1st AFRICA/MIDDLE-EAST EXPERT MEETING AND WORKSHOP ON THE HEALTH IMPACT OF AIRBORNE DUST
AMMAN, JORDAN, 2-5 NOVEMBER 2015

PARTICULATE MATTER AND HEALTH: Update on WHO's view on its impact on health with focus on mineral dust

MICHAL KRZYZANOWSKI, ScD, PhD

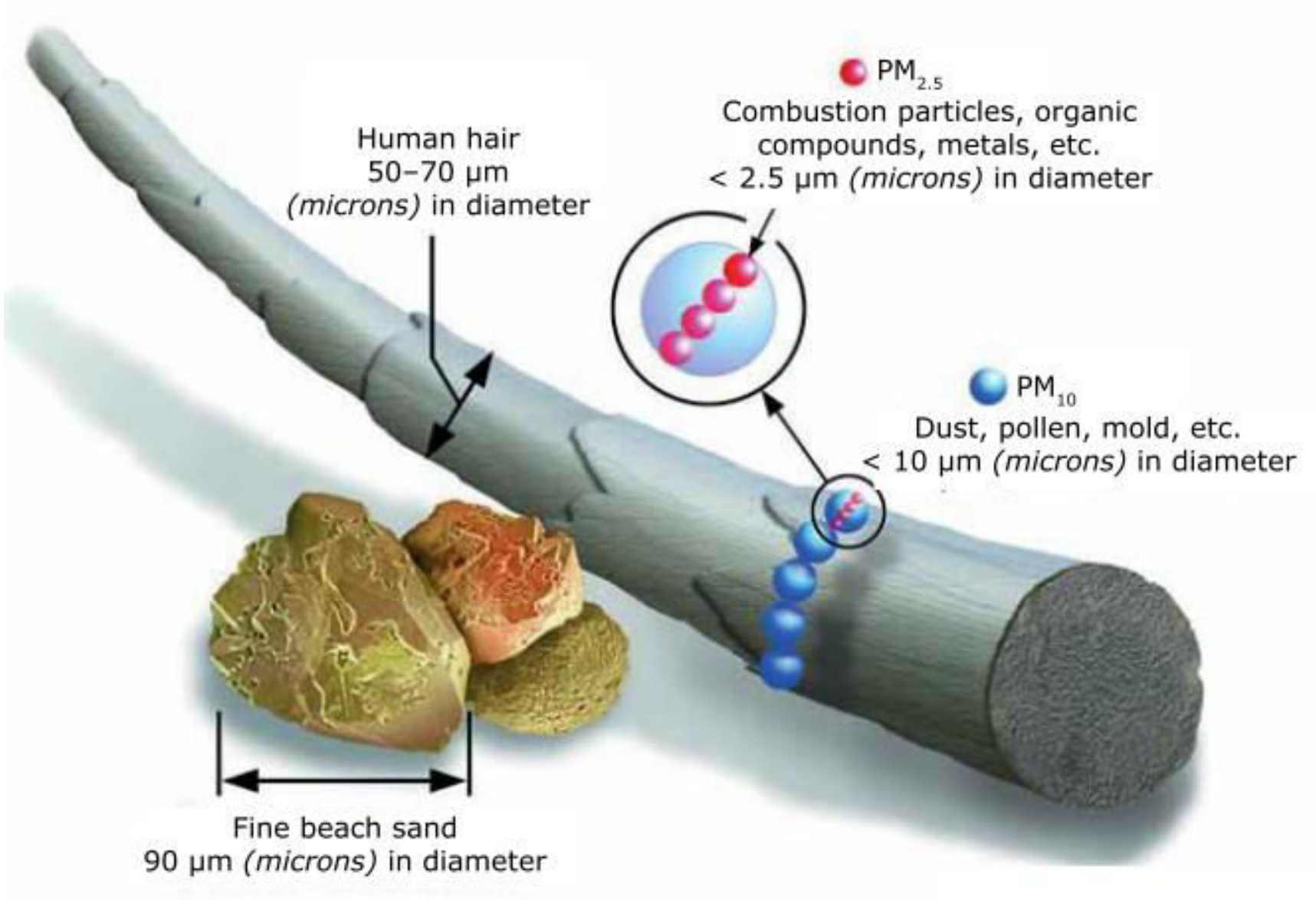
Visiting Professor, Kings College London

KING'S College LONDON

This presentation:

- PM levels and trends;
- Scientific evidence on health effects of particulate matter – results of recent research;
- Role of desert dust in causing health effects.

PM_{10} and $PM_{2.5}$ particle size



EEA 2013

Sources of PM

PM health impacts, Amman, Nov 2015

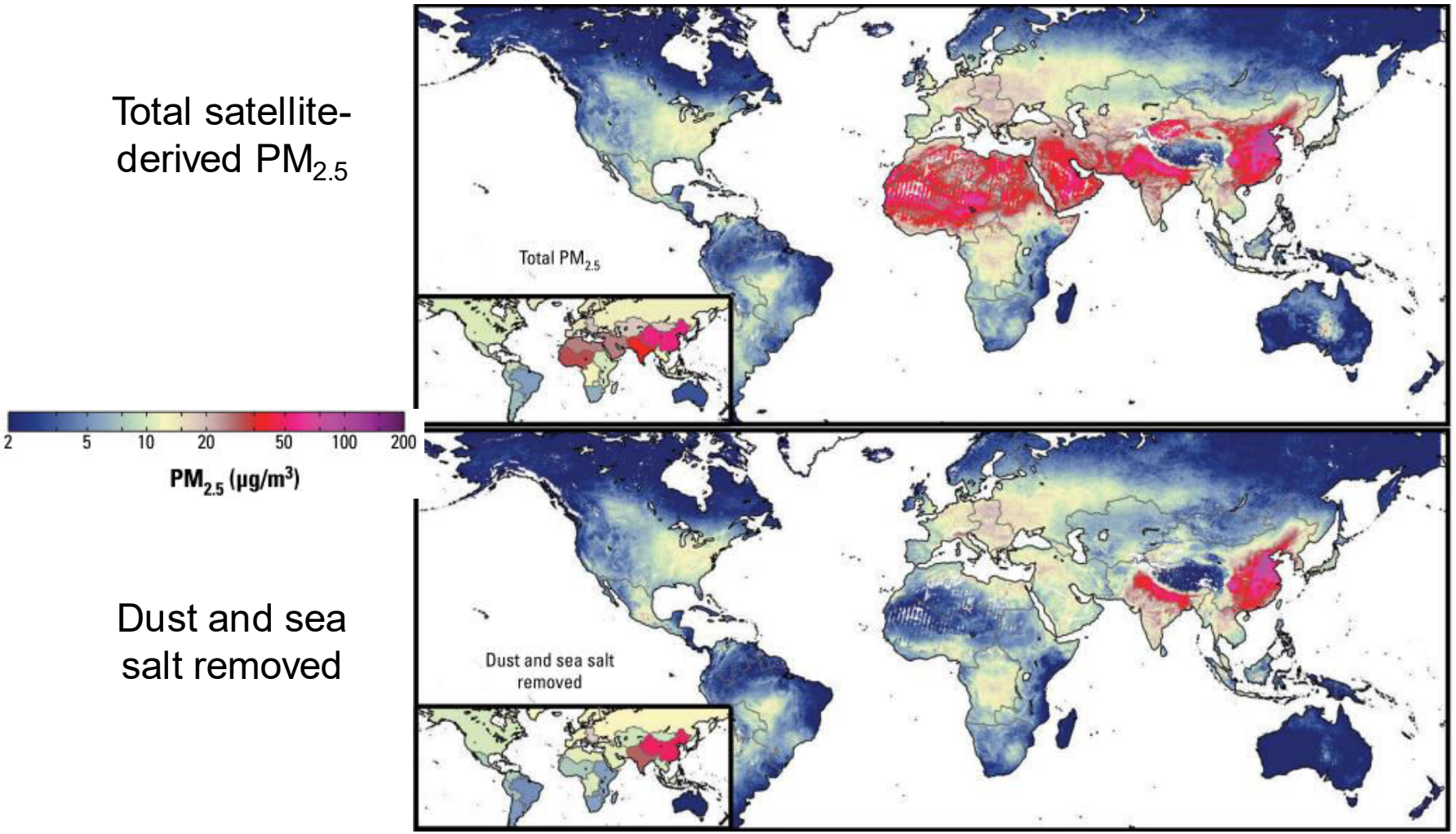
Amman, 8 Dec 2014

Dust storm in Homs, Syria, 7.09.2015

Omar Sandiki / Reuters

Global decadal (2001-2010) $PM_{2.5}$ concentrations

Total satellite-derived $PM_{2.5}$

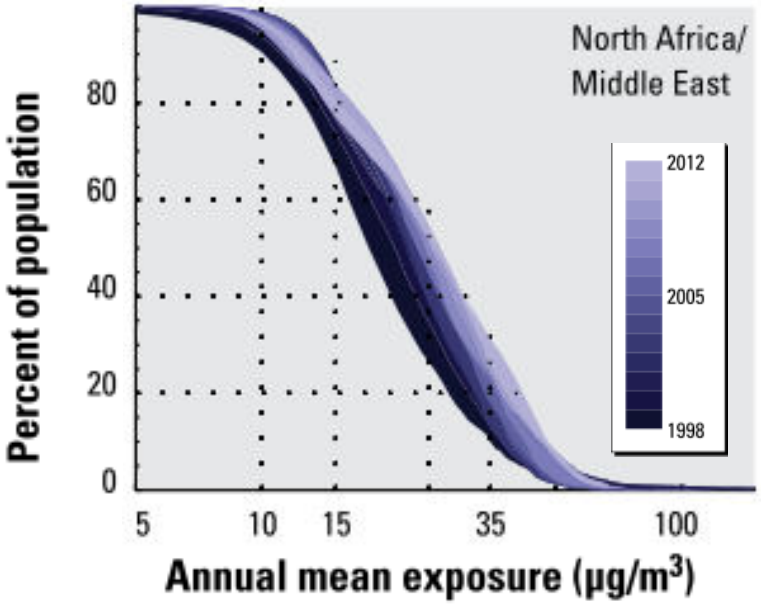


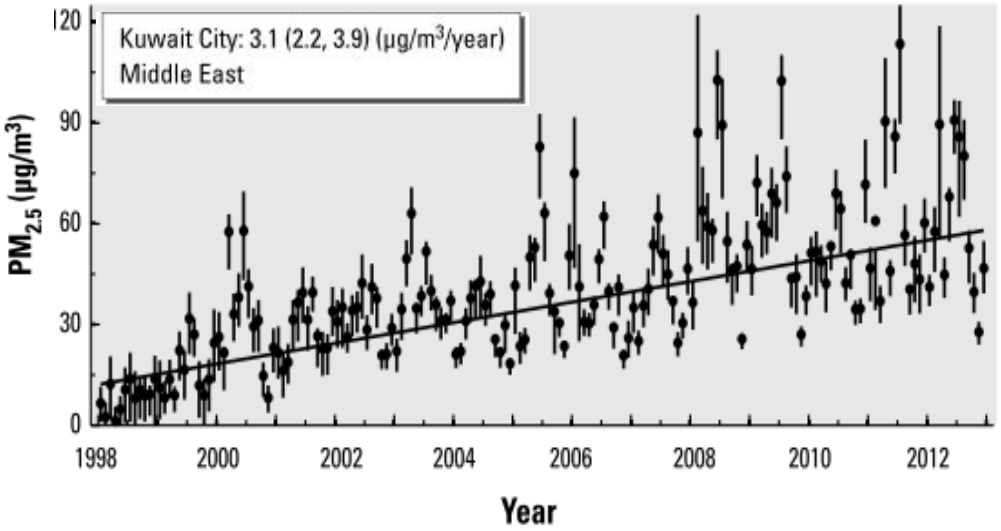
Dust and sea salt removed

Van Donkelaar et al. 2015

Population-weighted $PM_{2.5}$ long term means and trends

Region	2001–2010		1998–2012	
	$PM_{2.5}$ (mean µg/m^3 ± SD)	Dust- and sea salt–free $PM_{2.5}$ (mean µg/m^3 ± SD)	$PM_{2.5}$ trend [µg/m^3/year (95% CI)]	$PM_{2.5}$ trend [%/year (95% CI)]
Global	26.4 ± 21.4	21.2 ± 19.1	0.55 (0.43, 0.67)	2.1 (1.6, 2.6)
North Africa/Middle East	25.5 ± 10.7	11.5 ± 3.6	0.38 (0.17, 0.59)	1.5 (0.7, 2.3)



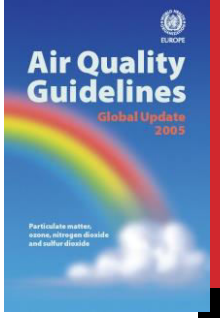


Van Donkelaar et al. 2015

This presentation:

- PM levels and trends;
- **Scientific evidence on health effects of particulate matter – results of recent research;**
- Role of desert dust in causing health effects.

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

WHO 2006

REVIHAAP: selected conclusions on PM

http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications

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).

WHO 2013

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.

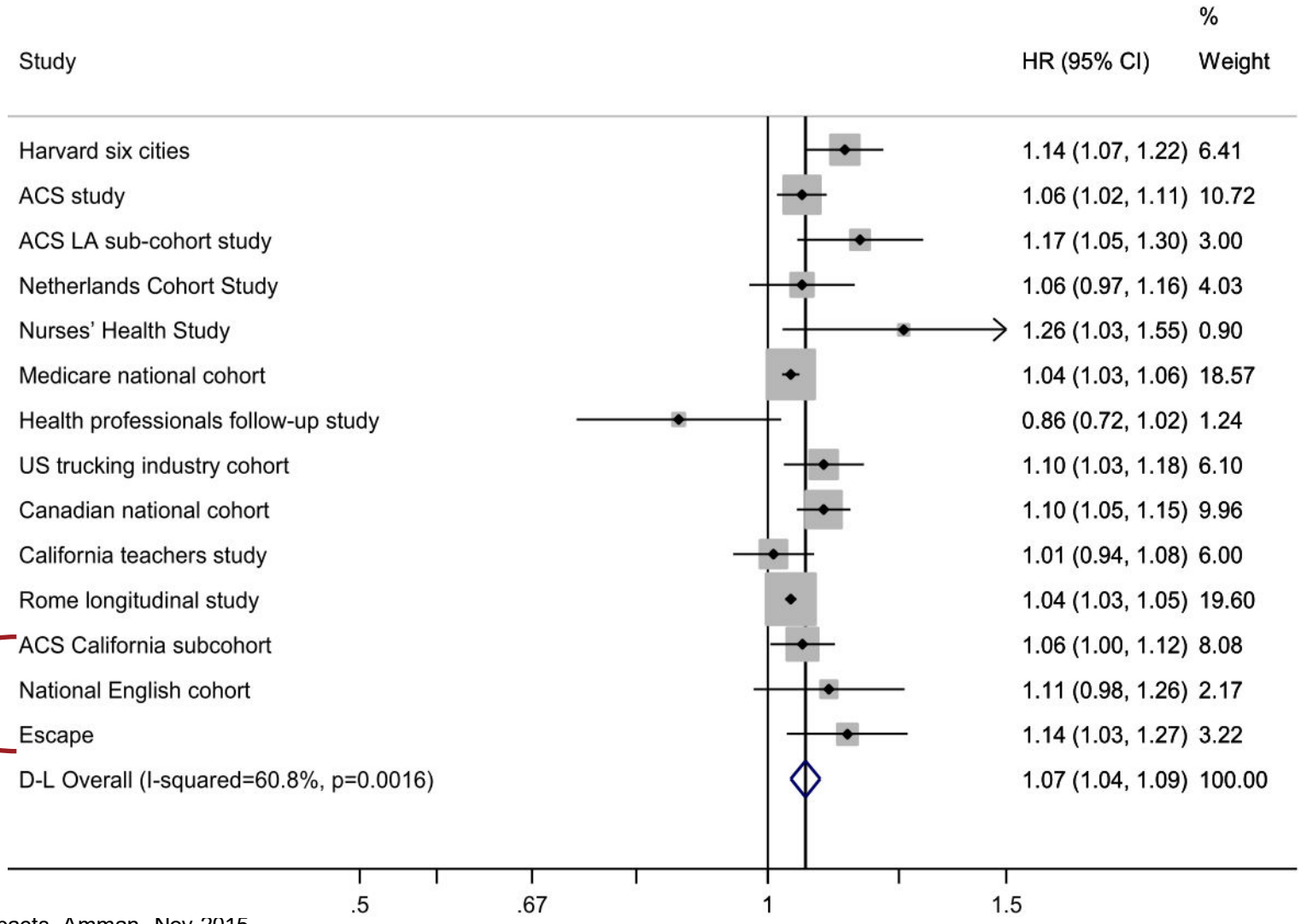
The Working Group also reviewed evidence regarding the carcinogenicity of outdoor air pollution in experimental animals. As part of this process, the IARC's earlier evaluations of diesel engine

Published Online
October 24, 2013
http://dx.doi.org/10.1016/S1470-2045(13)70487-X

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

The Lancet, 24 Oct 2013

Meta-analysis of the association between long-term exposure to $PM_{2.5}$ and all-cause (natural) mortality



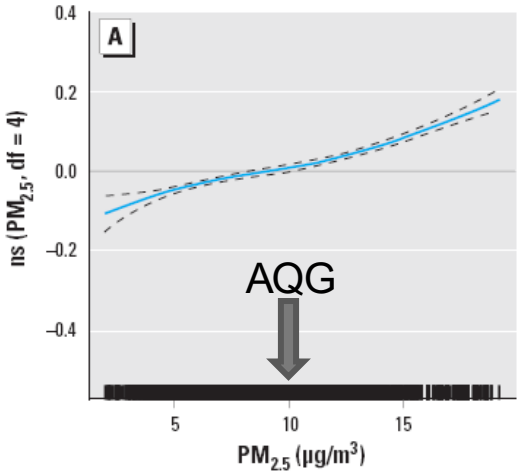
2013/14

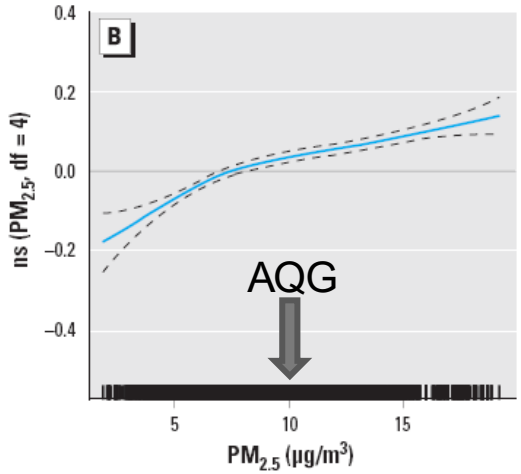
Forastiere et al, WHO 2014

Mortality and long-term $PM_{2.5}$ exposure

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

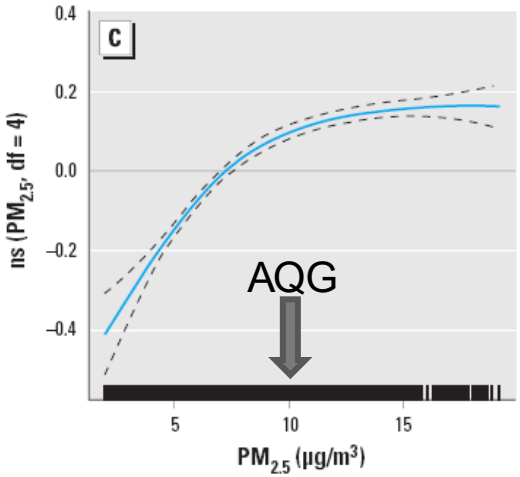
All non-accidental

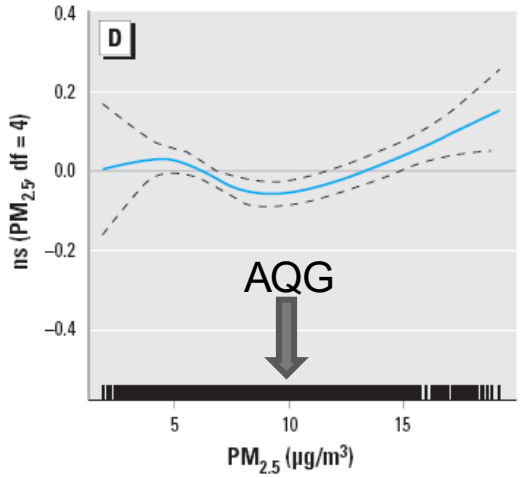




Cardiovascular

Ischemic heart disease

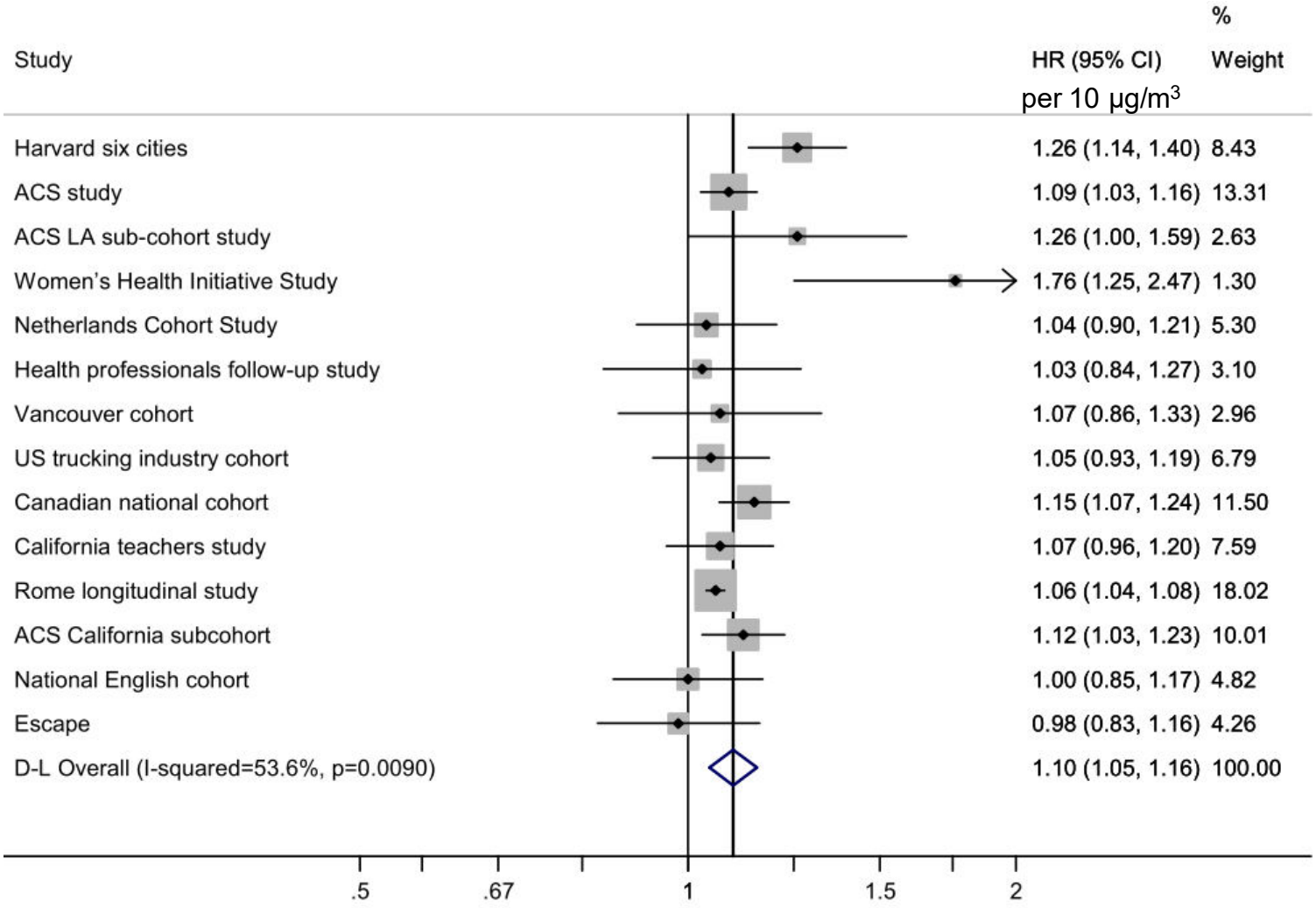




Cerebrovascular

Crouse et al, EHP 2012

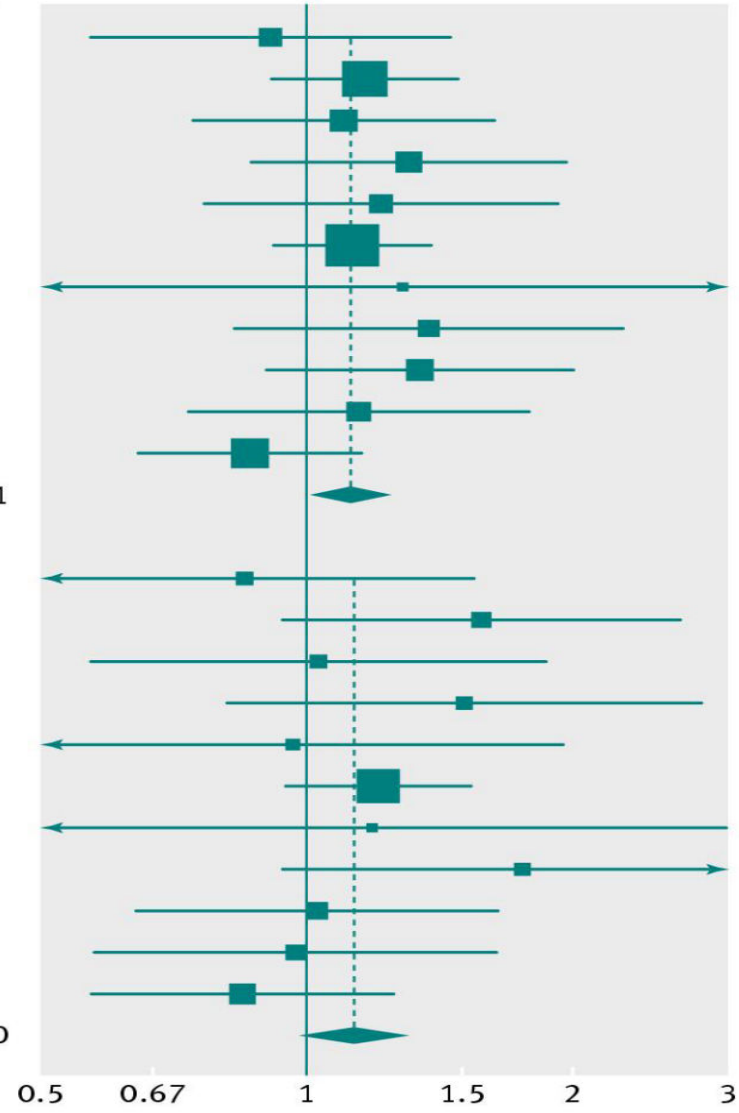
Long term $PM_{2.5}$ exposure and cardiovascular mortality



Forastiere et al, WHO 2014

Long term exposure to PM and incidence of acute coronary events in ESCAPE

(100,166 people in 11 cohorts followed for average 11.5 years)



Cohort	Weight (%)	Hazard ratio (95% CI)
PM_{10} (10 µg/m^3 increase)		
FINRISK	5	0.91 (0.57 to 1.45)
SNAC-K	19	1.16 (0.91 to 1.48)
Salt Twin G	7	1.10 (0.74 to 1.63)
60 year olds	7	1.30 (0.87 to 1.97)
SDPP	5	1.21 (0.77 to 1.92)
DCH	26	1.13 (0.92 to 1.38)
HNR	1	1.28 (0.49 to 3.39)
KORA	4	1.37 (0.83 to 2.28)
EPIC-Turin	7	1.34 (0.90 to 2.00)
SIDRIA-Turin	6	1.15 (0.74 to 1.78)
SIDRIA-Rome	13	0.86 (0.64 to 1.15)
D-L overall: I^2=0%, P=0.81	100	1.12 (1.01 to 1.25)
$PM_{2.5}$ (5 µg/m^3 increase)		
FINRISK	6	0.85 (0.47 to 1.55)
SNAC-K	8	1.58 (0.94 to 2.65)
Salt Twin G	6	1.03 (0.57 to 1.87)
60 year olds	5	1.51 (0.81 to 2.80)
SDPP	4	0.96 (0.48 to 1.95)
DCH	35	1.21 (0.95 to 1.53)
HNR	2	1.19 (0.47 to 2.99)
KORA	5	1.76 (0.94 to 3.28)
EPIC-Turin	9	1.03 (0.64 to 1.65)
SIDRIA-Turin	7	0.97 (0.58 to 1.64)
SIDRIA-Rome	13	0.85 (0.57 to 1.25)
D-L overall: I^2=0%, P=0.60	100	1.13 (0.98 to 1.30)

Cesaroni et al. BMJ 2014

Health indicators functionally related to $PM_{2.5}$ or PM_{10} 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.

http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications

WHO 2013

Air pollution (PM) source types associated with health effects (conclusions of WHO REVIHAAP project)

- Carbonaceous material from traffic;
- Coal combustion (sulfate-contaminated particles);
- Oil or coal combustion in shipping, power generation, metal industry;
- Biomass combustion (including residential wood combustion);
- Traffic-generated dust, including road, brake and tyre wear;
- Desert dust episodes.

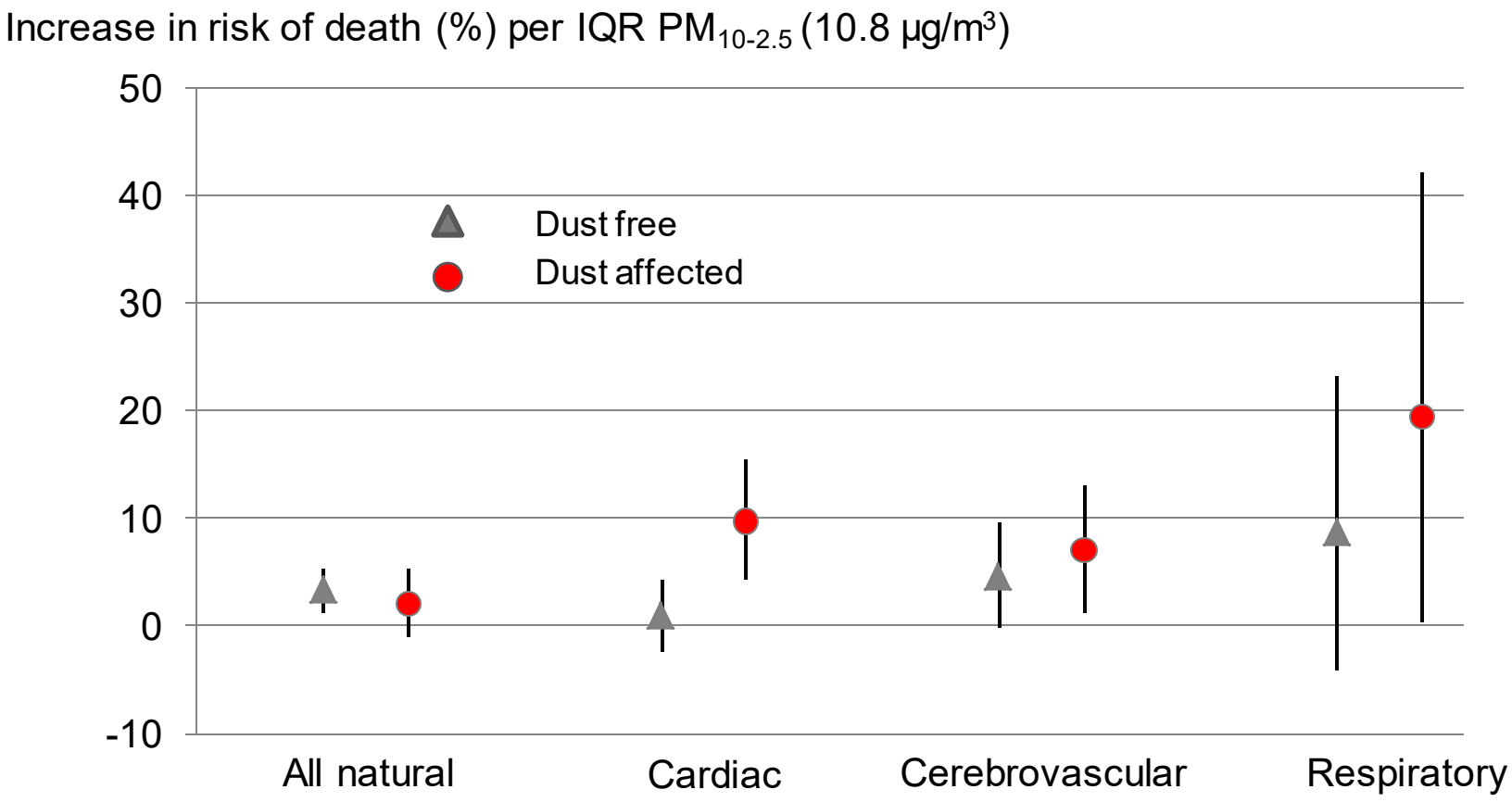
WHO 2013

This presentation:

- PM levels and trends;
- Scientific evidence on health effects of particulate matter – results of recent research;
- **Role of desert dust in causing health effects.**

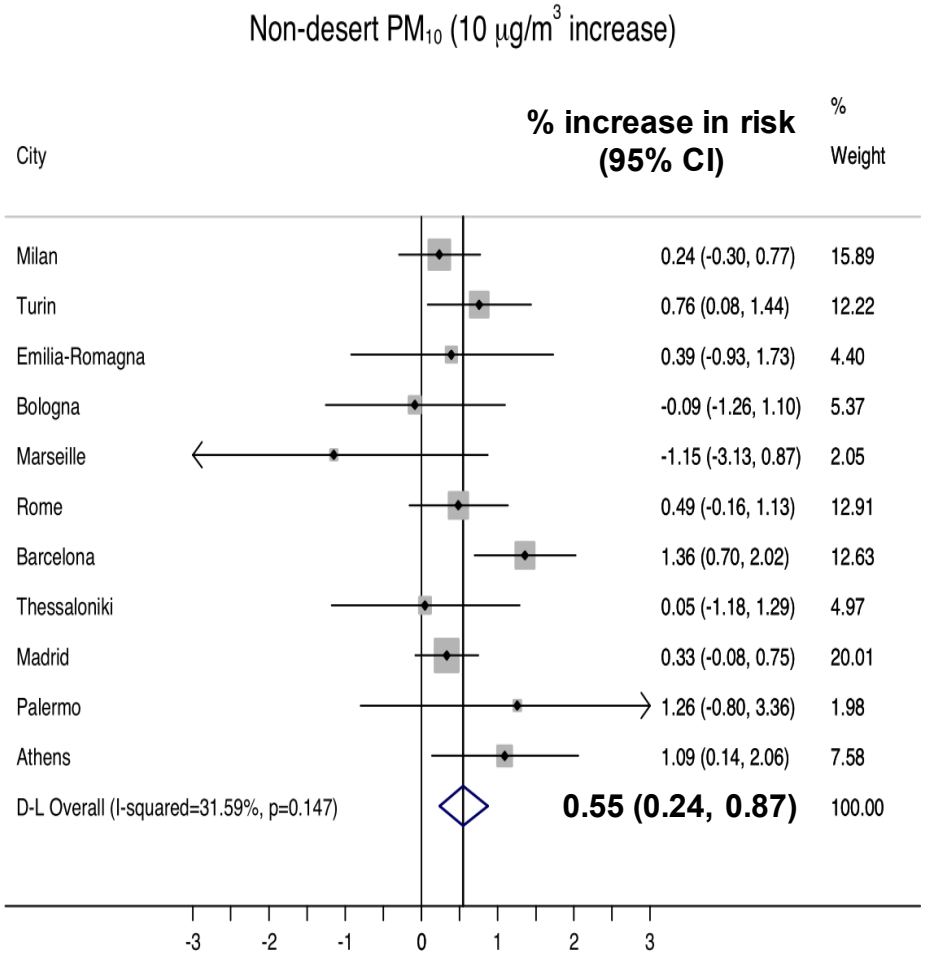
Effects of Saharan dust on association between mortality and $PM_{10-2.5}$

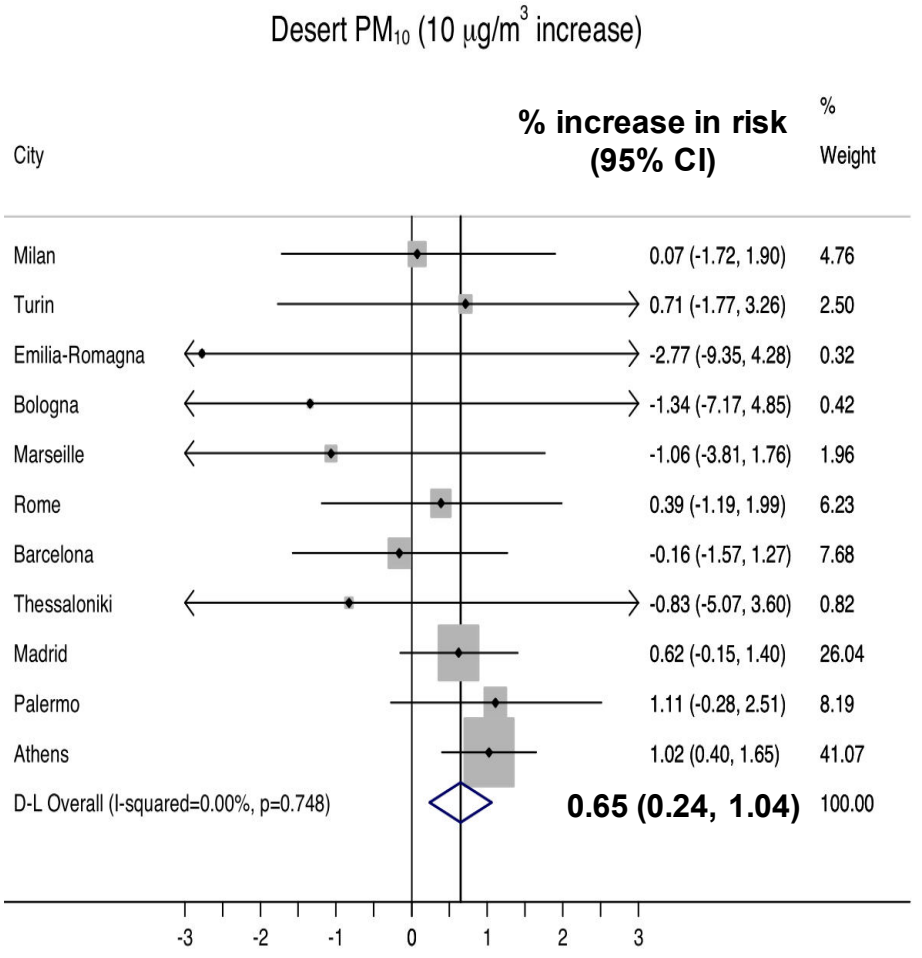
Time series study in Rome, Italy, with 80 423 deaths in 2001-2004



Mallone et al, EHP 2011

Risk of natural mortality associated with non-desert PM_{10} and desert PM_{10} in Southern Europe: MED-PARTICLES Study



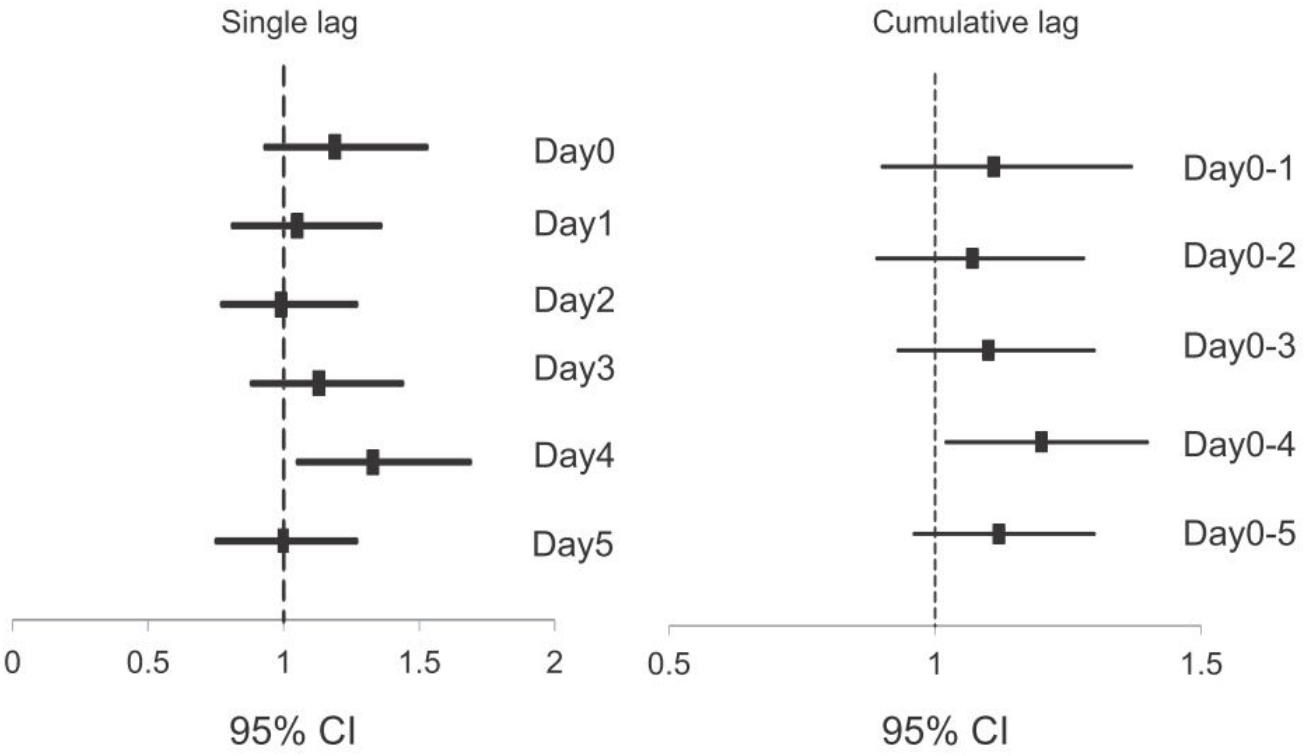


Staffogia et al. EHP 2015

Acute myocardial infarction (AMI) and Asian dust (AD)

Odds ratios for AD days vs. non-AD days

A case-crossover study of hospitalization because of AMI among 3068 consecutive patients of 4 AMI centres in Fukuoka, Japan, and data for AD 2003-2010.



Matsukawa et al, Circ Cardiovasc Qual Outcomes. 2014

The nature of pollutant materials carried in dust storms

Location	Biological material
Kuwait & Iraq	*Mycobacterium*, *Brucella*, *Coxiella Burnetii*, *Clostridium perfingens*, *Bacillus*
West Africa	*Neissera meningitides*
Taiwan	Influenza virus
Japan	Pollen spores
Crete	Bacteria
Korea	Bacteria
Israel	Fungal communities
Iran	Fungi: *Cladosporium*, *Alternaria*, *Aspergillus*, *Penicillium* and *Rhizophus*
Turkey	Thermophilic bacteria (*Geobacillus*)
Israel	Bacteria and fungi
Iran	Bacteria and fungi

Location	Nature of substance(s)
France	Radioactive cesium (^{137}Cs) from Sahara
Japan	Radioactive cesium (^{137}Cs) from China and Mongolia
Japan	Enriched uranium from Central Asia
	Plutonium from Saharan atomic tests
	Heavy metals from China
	Heavy metals from China
	Heavy metals
	Sulphates and nitrates
	Polycyclic aromatic hydrocarbons
	Polycyclic aromatic hydrocarbons and fatty acids
	Phosalone from Aral Sea
	Heavy metals, organochlorine pesticides, Dioxins from Aral Sea
	Arsenic
	Dioxins and PCBs from China

Goudi, Env Internat 2014

Desert dust health effects: conclusions of WHO REVIHAAP project

- After the 2005 global update of the WHO air quality guidelines, several new studies reported positive associations between short-term exposure to PM_{10} or coarse particles and mortality during desert dust episodes;
- The results for cause-specific mortality or for hospitalizations have not been fully consistent for coarse particles and desert dust episodes;
- **Evidence for an effect of desert dust on human health is increasing, but at the moment it is not clear whether crustal, anthropogenic, or biological components of dust are most strongly associated with the effects.**

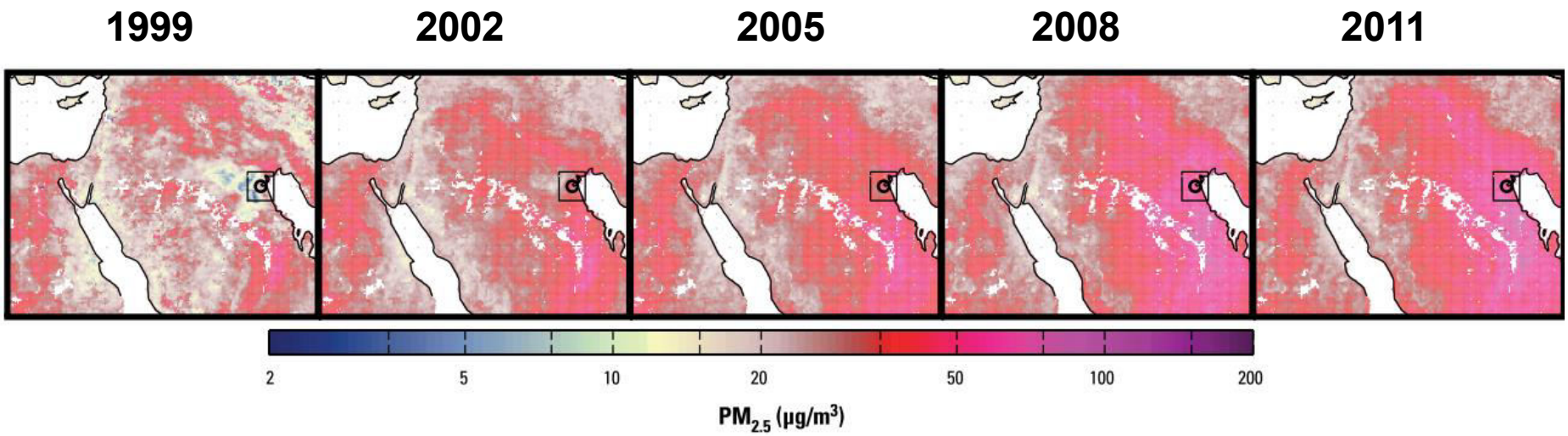
WHO 2013

Conclusions

- Fine particulate matter ($PM_{2.5}$) causes cardiovascular diseases and rspiratory cancers, and is related to other health problems;
- Various sources (especially combustion) contribute to population exposure to PM and to its health effects;
- Health risk increases proportionally to the exposure level, also at relatively low PM concentrations (even below WHO AQG level);
- Desert dust contributes to the impacts of $PM_{2.5}$ mass but scientific evidence on the type and magnitude of health effects specific to desert dust is scarce:
- More research conducted in desert dust affected countries is needed to elucidate aspects of effects specific to those exposures.

Thank you!

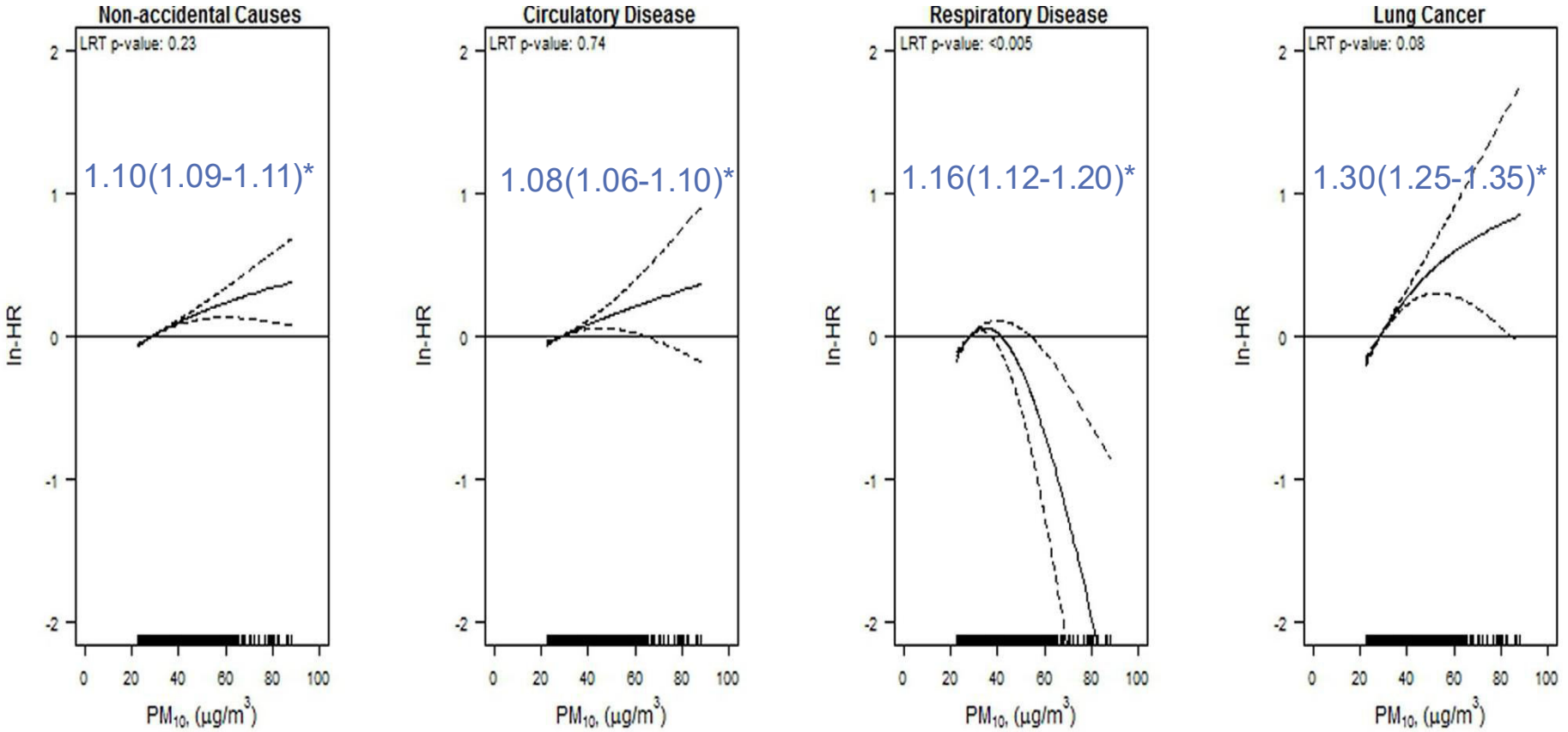
Three-year running average of satellite-derived $PM_{2.5}$ concentrations over Middle East



Van Donkelaar et al. 2015

Long-term exposure to PM_{10} and mortality.

Dutch Environmental Longitudinal Study (DUELS) of 7.1 million adults (age 30+), 2004-2011



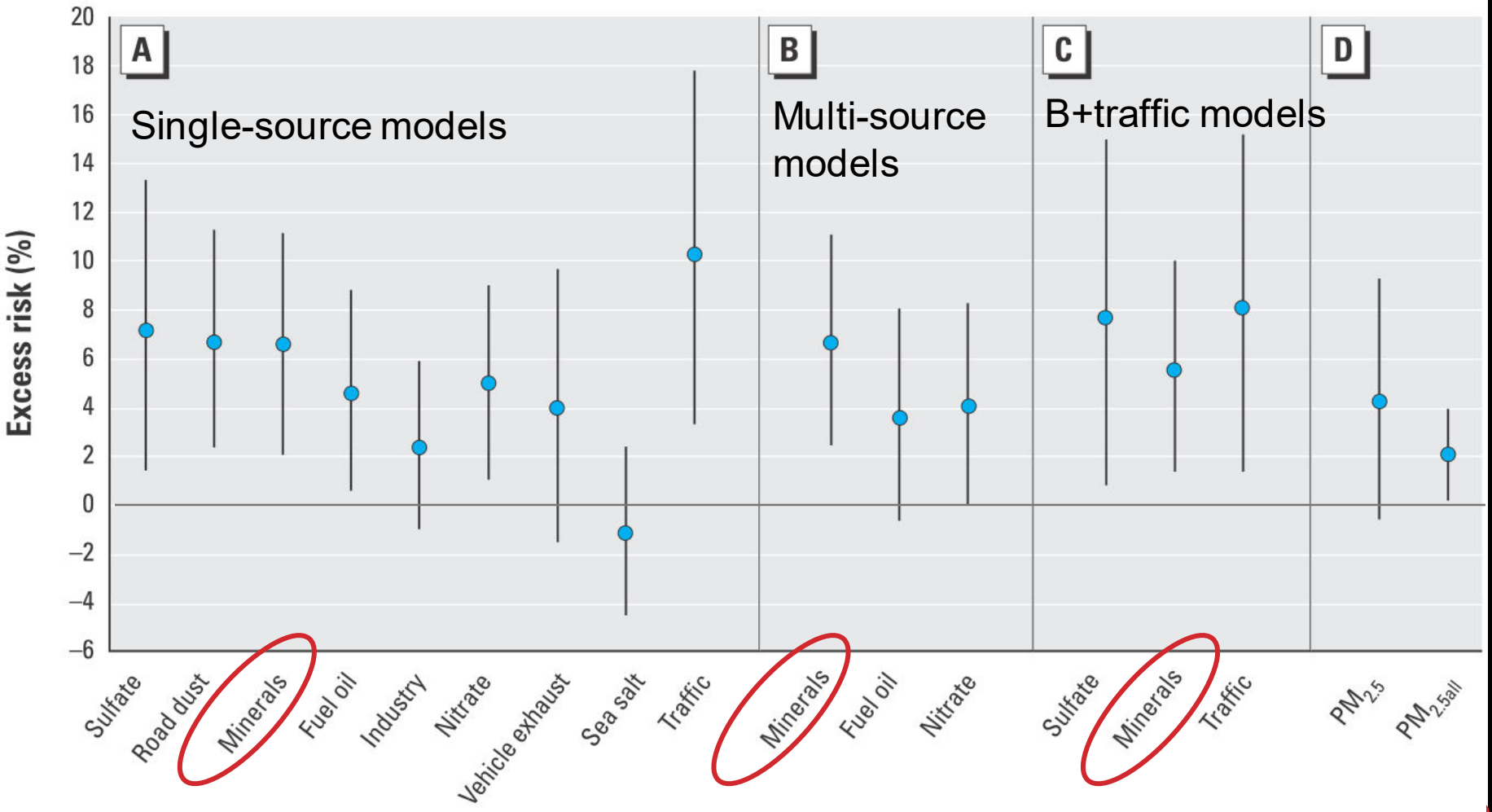
*RR(95%CI) per 10 µg/m^3 PM_{10}, Adjusted for age, gender, marital status, region of origin, household income

Median PM_{10} = 29 µg/m^3, IQR=2.5 µg/m^3

Fischer et al, EHP 2015

Cardiovascular mortality excess risks (95% CIs) and IQR increases in sources of $PM_{2.5}$ (lag 2)

Case cross-over study in Barcelona, 2003-2007



Ostro et al, EHP 2011

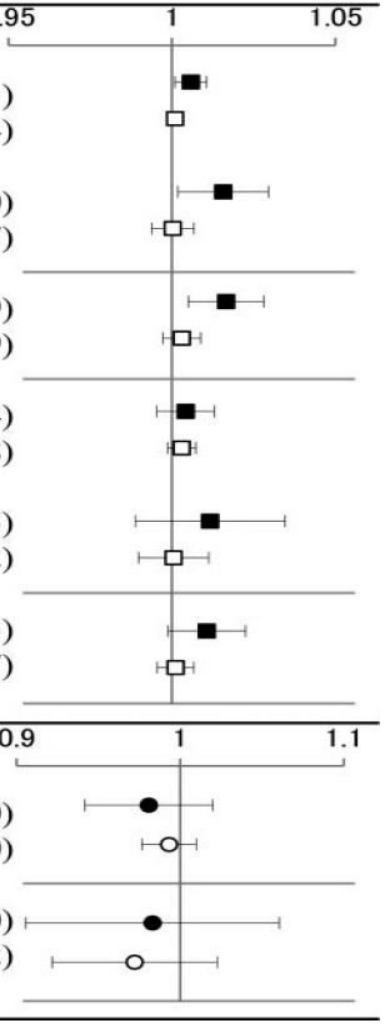
Cause-specific mortality and Asian dust or suspended particulate matter (SPM)

Relative risks (RR) in a two-pollutant model

Time-series analysis targeting ca. 1.4 million people aged 65+ living in 47 cities in western Japan (2005-10).

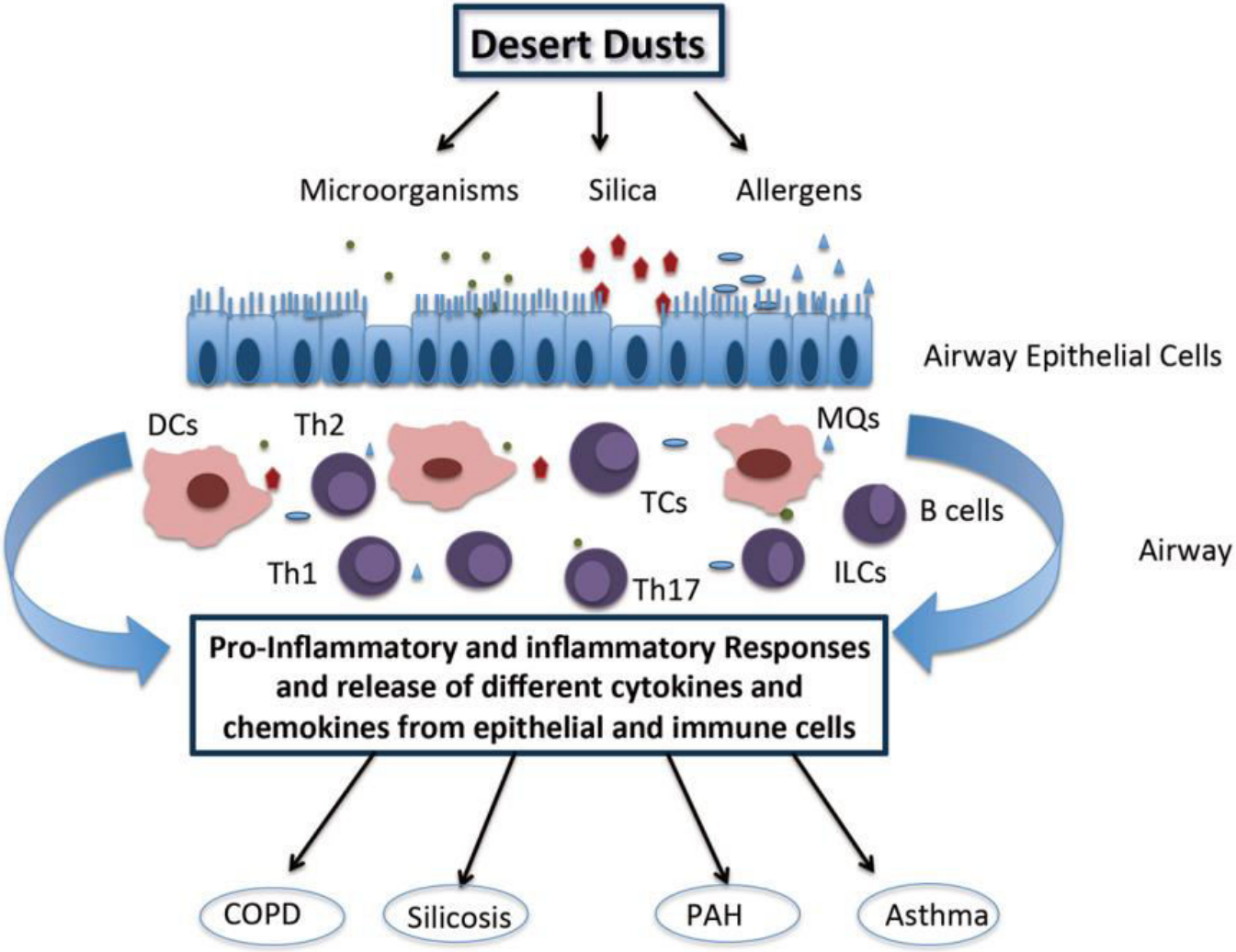
SPM ≅ PM_8

	area	RR	(95% CI)
Asian dust			
circulatory disease			
Lag 1	north	1.006	(1.001 to 1.011)
	south	1.001	(0.999 to 1.004)
Lag 0-6	north	1.016	(1.002 to 1.030)
	south	1.000	(0.994 to 1.007)
heart disease			
Lag 0-2	north	1.017	(1.005 to 1.029)
	south	1.003	(0.998 to 1.009)
cerebrovascular disease			
Lag 1	north	1.004	(0.996 to 1.014)
	south	1.003	(0.999 to 1.008)
Lag 0-6	north	1.012	(0.990 to 1.035)
	south	1.001	(0.990 to 1.012)
pulmonary disease			
Lag 0-2	north	1.011	(0.999 to 1.023)
	south	1.001	(0.996 to 1.007)
SPM			
circulatory disease			
Lag 0-6	north	0.981	(0.944 to 1.020)
	south	0.993	(0.977 to 1.010)
arrhythmia			
Lag 2	north	0.983	(0.913 to 1.060)
	south	0.972	(0.926 to 1.022)



Kashima et al. Occup Environ Med 2012

Immune responses to different particles in desert dust



Dcs = Dendritic cells
MQs = Macrophages
ILCs = Innate lymphoid cells
TCs = T cytotoxic cells
Th1 = T helper cell type 1
Th2 = T helper cell type 2
Th17 = T helper cell type 17

Esmaeil et al. Am J Clin Exp Immunol 2014

Health effects of $PM_{2.5}$ exposure