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HEALTH EFFECTS OF AIR POLLUTION IN EUROPE

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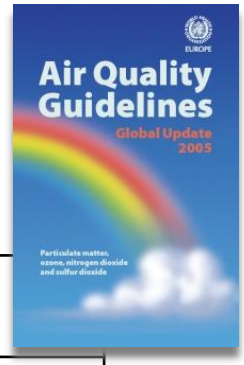
This presentation:

- Health effects co outdoor air pollutants:
  - Particulate matter;
  - NO_2;
  - Ozone;
- Health effects of indoor air pollutants - CO
- Air pollutants exposure assessment (…sensors)

WHO AQG: Global update 2005: Summary of AQG values

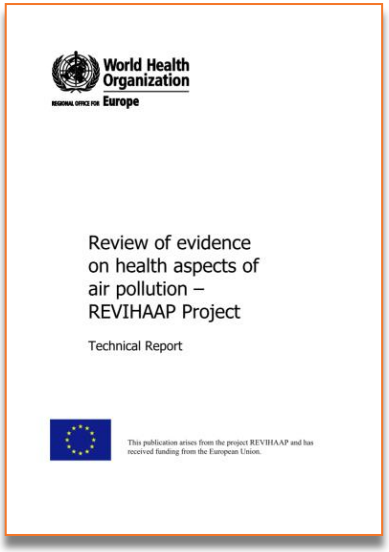


Pollutant	Averaging time	AQG value
Particulate matter		
$PM_{2.5}$	1 year	10 µg/m^3
	24 hour (99th percentile)	25 µg/m^3
PM_{10}	1 year	20 µg/m^3
	24 hour (99th percentile)	50 µg/m^3
Ozone, O_3	8 hour, daily maximum	100 µg/m^3
Nitrogen dioxide, NO_2	1 year	40 µg/m^3
	1 hour	200 µg/m^3
Sulfur dioxide, SO_2	24 hour	20 µg/m^3
	10 minute	500 µg/m^3

AQG levels recommended to be achieved everywhere in order to significantly reduce the adverse health effects of pollution

Recent WHO reviews of evidence on health effects of air pollution

1. "Review of evidence on health aspects of air pollution - REVIHAAP"
   http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf



2. "Health risks of air pollution in Europe – HRAPIE: Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide"
   http://www.euro.who.int/__data/assets/pdf_file/0006/238956/Health-risks-of-air-pollution-in-Europe-HRAPIE-project,-Recommendations-for-concentrationresponse-functions-for-costbenefit-analysis-of-particulate-matter,-ozone-and-nitrogen-dioxide.pdf?ua=1

REVIHAAP: selected conclusions on PM

The scientific conclusions of the 2005 WHO Guidelines about the evidence for a causal link between $PM_{2.5}$ and adverse health outcomes in humans have been confirmed and strengthened and, thus, clearly remain valid.

- New studies on short- and long-term effects;
- Long-term exposures to $PM_{2.5}$ are a cause of cardiovascular mortality and morbidity;
- More insight on physiological effects and plausible biological mechanisms linking short- and long-term $PM_{2.5}$ exposure with mortality and morbidity;
- Studies linking long-term exposure to $PM_{2.5}$ to several new health outcomes (e.g. atherosclerosis, adverse birth outcomes, childhood respiratory disease).

IARC: Air pollution causes cancer

The carcinogenicity of outdoor air pollution

In October, 2013, 24 experts from 11 countries met at the International Agency for Research on Cancer (IARC), Lyon, France, to assess the carcinogenicity of outdoor air pollution. This assessment was the last in a series that began with specific combustion products and sources of air pollution and concluded with the complex mixture that contains all of them. The results of this most recent assessment will be published as volume 109 of the IARC Monographs.[1]

Outdoor air pollution is a mixture of

The IARC Working Group unanimously classified outdoor air pollution and particulate matter from outdoor air pollution as carcinogenic to humans (IARC Group 1), based on sufficient evidence of carcinogenicity in humans and experimental animals and strong mechanistic evidence.

The findings regarding the carcinogenicity of outdoor air pollution as a mixture, and of particulate matter specifically, are remarkably consistent in epidemiological research, studies of cancer in experimental animals, and a

to traffic or traffic emissions, in studies that were adjusted for tobacco smoking. However, most studies assessed exposure only by employment in occupations with potentially high exposure to outdoor air pollution, so the results did not weigh heavily in the evaluation.

The Working Group also reviewed evidence regarding the carcinogenicity of outdoor air pollution in experimental animals. As part of this process, the IARC's earlier evaluations of diesel engine

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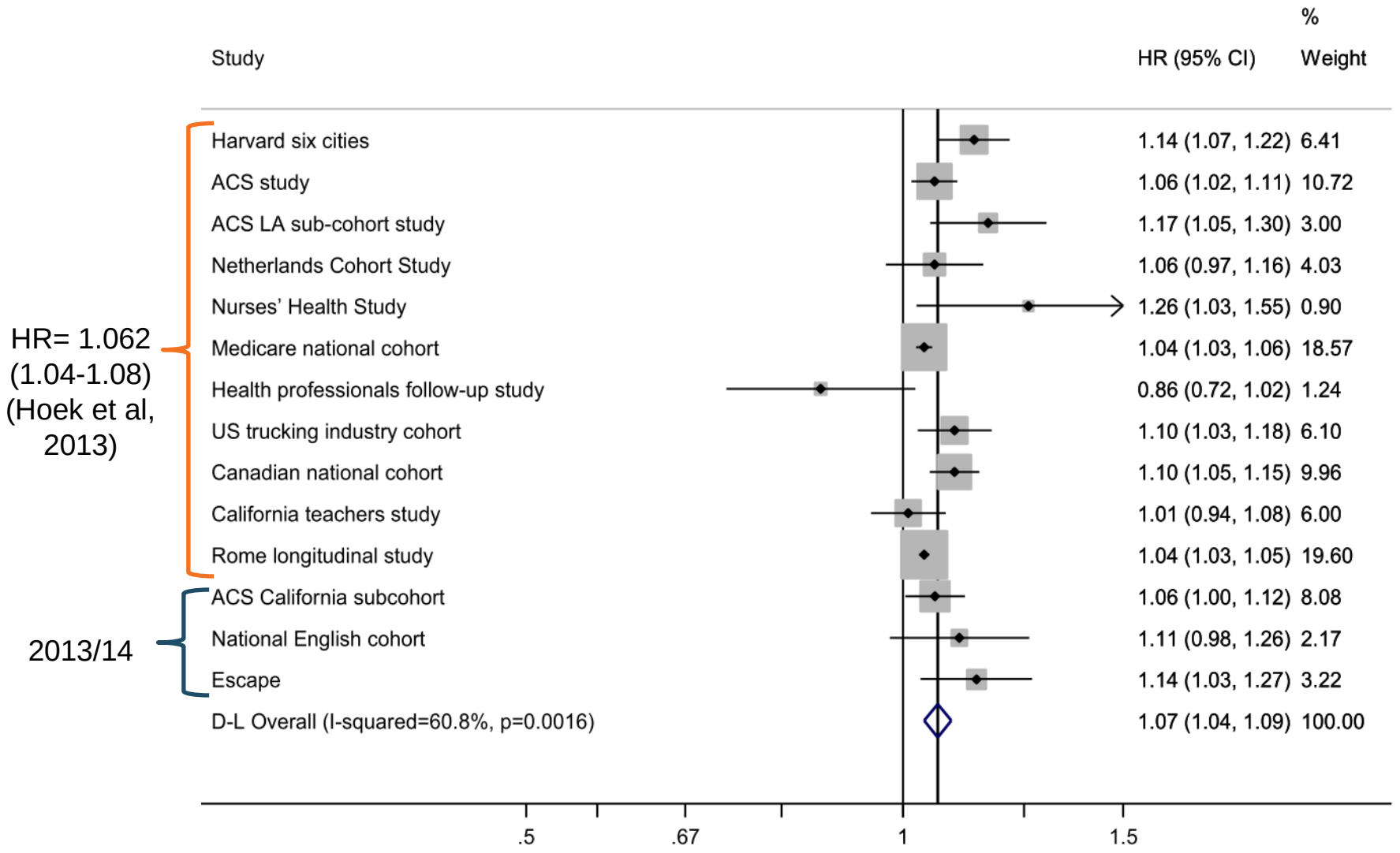
For more on the **IARC Monographs** see http://monographs.iarc.fr/

Meta-analysis of the association between long-term exposure to PM2.5 and all-cause (natural) mortality

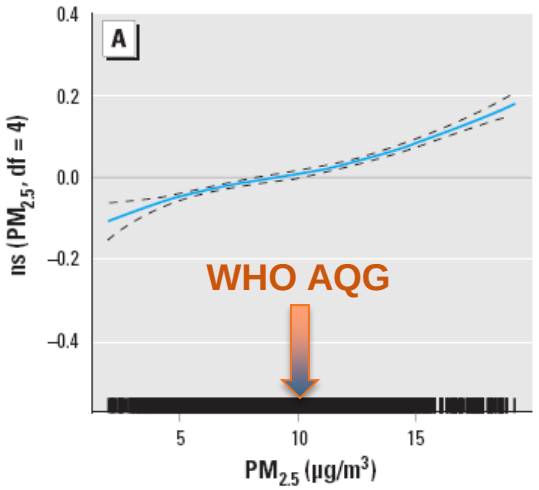


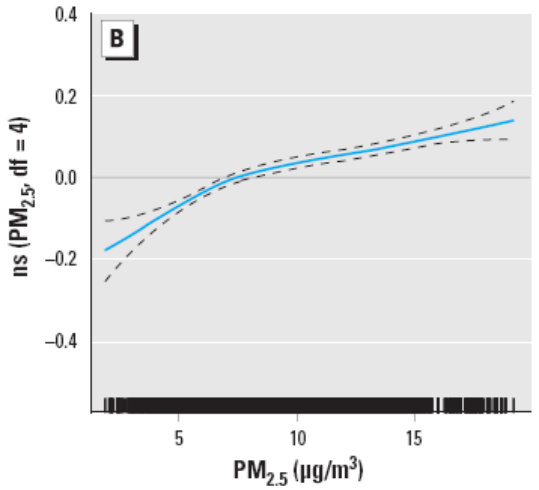
Forastiere et al, WHO 2014

Mortality and long-term PM2.5 exposure

Results of a Canadian cohort study (2.1 million adults, 1991-2001)

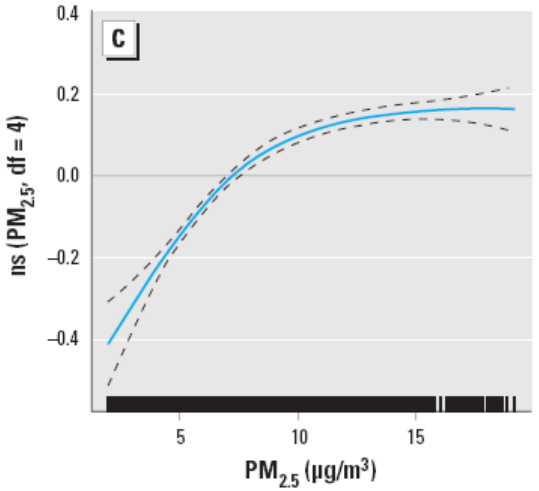
All non-accidental

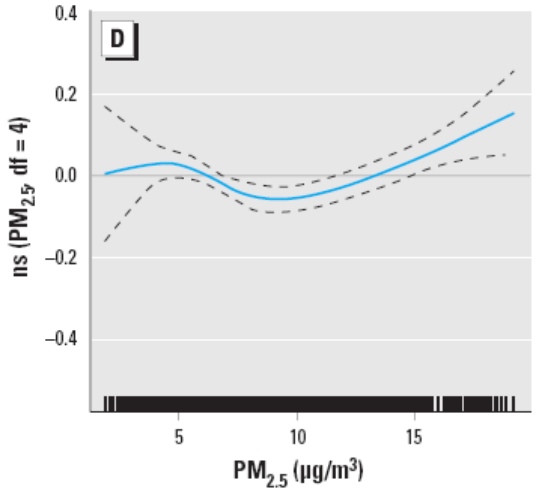




Cardiovascular

Ischemic heart disease

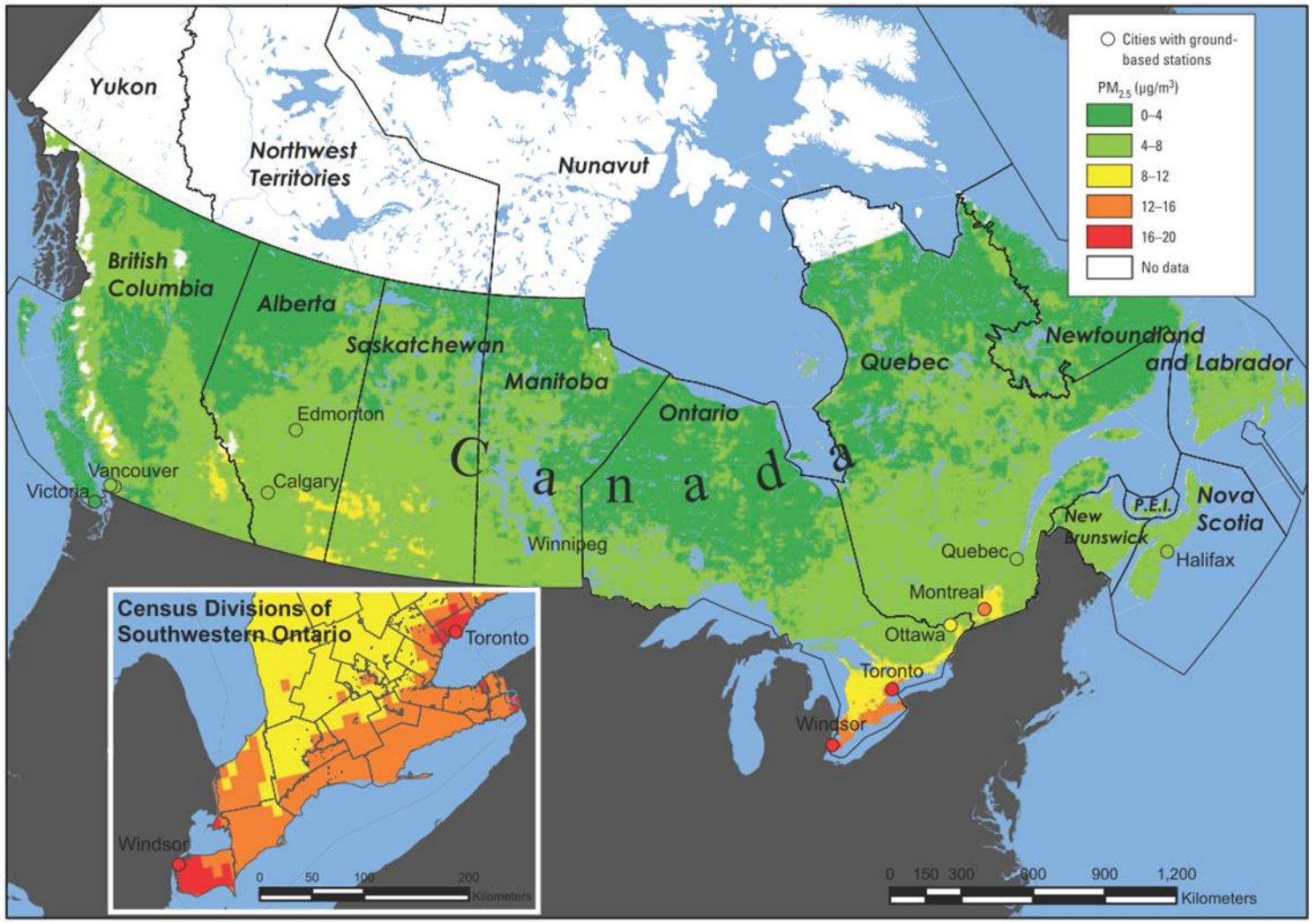




Cerebrovascular

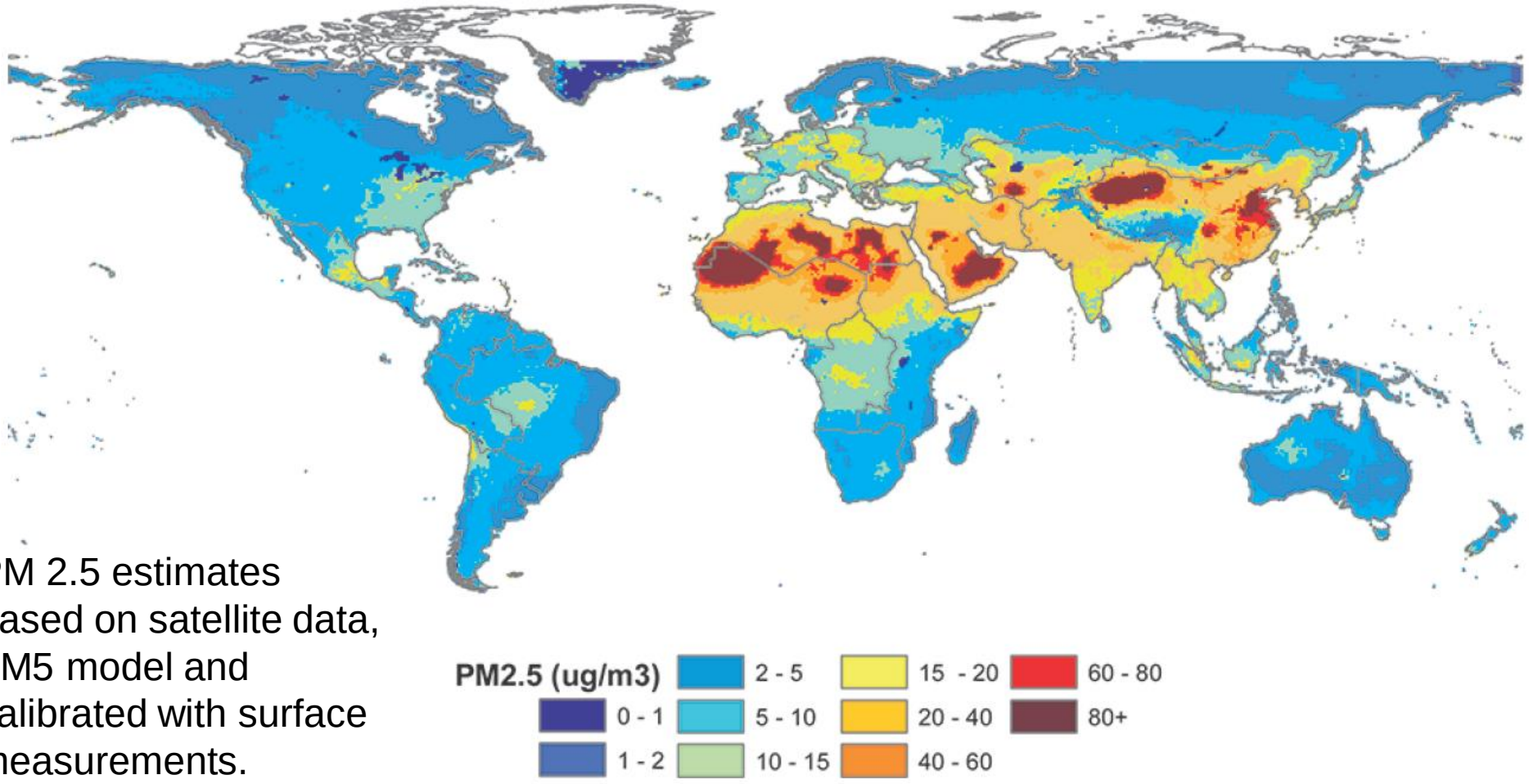
Crouse et al, EHP 2012

Mean satellite-derived estimates of $PM_{2.5}$ across Canada, 2001–2006



Crouse et al, EHP 2012

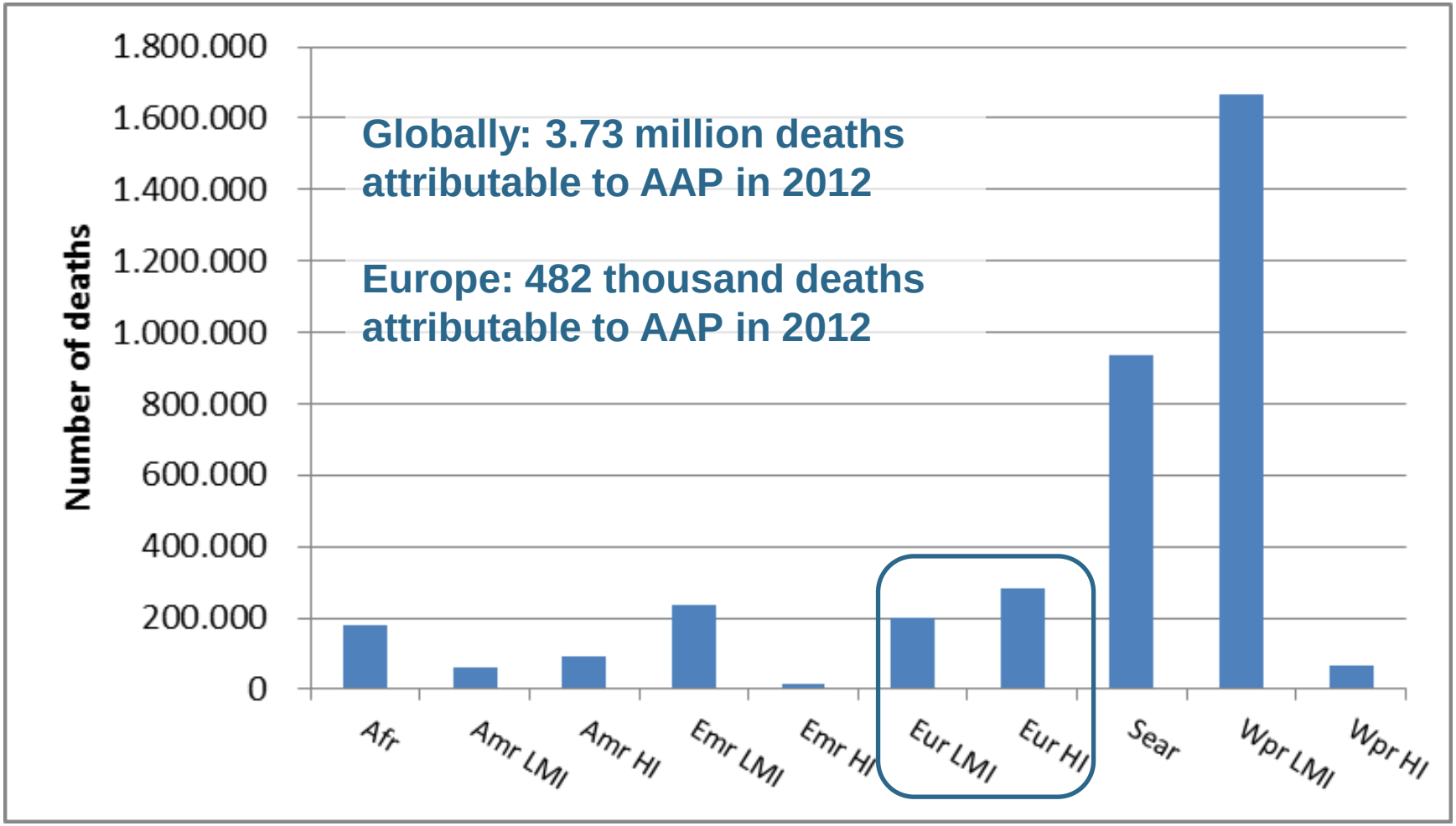
Estimated 2005 annual average PM2.5 concentrations – GBD2010 project



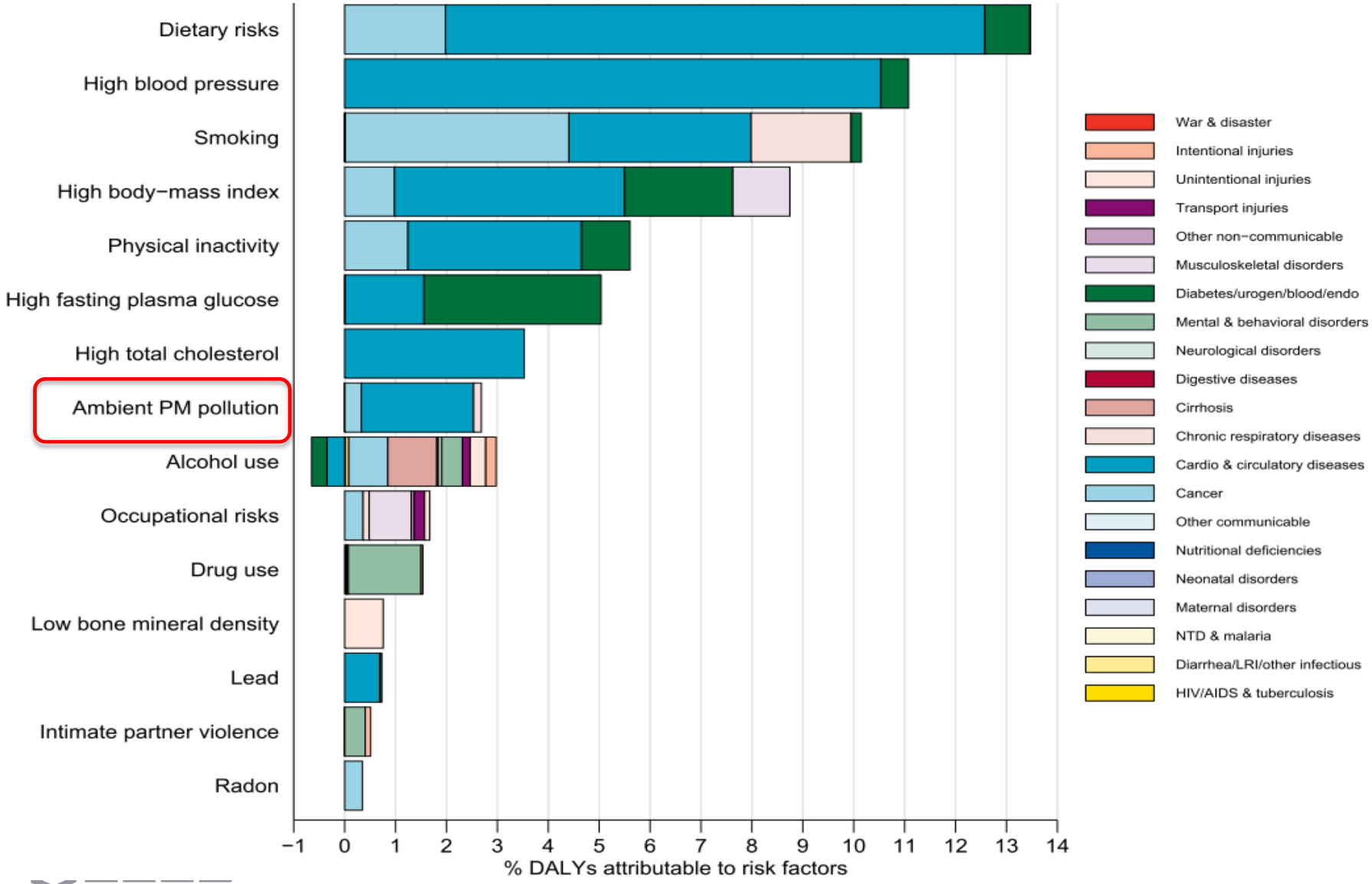
PM 2.5 estimates based on satellite data, TM5 model and calibrated with surface measurements.

Brauer et al, Env Sc Technol. 2012

Health burden of ambient air pollution in 2012: WHO estimates



Burden of disease attributable to 15 leading risk factors in Italy, 2010, (% Italy DALYs): GBD 2010 study



http://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_italy.pdf

Health indicators functionally related to PM2.5 or PM10 exposure: HRAPIE project results

Effects of long-term exposure:

- Mortality, all (natural) cause, age 30+
- Mortality, CVDs, ischaemic heart disease, COPD, trachea, bronchus and lung cancer, age 30+;
- Post-neonatal infant mortality (all cause);
- Prevalence of bronchitis in children;
- Incidence of chronic bronchitis in adults.

Effects of short-term exposure:

- Mortality, all cause, all ages;
- Hospital admissions for CV and respiratory diseases, all ages;
- Restricted activity days, all ages;
- Work days lost, age 20-65;
- Incidence of asthma symptoms in asthmatic children, age 5–19 years.

REVIHAAP: Specific effects of PM components or indicators

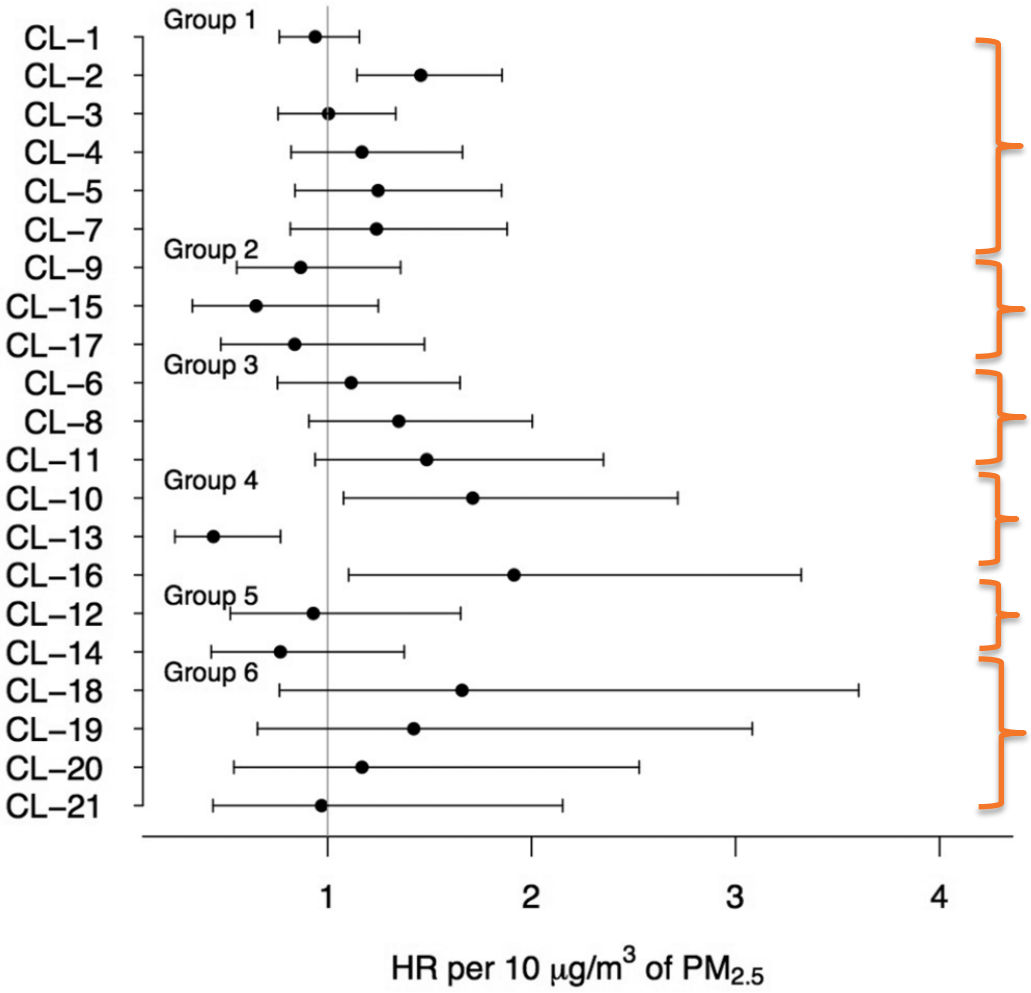
- Black carbon, secondary organic aerosols, and secondary inorganic aerosols may provide valuable metrics for the effects of mixtures of pollutants from a variety of sources.

- Short-term exposures to coarse particles (including crustal material) are associated with adverse respiratory and cardiovascular health effects, including premature mortality.

- There is increasing, though as yet limited, epidemiological evidence on the association between short-term exposures to ultrafine (< 0.1 µm) particles and cardiorespiratory health, as well as the health of the central nervous system.

PM2.5 and survival: effects modification by PM composition

Over 19 million US adults (age 65+) followed 2000-2010 in 81 US cities; ca. 6 million deaths recorded



1. Eastern US, High sulfate
2. Low sulfate, high nitrate and K
3. Midwest US: high sulfate, nitrate, Mn, Zn, Fe, Pb
4. Seaports: high Na, Cl, K (sea); high Ni, V (heavy oil combustion)
5. West US: high Ca, Si, Ti, Fe
6. Single city clusters

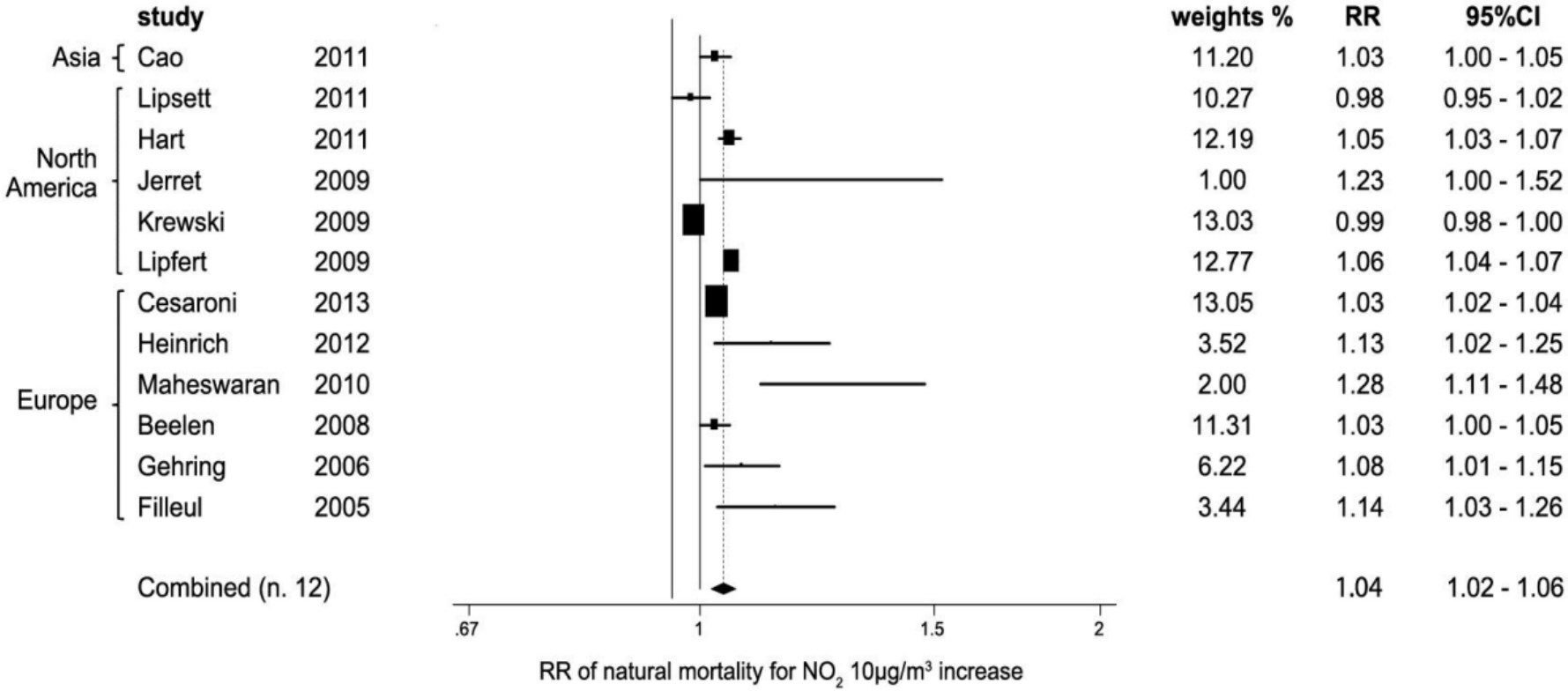
Clusters of cities with similar composition of PM

Kioumourtzoglou et al, 2015

REVIHAAP: selected conclusions on NO_2

- New studies document associations between day-to-day variations in NO_2 and variations in mortality, hospital admissions, and respiratory symptoms;
- New studies showing associations between long-term exposure to NO_2 and mortality and morbidity;
- Both short- and long-term studies have found these adverse associations at concentrations that were at or below the current EU LV (= WHO AQG);
- The associations between NO_2 and short-term health effects in many studies remain after adjustment for other pollutants (including PM_{10}, $PM_{2.5}$, black smoke);
- … **it is reasonable to infer that NO_2 has some direct effects.**

Meta-analysis of the association between long-term exposure to NO_2 and all-cause (natural) mortality

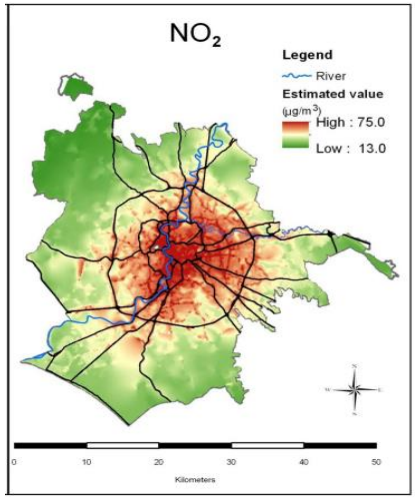


Test for heterogeneity: $\chi^2 = 102.28$ dl = 11
$p = 0.001$ $I^2 = 89\%$
Test for overall effect: $z = 3.632$ $p = 0.001$

Comment: 3 studies from 2013/14 – lower RRs

Faustini et al 2014

NO_2 and mortality: cohort study in Rome (1.3 million adults followed from 2001 to 2010)

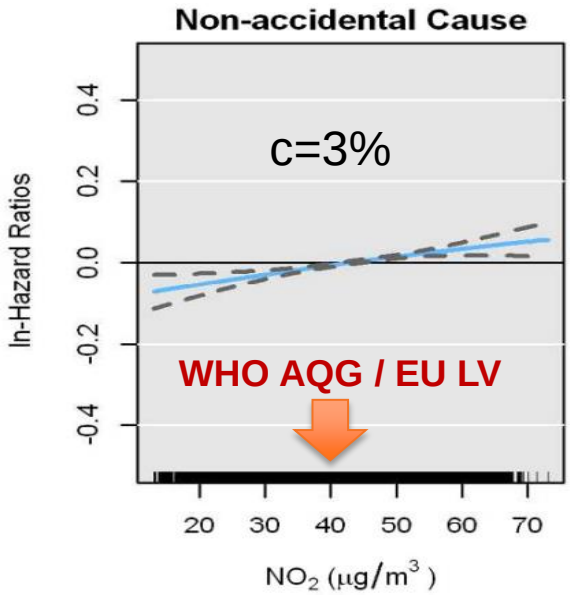


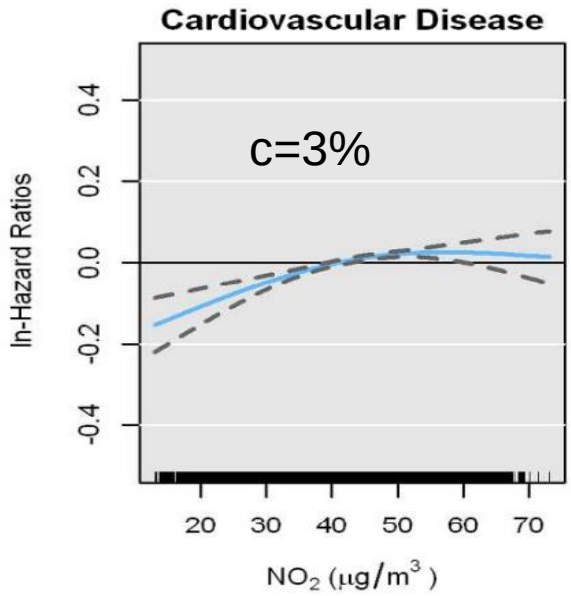
Long term mean NO_2 estimates:

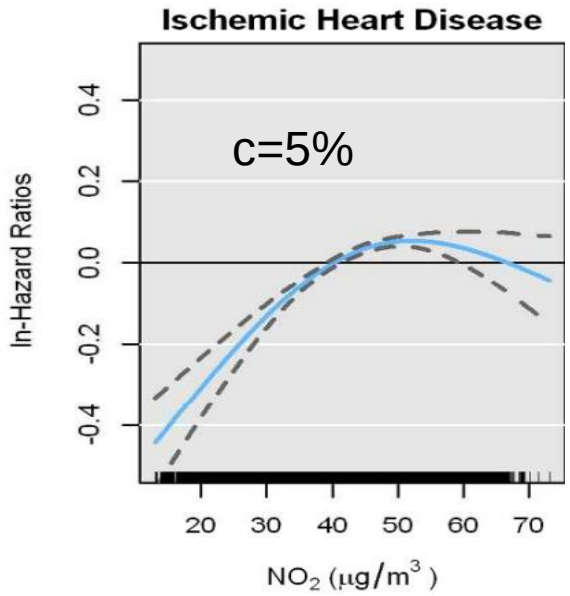
- Ogawa badges in 78 sites, 1-week in Feb, May, Oct 2007
- LUR model

Quintiles of NO_2: 37, 43, 46, 50 μg/m^3

c= % increase in risk per 10 μg/m^3

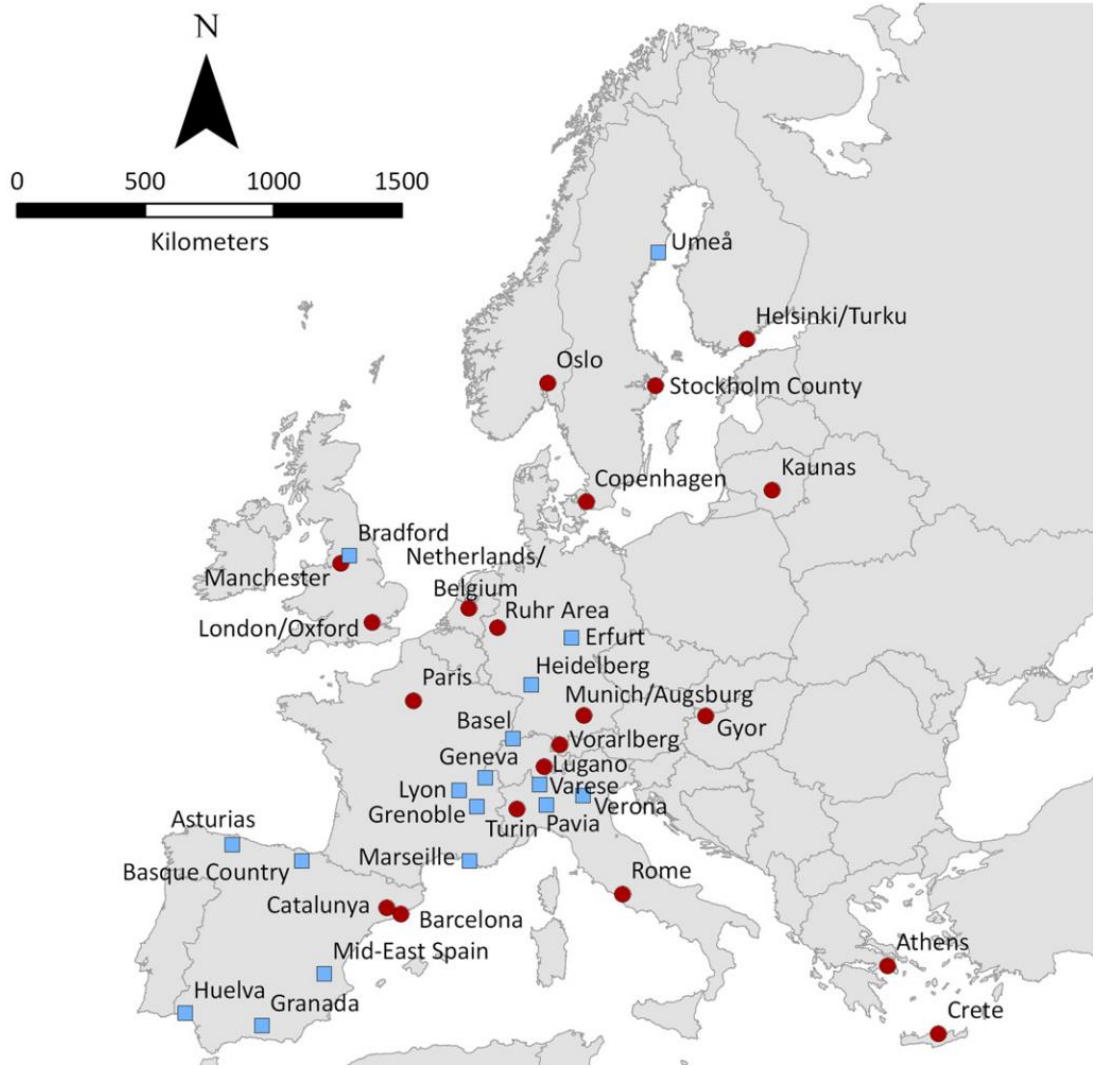






Cesaroni et al. EHP 2013

NO_2 assessment in ESCAPE



- NO_2 and NO_x (Ogawa badges)
- NO_2, NO_x and PM

14-80 monitoring sites in each location; total: >1400 sites across Europe

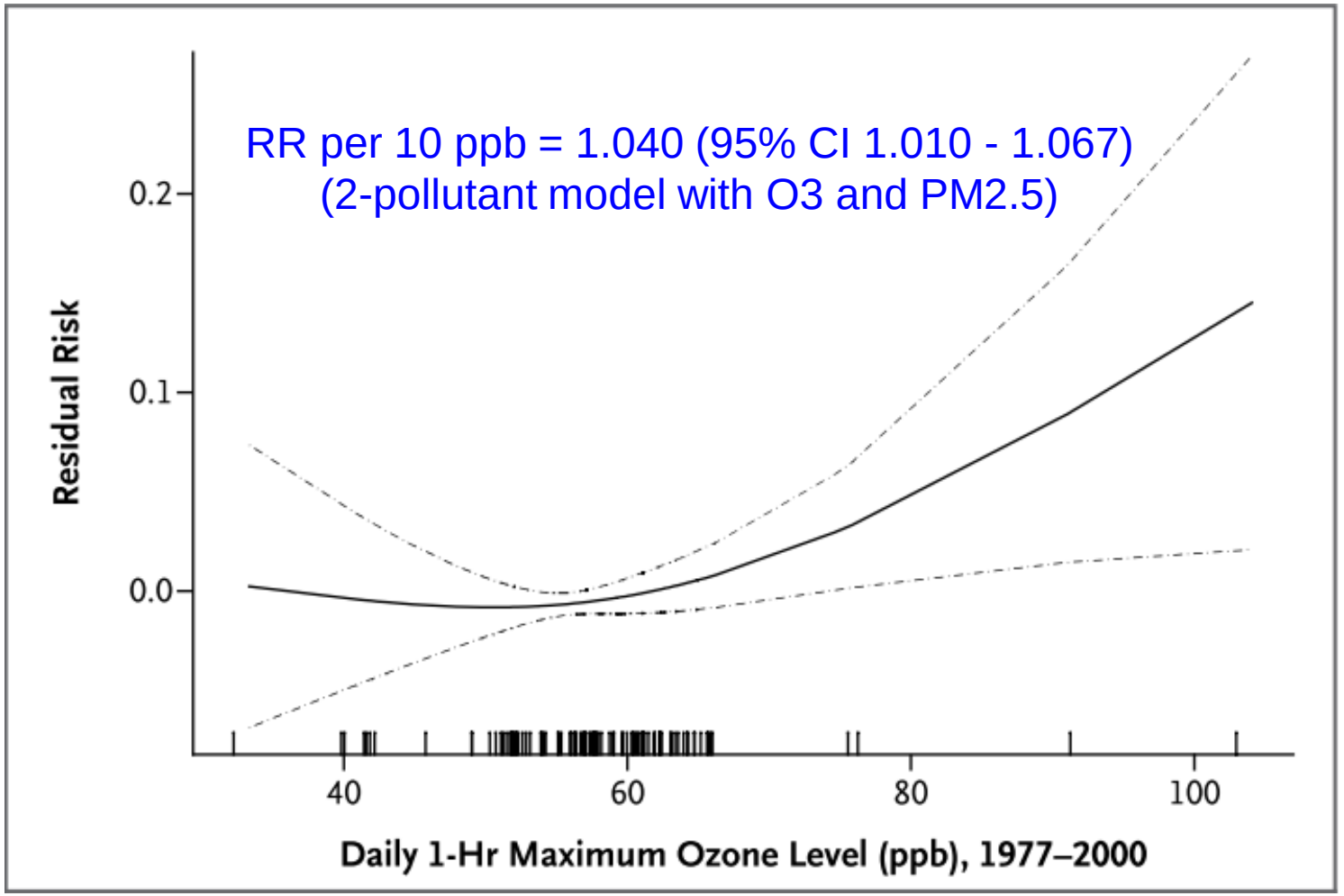
Cyrys et al, Atm Env 2012

REVIHAAP: selected conclusions on ozone

- Adverse effects of exposure to daily ozone concentrations (maximum daily 1-hr or 8-hr mean) on:
  - all-cause, cardiovascular and respiratory mortality;
  - respiratory and cardiovascular hospital admissions.
- The evidence for a threshold for short term exposure is not consistent, but where a threshold is observed, it is likely to lie below 90 µg/m^3 (max 1-hr).
- New evidence for an effect of long-term exposure to ozone on:
  - respiratory (and cardiorespiratory) mortality (ACS study);
  - mortality among persons with potentially predisposing conditions (COPD, diabetes, congestive heart failure, and myocardial infarction);
  - asthma incidence, asthma severity, hospital care for asthma and lung function growth.

Long term O3 exposure and risk of death due to respiratory causes

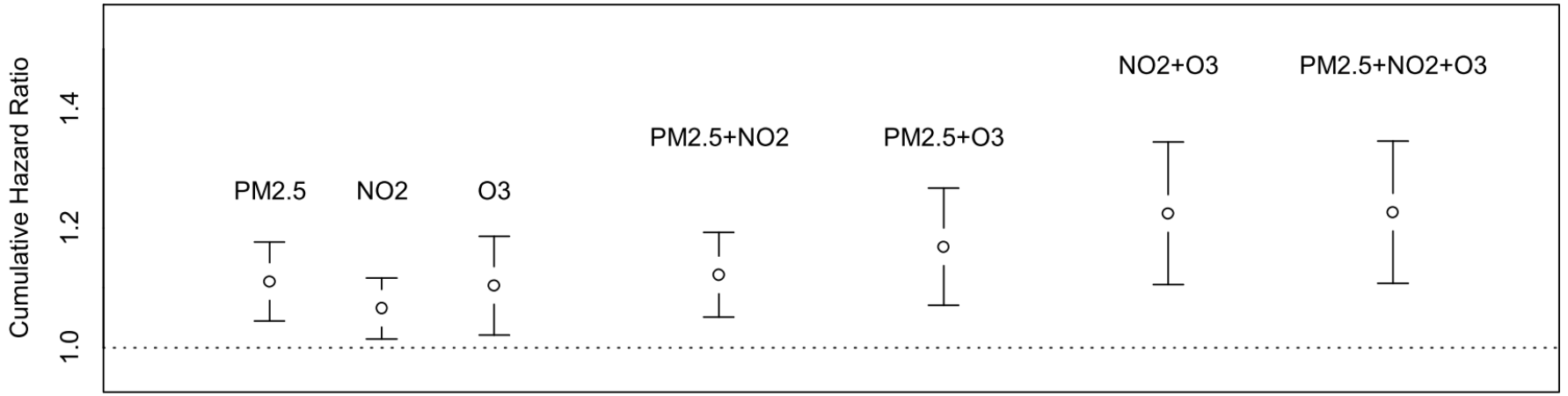
ACS cohort of 448 thousand adults followed for 18 years



Jerrett et al, NEJM 2009

Individual and multi-pollutant cumulative hazard ratios: IHD mortality

- 18 years follow up of 73,711 subjects from ACS cohort in California
- PM2.5 and NO2: LUR models
- O3: inverse distance weighting interpolation



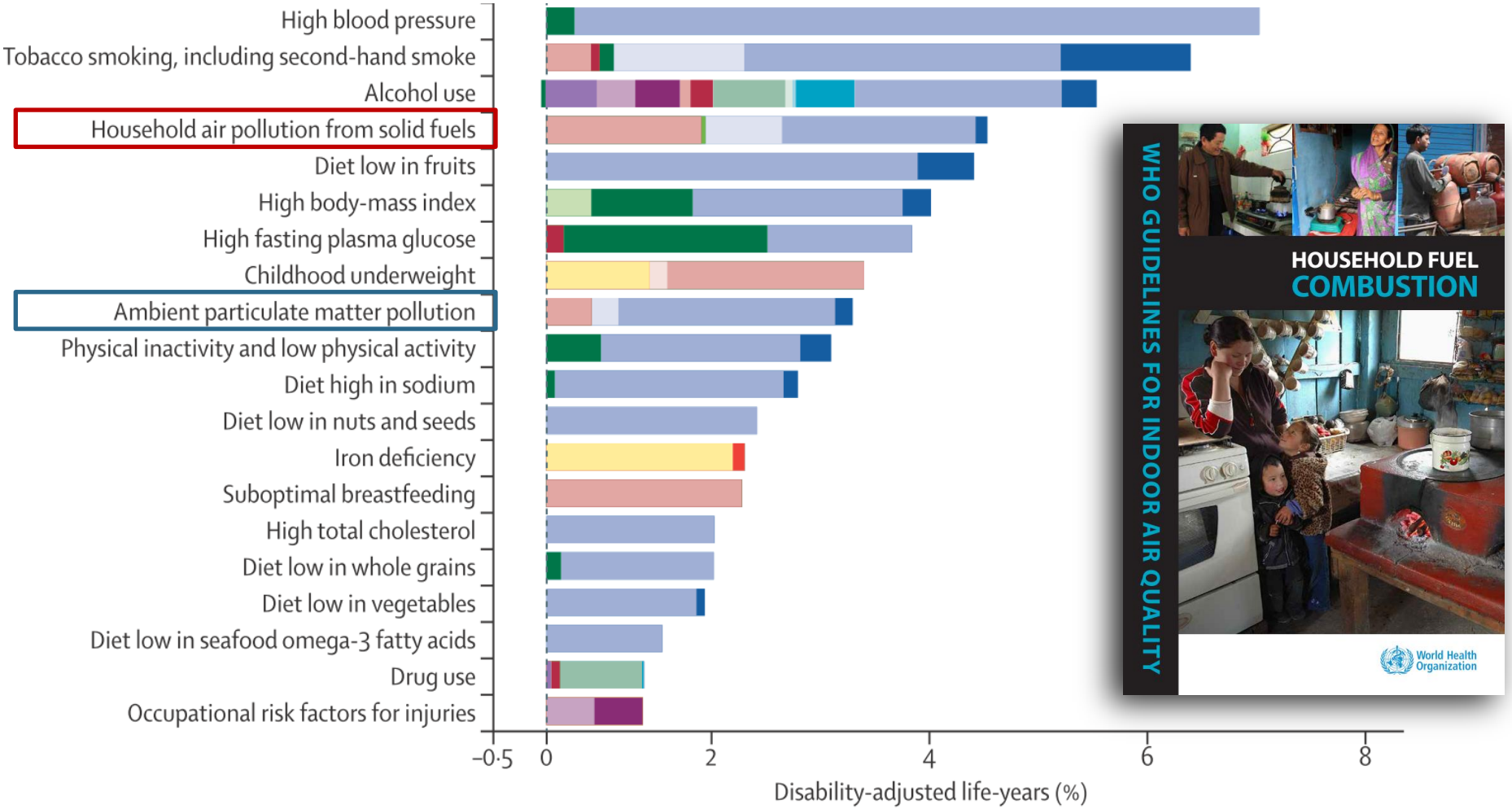
	$PM_{2.5}$ LUR	NO_2 LUR
$PM_{2.5}$ LUR	--	--
NO_2 LUR	55.10	--
Ozone IDW	55.81	-0.71

Selected conclusions:

- Several combustion-related components related to mortality
- Study effects of NO2 and O3 jointly
- Increase precision of O3 exposure assessment

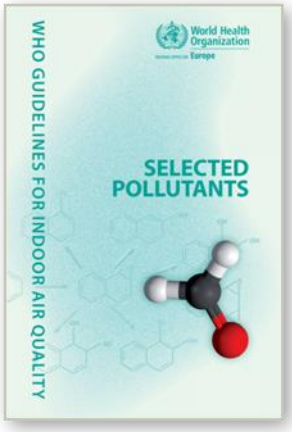
Jerrett et al, AJRCCM 2013

Burden of Disease due to 20 leading risk factors in 2010: results of the GBD2010 study (% of global DALYs)



Lim et al, The Lancet 2012

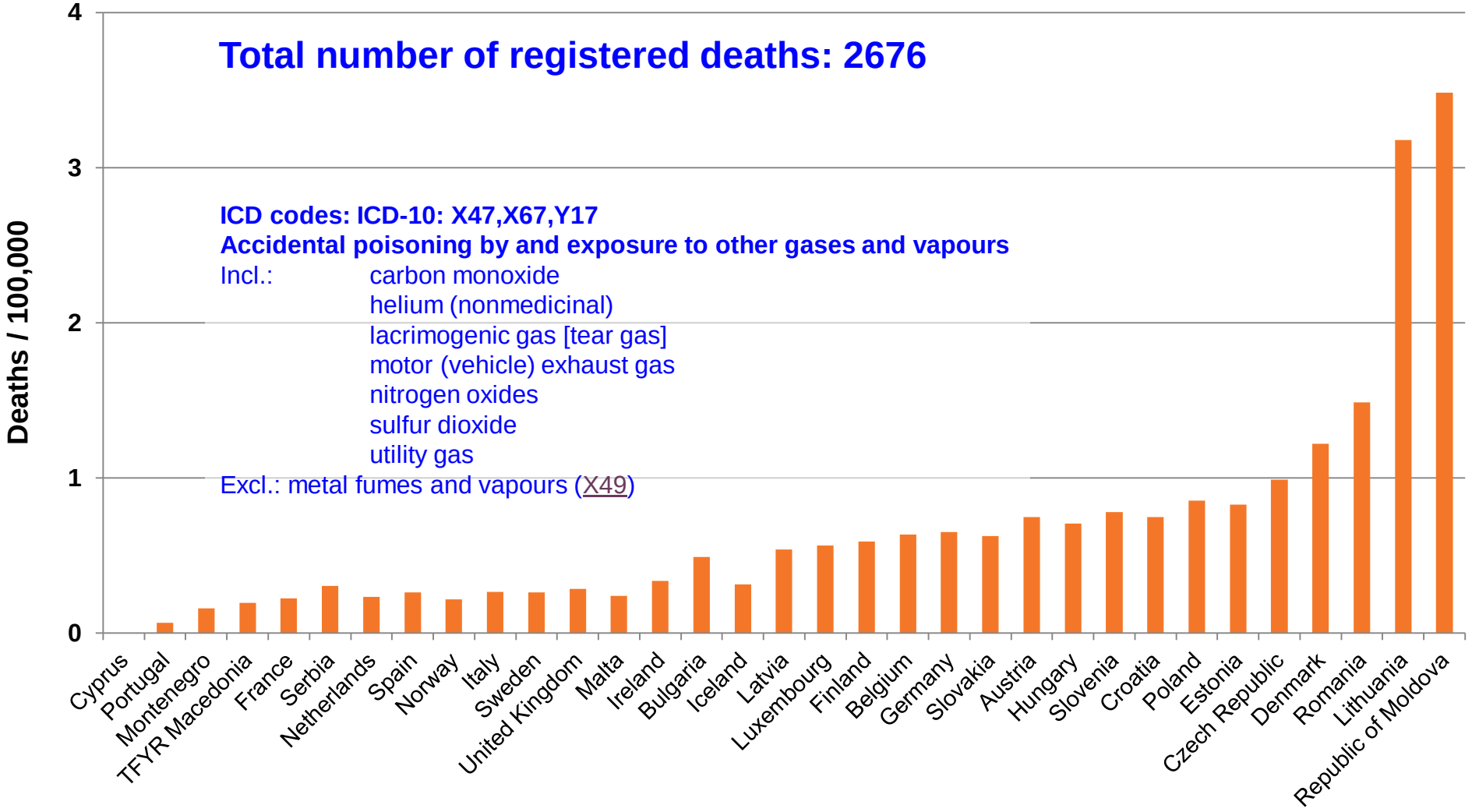
WHO air quality guidelines: carbon monoxide



Averaging time	Guideline concentration (mg/m^3)	Comments
15 minutes	100	Excursions to this level should not occur more than once per day Light exercise.
1 hour	35	
8 hours	10	Arithmetic mean concentration Light to moderate exercise
24 hours	7	Arithmetic mean concentration Awake and alert but not exercising

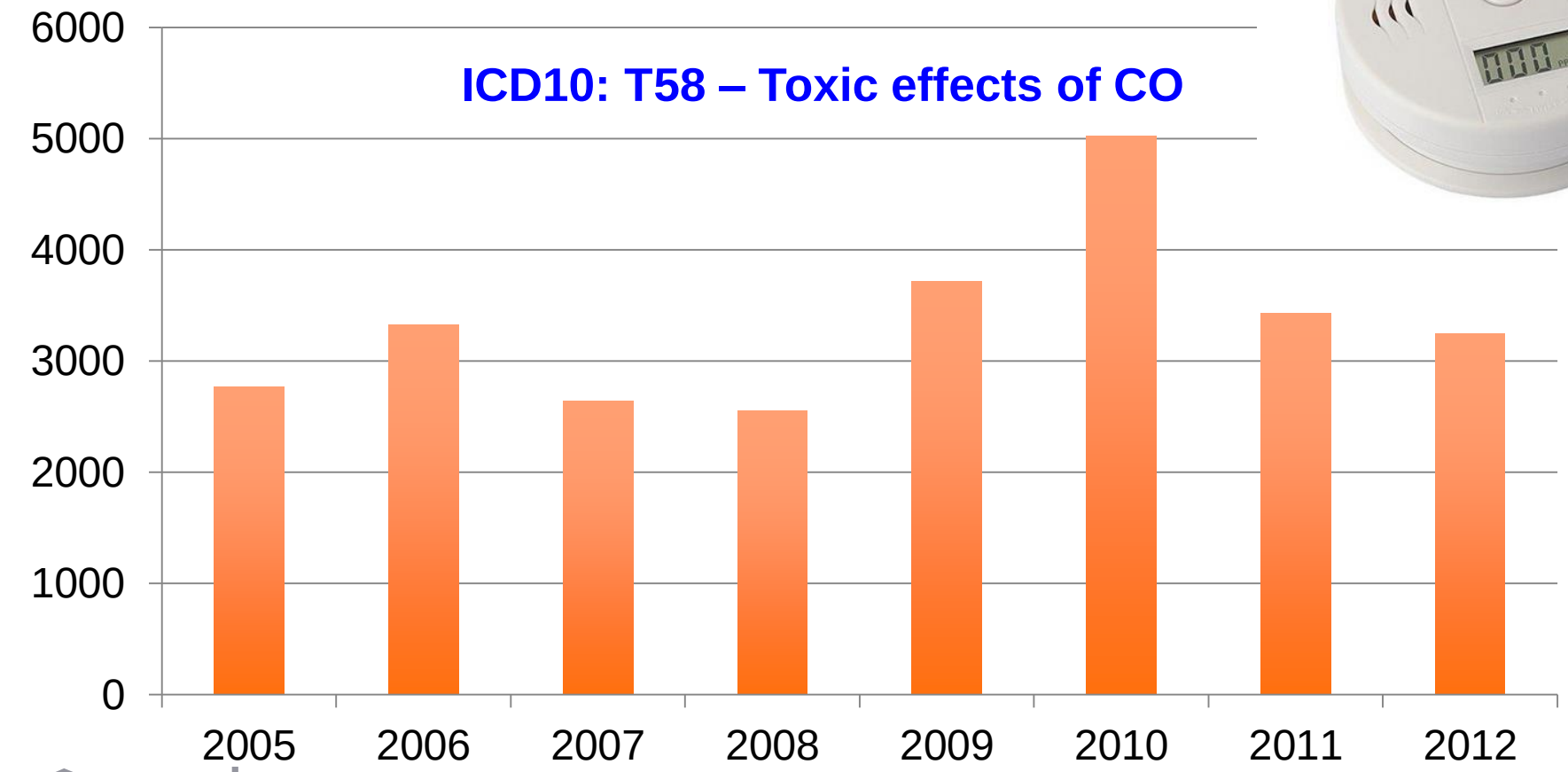
WHO 2010

Deaths due to CO poisoning, Europe, 2012



WHO/Euro DMDB 2014

Hospital admissions due to CO poisoning in Poland



CONCLUSIONS

1. Considerable amount of new scientific information on health effects of **PM, NO_2 and O_3** observed at levels commonly present in Europe, has been published in the recent years. It:
   - supports the scientific conclusions of the **WHO Air Quality Guidelines of 2005**;
   - indicates that the effects can occur at relatively low air pollution concentrations;
   - provides scientific arguments for the decisive actions to improve air quality and reduce the burden of disease associated with air pollution in Europe.

2. **Ogawa badges** are widely used in **epidemiological studies** on health effects of long-term exposure to **NO_2 and CO sensors in alarm devices**.

3. Further understanding of health effects of air pollution needs further advance in exposure assessment (monitoring + modelling), possibly using new sensors to:
   - simultaneously assess various components of the pollution mixture;
   - further reduce exposure assessment error in epi studies;
   - expand of the parameters assessed (including UFP, metals, BC, …)

Thank you!