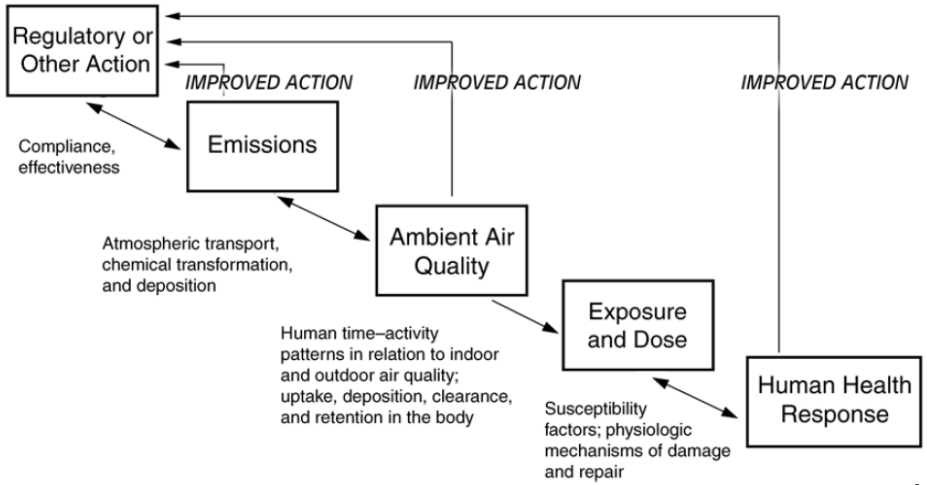
Understanding of disease causation;

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 <u>conditions</u> 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!



HEI 2016

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?