DIEP Lazio
Dipartimento di Epidemiologia del Servizio Sanitario Regionale
Regione Lazio

Health Effects of Air Pollution

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Varenna, July 23 2017

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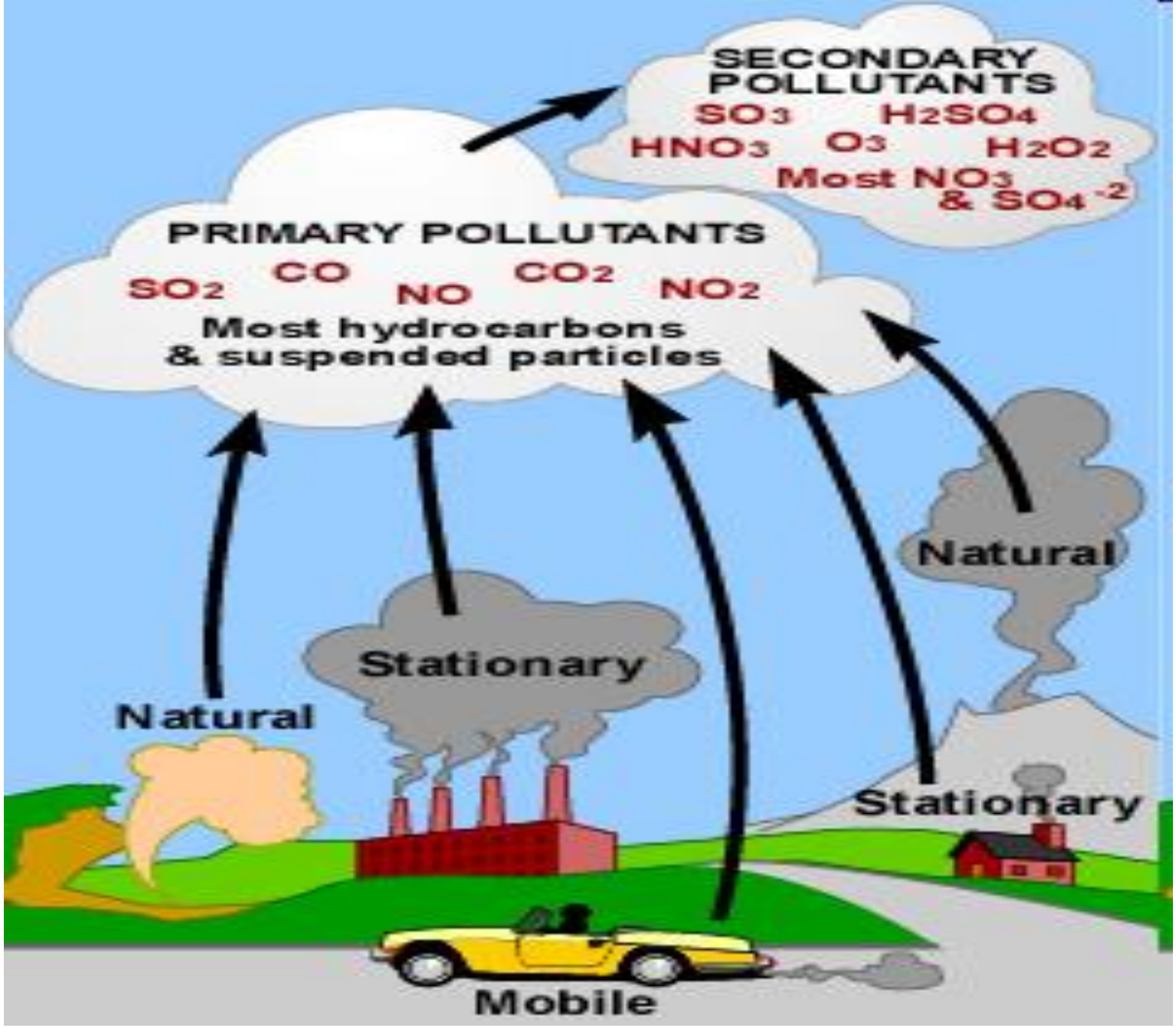


From http://www.epa.gov/oar/oaqps/eog/course422/ap3.html

PARTICULATE MATTER

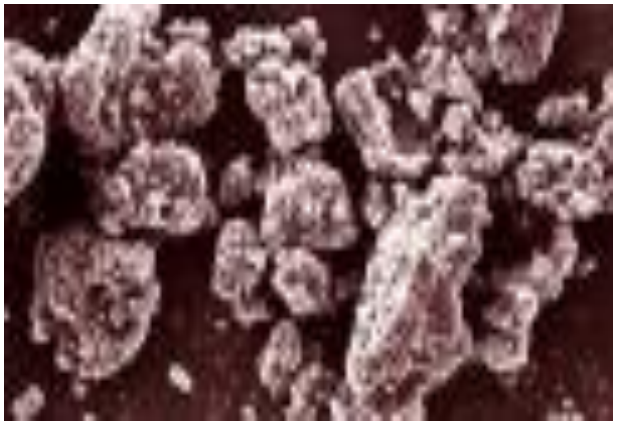
- Complex heterogeneous mixture of solid and liquid components

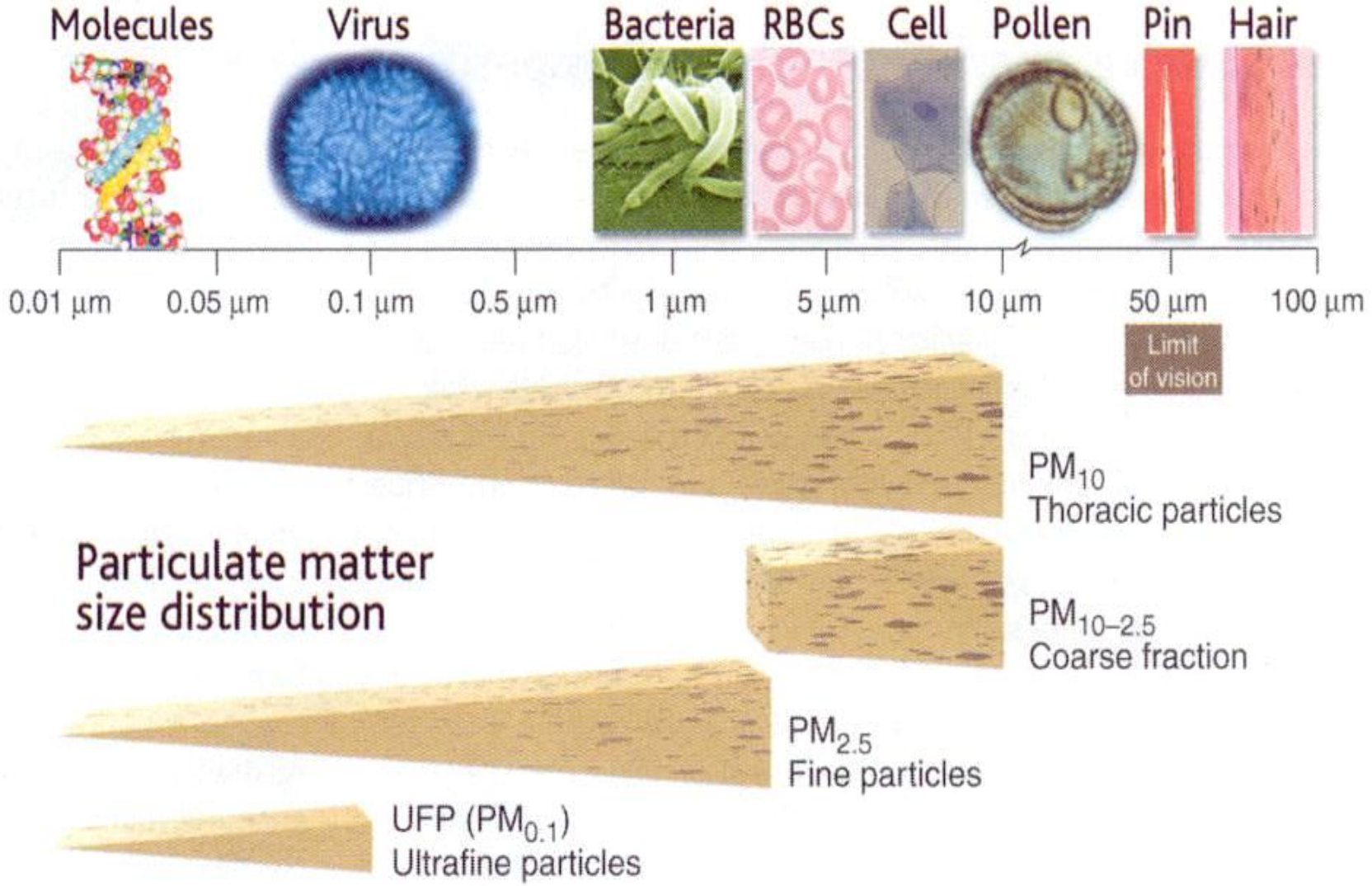
- Sources:
  - Power plants and industry
  - Motor vehicles
  - Domestic coal burning
  - Natural sources (volcanoes, dust storms)
  - Secondary small particles from gases (nitrates and sulfates)

Particulate matter - definitions

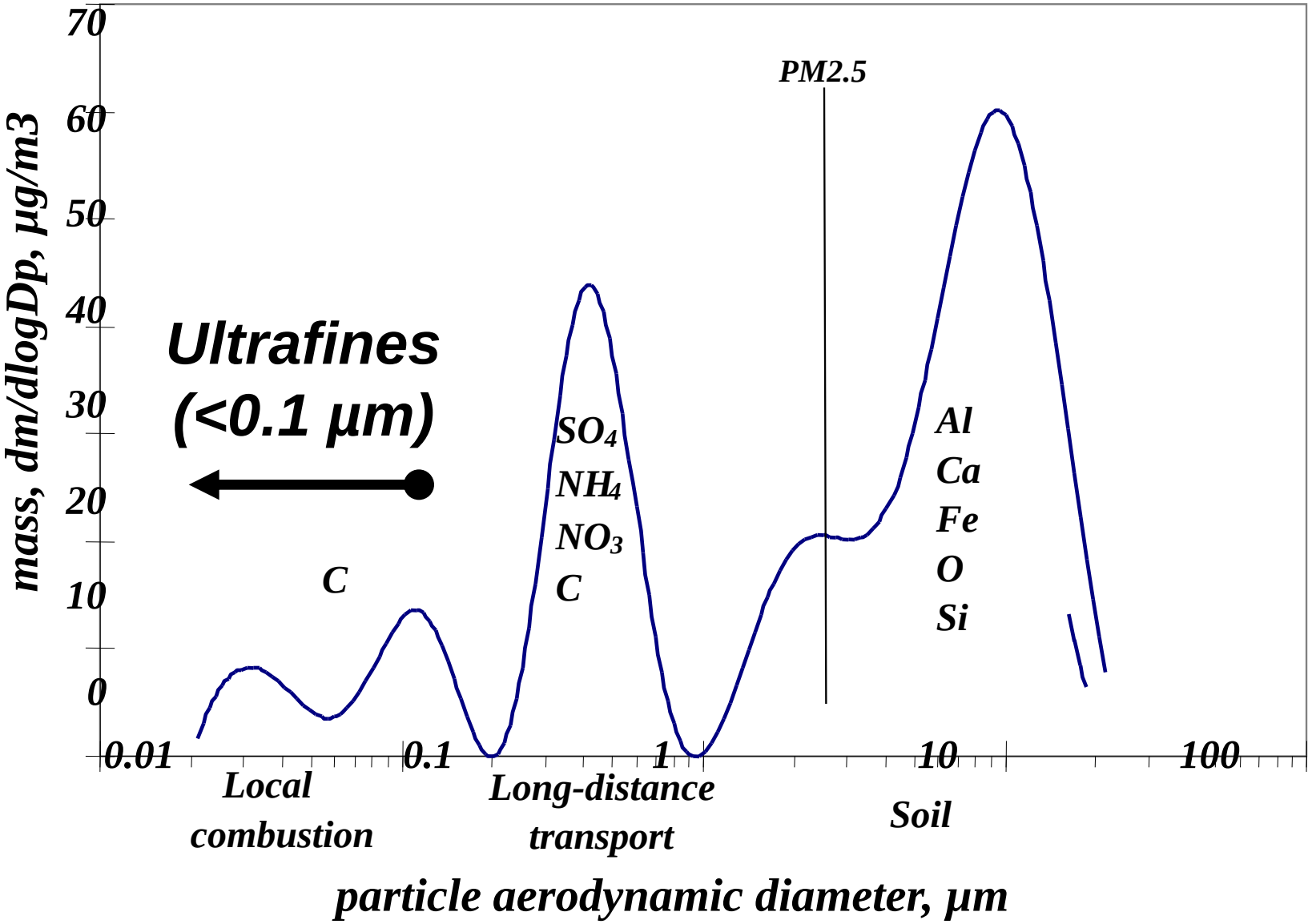
A complex mixture of airborne solid and liquid particles, including soot, organic material, sulfates, nitrates, other salts, metals, biological materials.

- PM_{10} -- inhalable particles
- $PM_{2.5}$ -- fine particles
- PM_{10}-$PM_{2.5}$ -- coarse particles
- $PM_{0.1}$ -- ultrafine particles

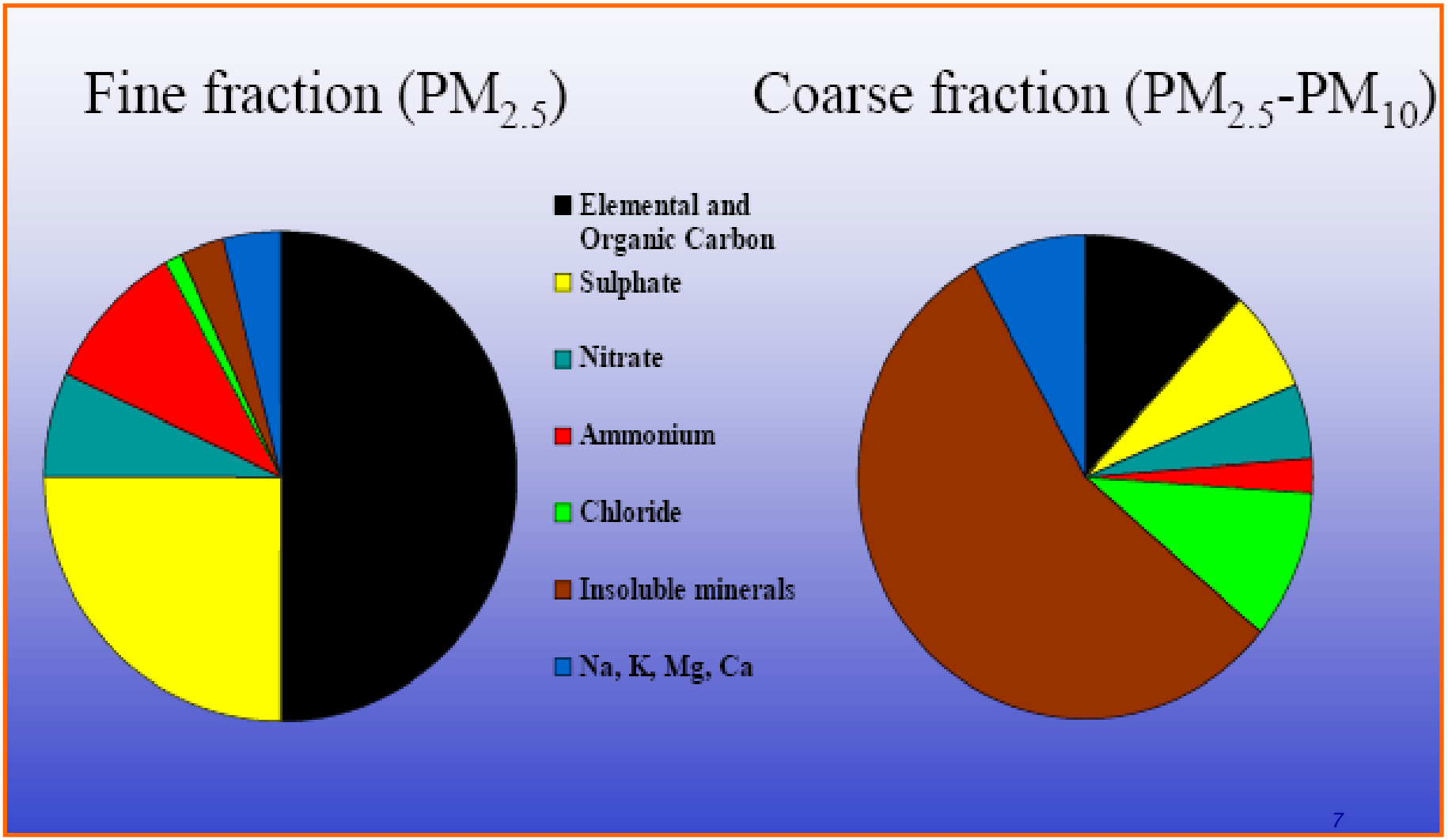


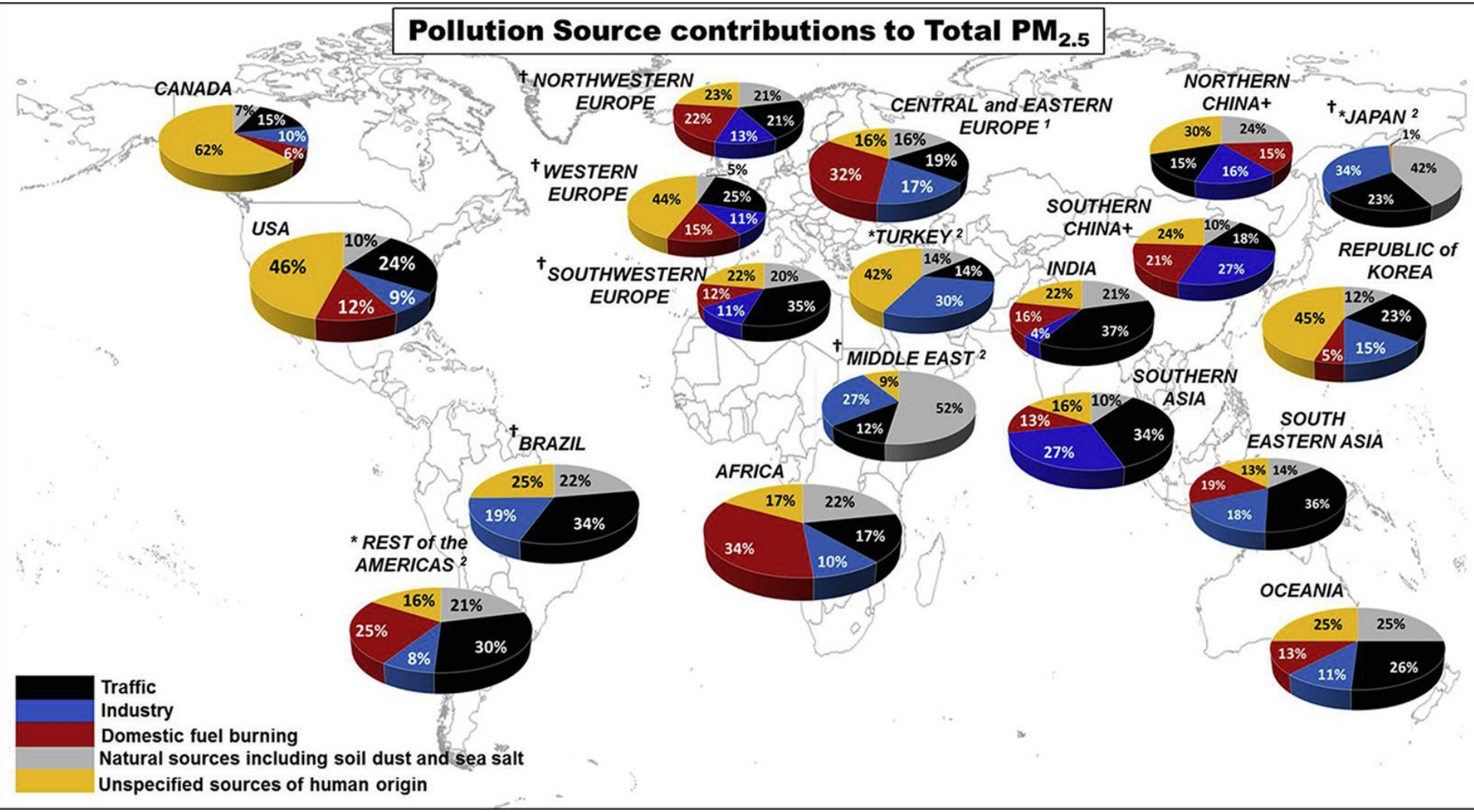


Science 307:1857-1861, News Focus, March 2005


mass, dm/dlogDp, µg/m3
70
60
50
40
30
20
10
0
PM2.5
Ultrafines
(<0.1 µm)
C
SO4
NH4
NO3
C
Al
Ca
Fe
O
Si
0.01
0.1
1
10
100
Local
combustion
Long-distance
transport
Soil
particle aerodynamic diameter, µm

Particulate Matter

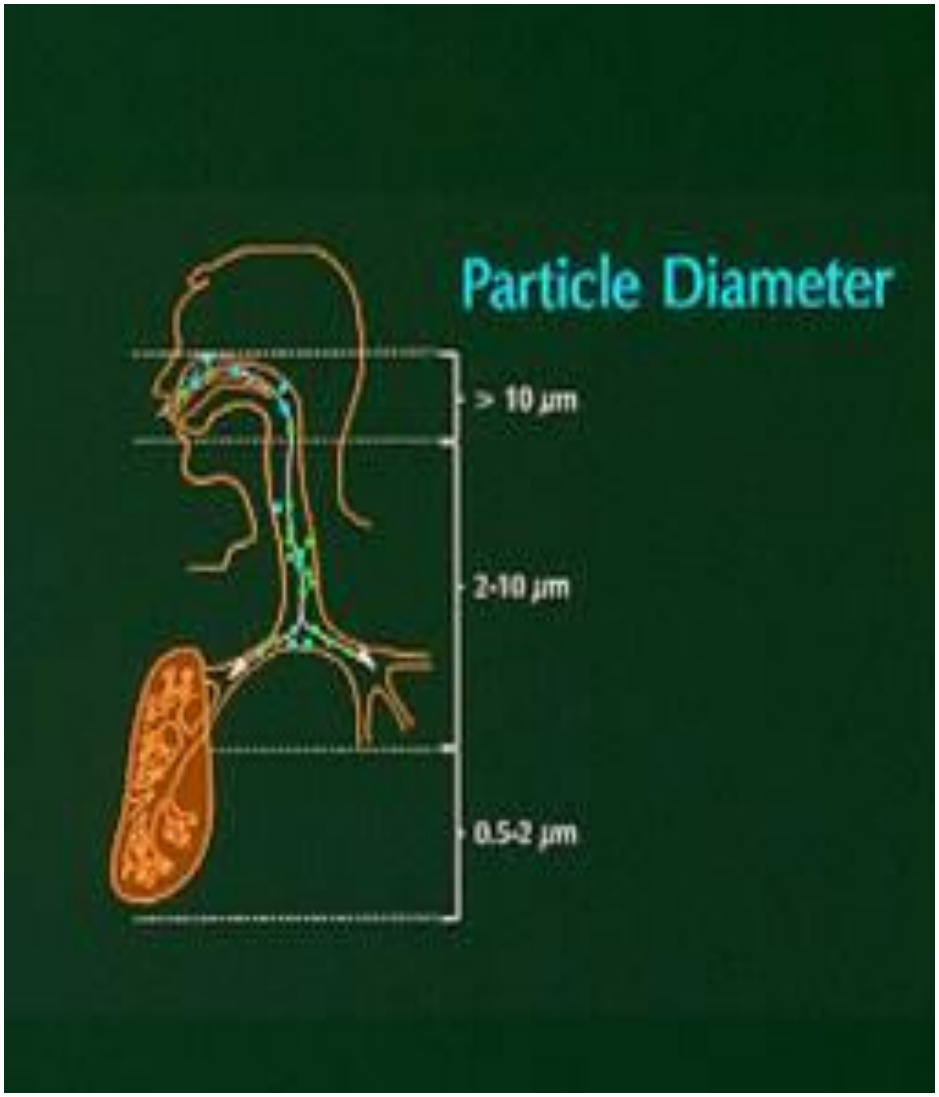




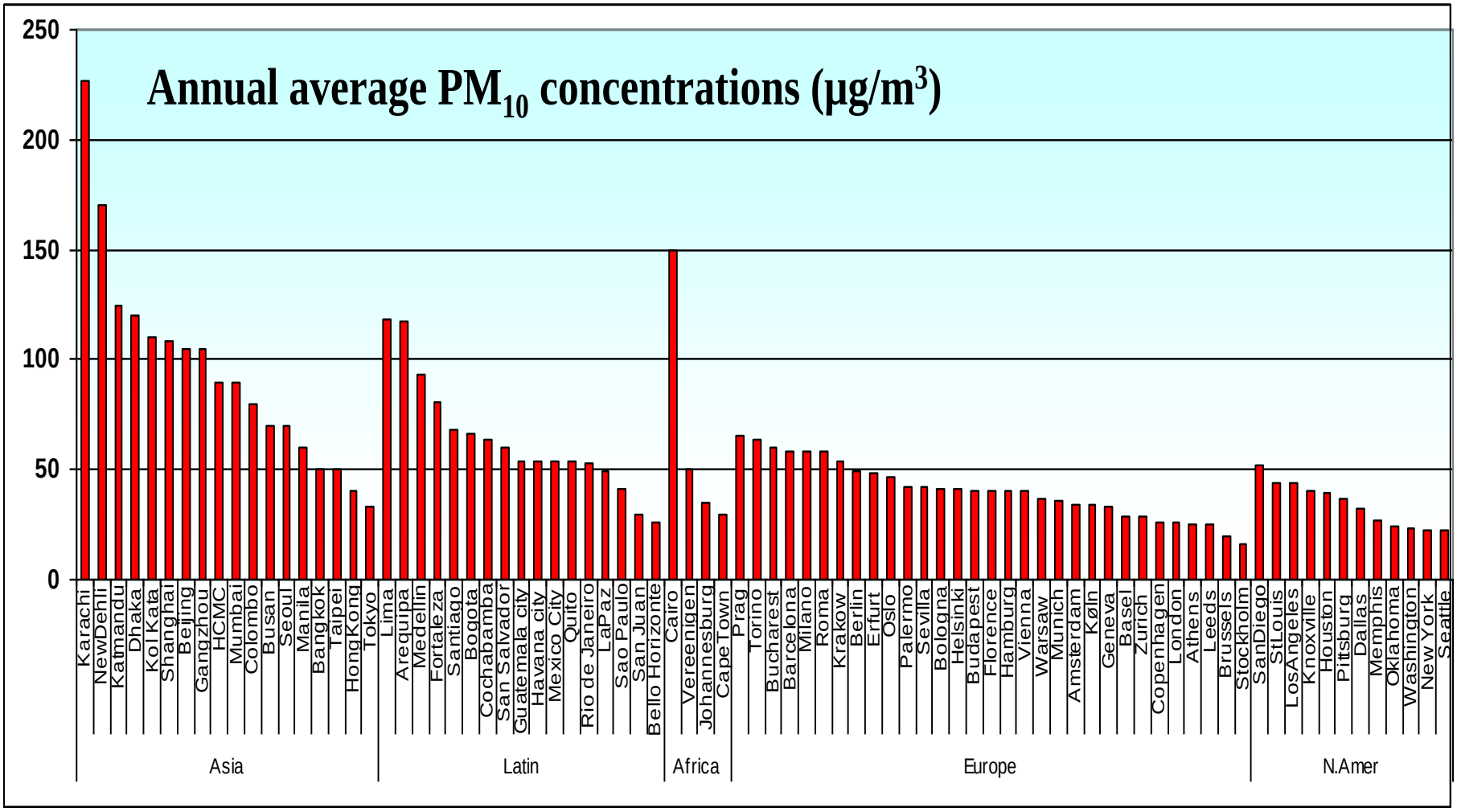
Karagulian F et al , Atmosph Env, 120(2015), 475–483

SIZE MATTERS

- Coarse particles (2.5–10 microns) deposited in the upper respiratory tract and large airways
- Fine particles (< 2.5 microns) may reach terminal bronchioles and alveoli



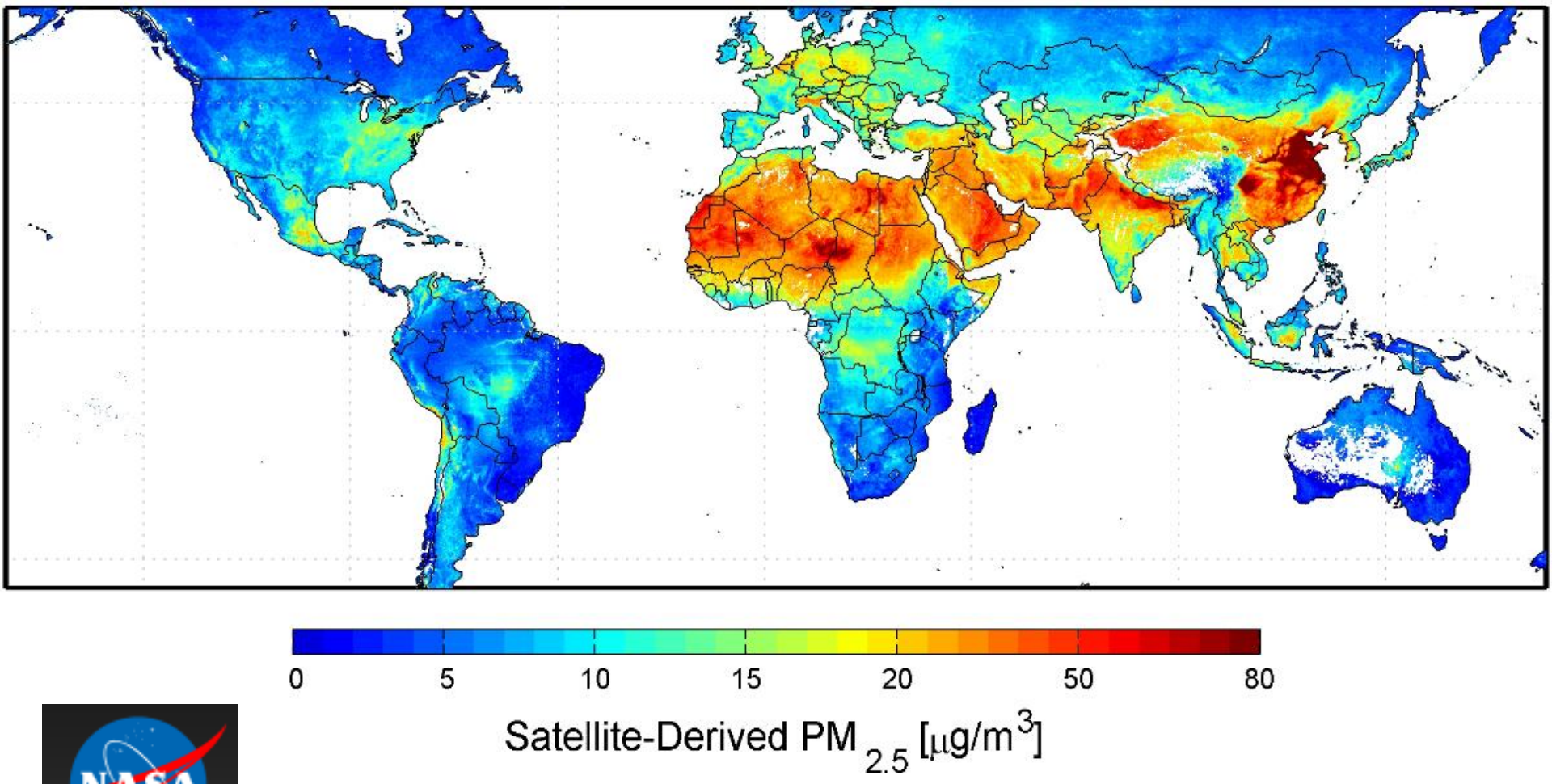
Annual average PM10 concentrations observed in selected cities worldwide, 2000-2004



Global Estimates of Ambient Fine Particulate Matter Concentrations from Satellite-Based Aerosol Optical Depth: Development and Application

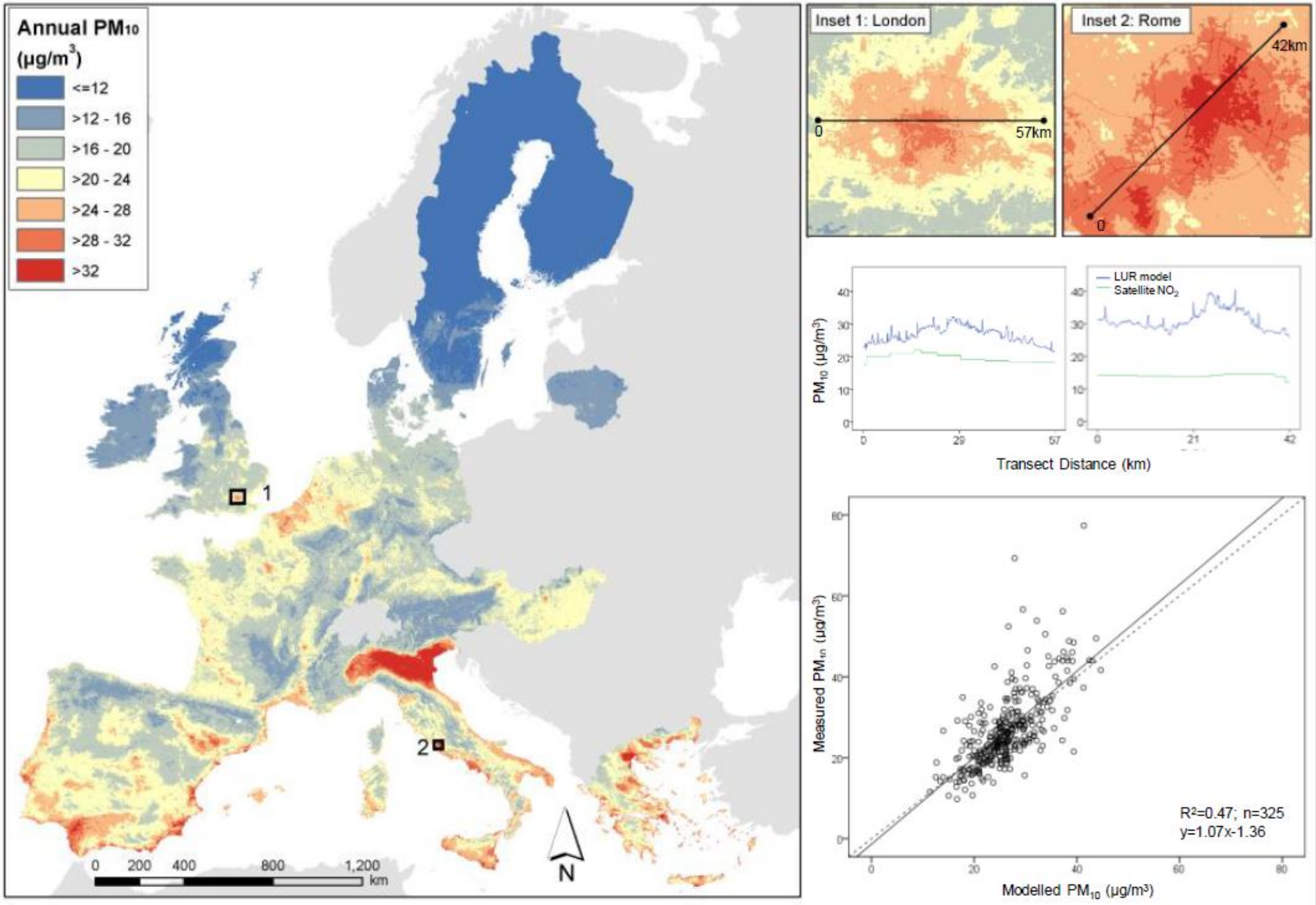
Aaron van Donkelaar,[1] Randall V. Martin,[1,2] Michael Brauer,[3] Ralph Kahn,[4] Robert Levy,[4] Carolyn Verduzco,[1] and Paul J. Villeneuve[5,6]

Environ Health Perspect 118:847–855 (2010).



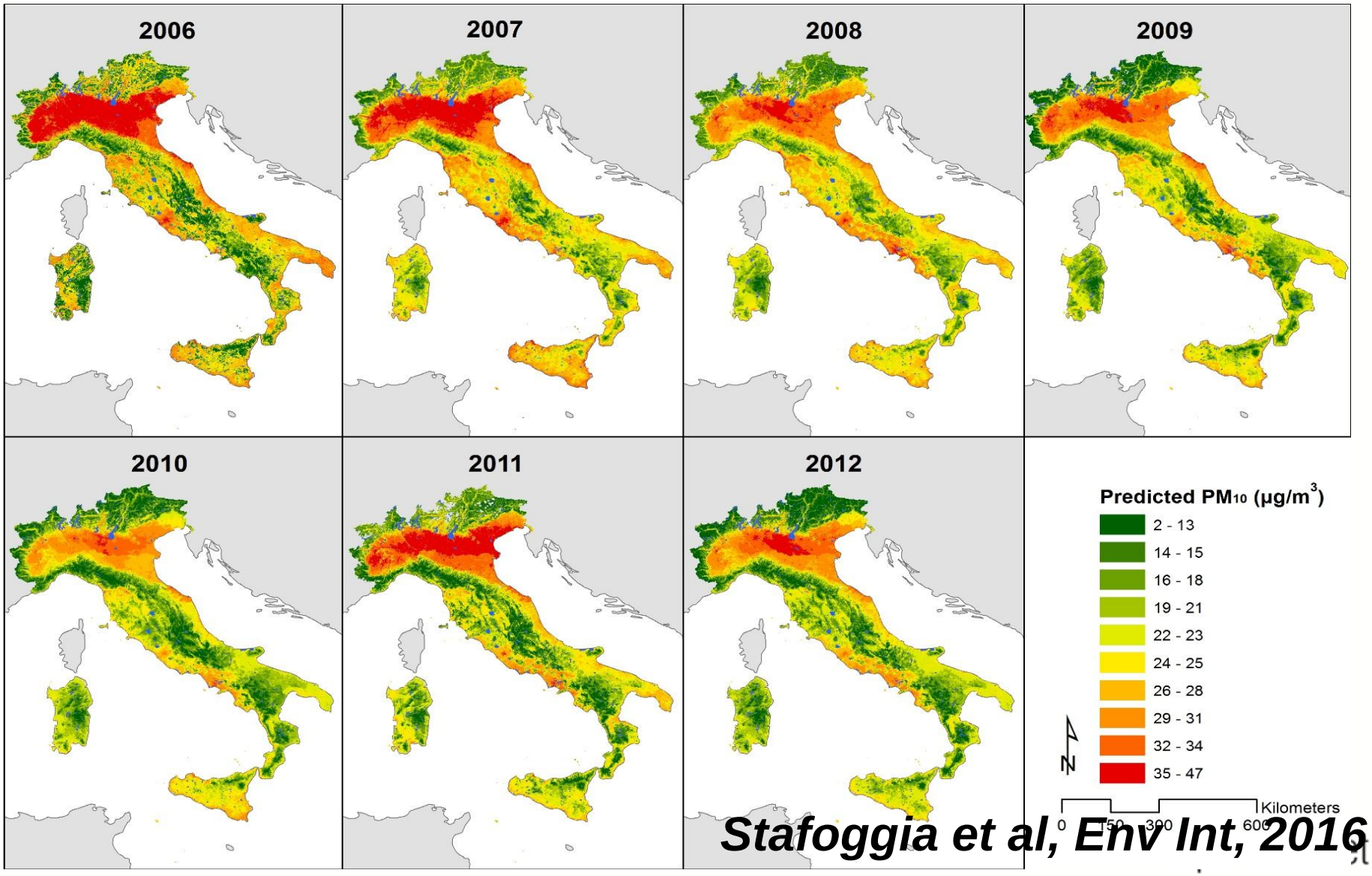
Satellite-derived map of $PM_{2.5}$ averaged over 2001-2006. Credit: Dalhousie University, Aaron van Donkelaar

Fig 2. PM10 2007 Satellite



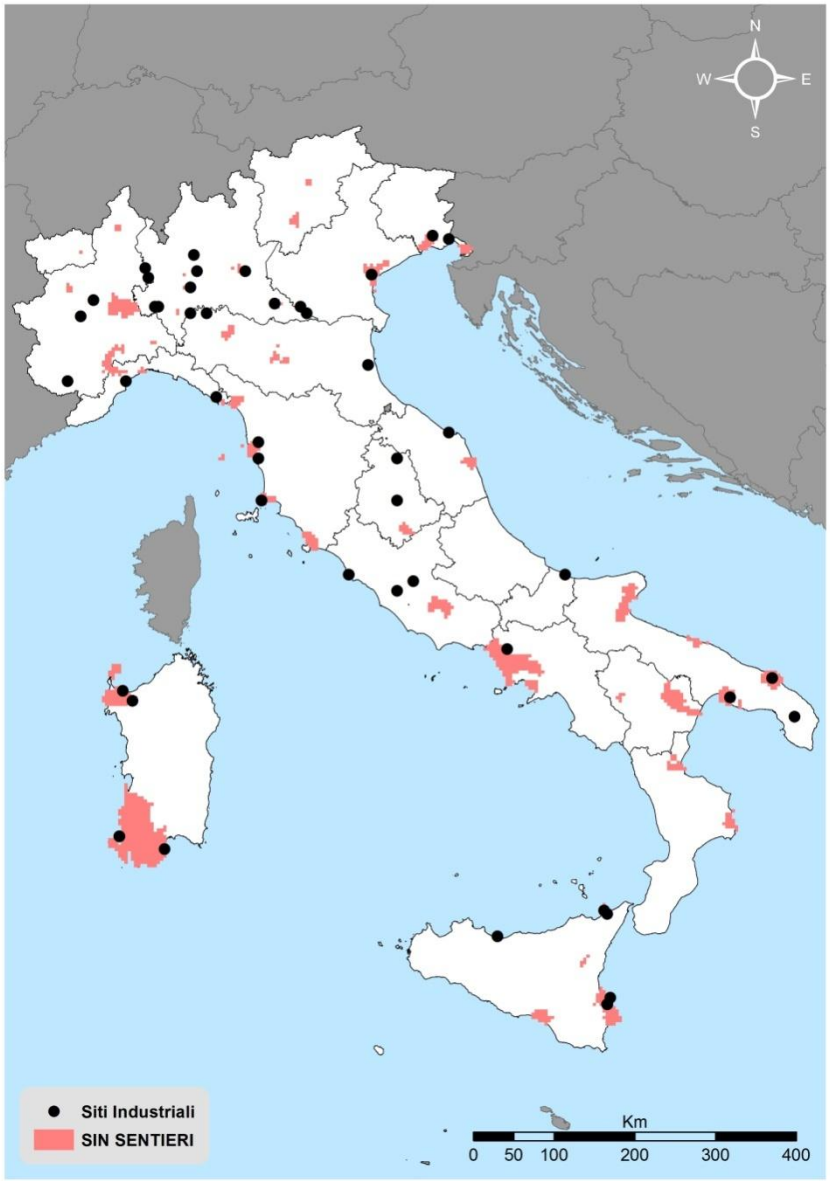
AIR POLLUTION MAPS, ITALY, 2006-2012

Maps of PM_{10} in Italy at high resolution using satellite data (1 Km grid)



Stafoggia et al, Env Int, 2016

Industrial sites in Italy



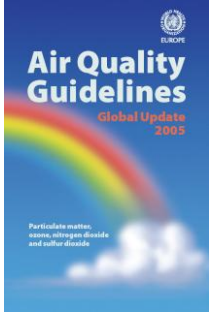
61 industrial sites (44 municipalities)

European Pollutant Release and Transfer Register (E-PRTR)

”Revealing the costs of air pollution from industrial facilities in Europe”

European Environmental Agency, 2011

WHO AQG Summary (2005)



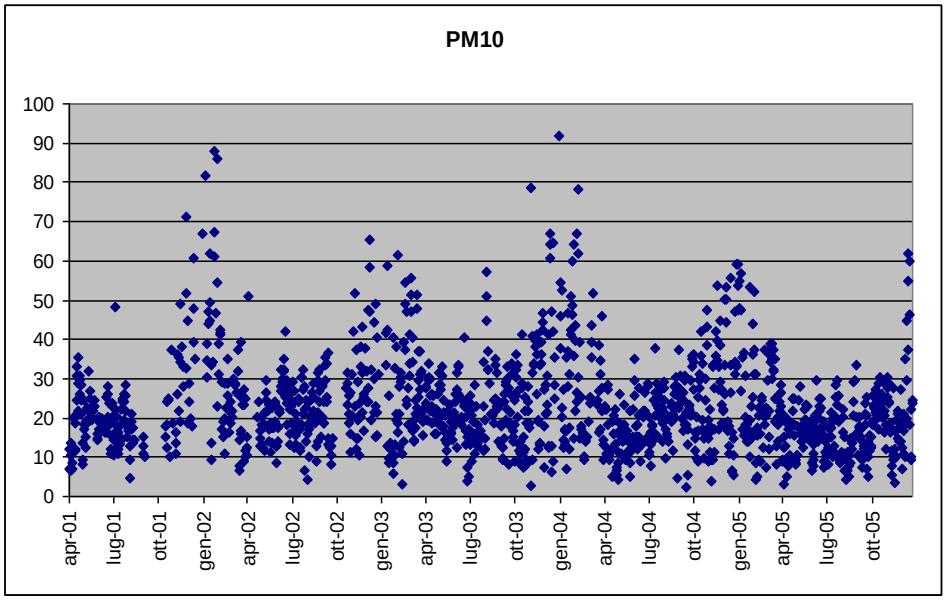
Pollutant	Averaging time	AQG value	*EU standard (target or limit value)*
Particulate matter			
$PM_{2.5}$	1 year	10 µg/m^3	*25 µg/m^3*
	24 hour (99th percentile)	25 µg/m^3	*--*
PM_{10}	1 year	20 µg/m^3	*40 µg/m^3*
	24 hour (99th percentile)	50 µg/m^3	*50 µg/m^3****
Ozone, O_3	8 hour, daily maximum	100 µg/m^3	*120 µg/m^3****
Nitrogen dioxide, NO_2	1 year	40 µg/m^3	*40 µg/m^3*
	1 hour	200 µg/m^3	*200 µg/m^3****
Sulfur dioxide, SO_2	24 hour	20 µg/m^3	*125 µg/m^3****
	10 minute	500 µg/m^3	*350 µg/m^3*** (1 hr)*

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

THE EFFECTS OF AIR POLLUTION ON HEALTH ARE OFTEN CONVENIENTLY CLASSIFIED:

In short-term and long-term effects

although there is probably a continuum of effects in the time scale, which are not yet fully understood.

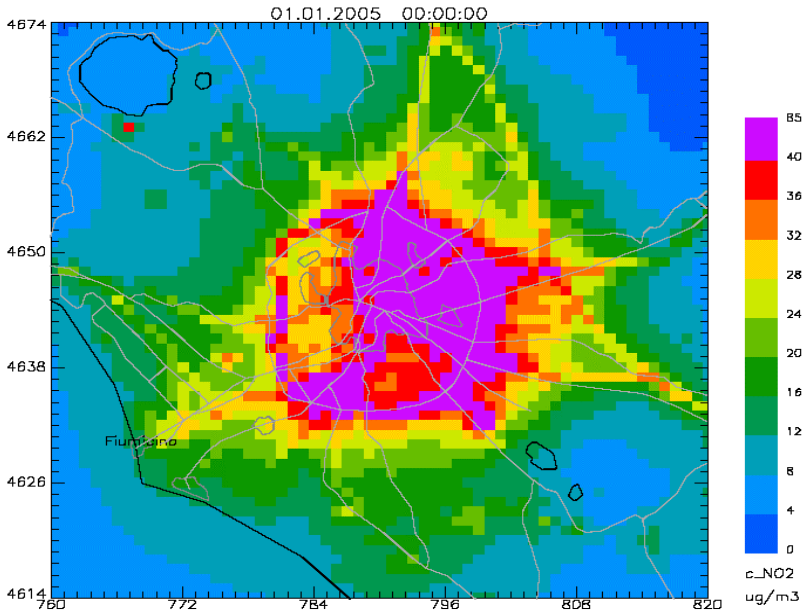


Acute effects

Temporal differences

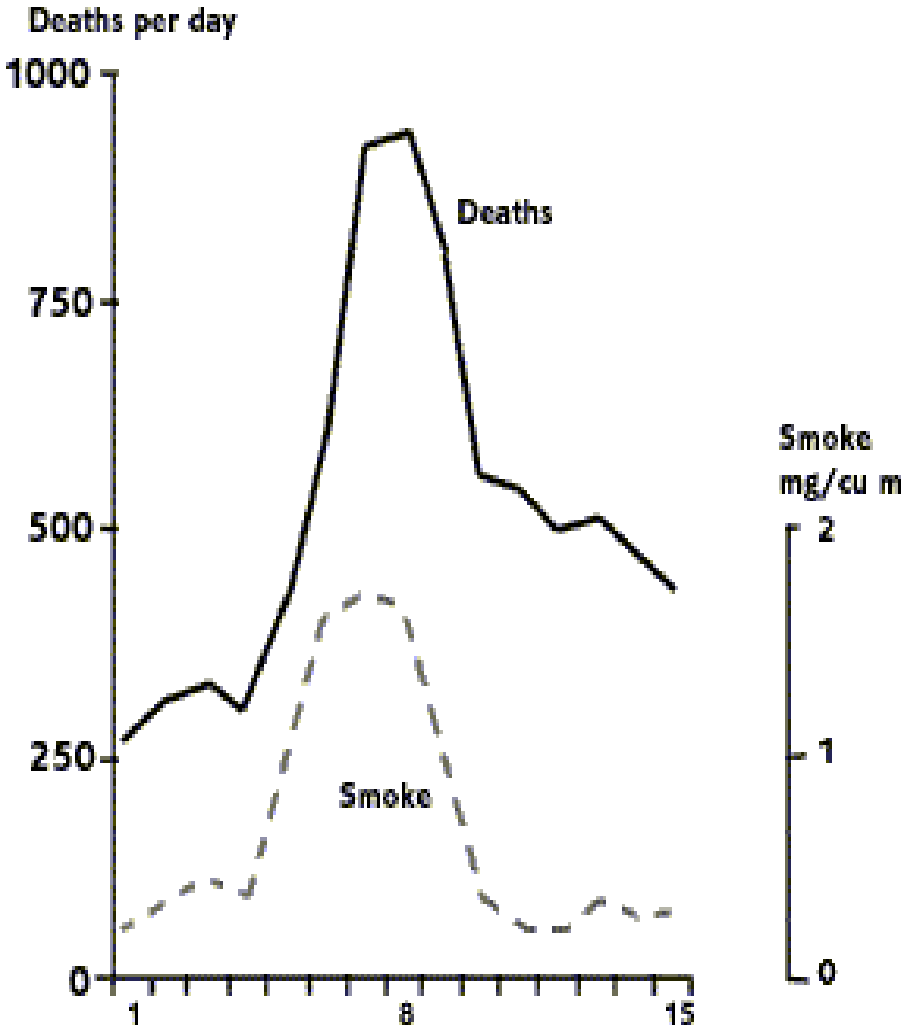
Chronic effects

Spatial differences



Short-term health effects

Deaths from London Smog, December 1952



Long-term health effects

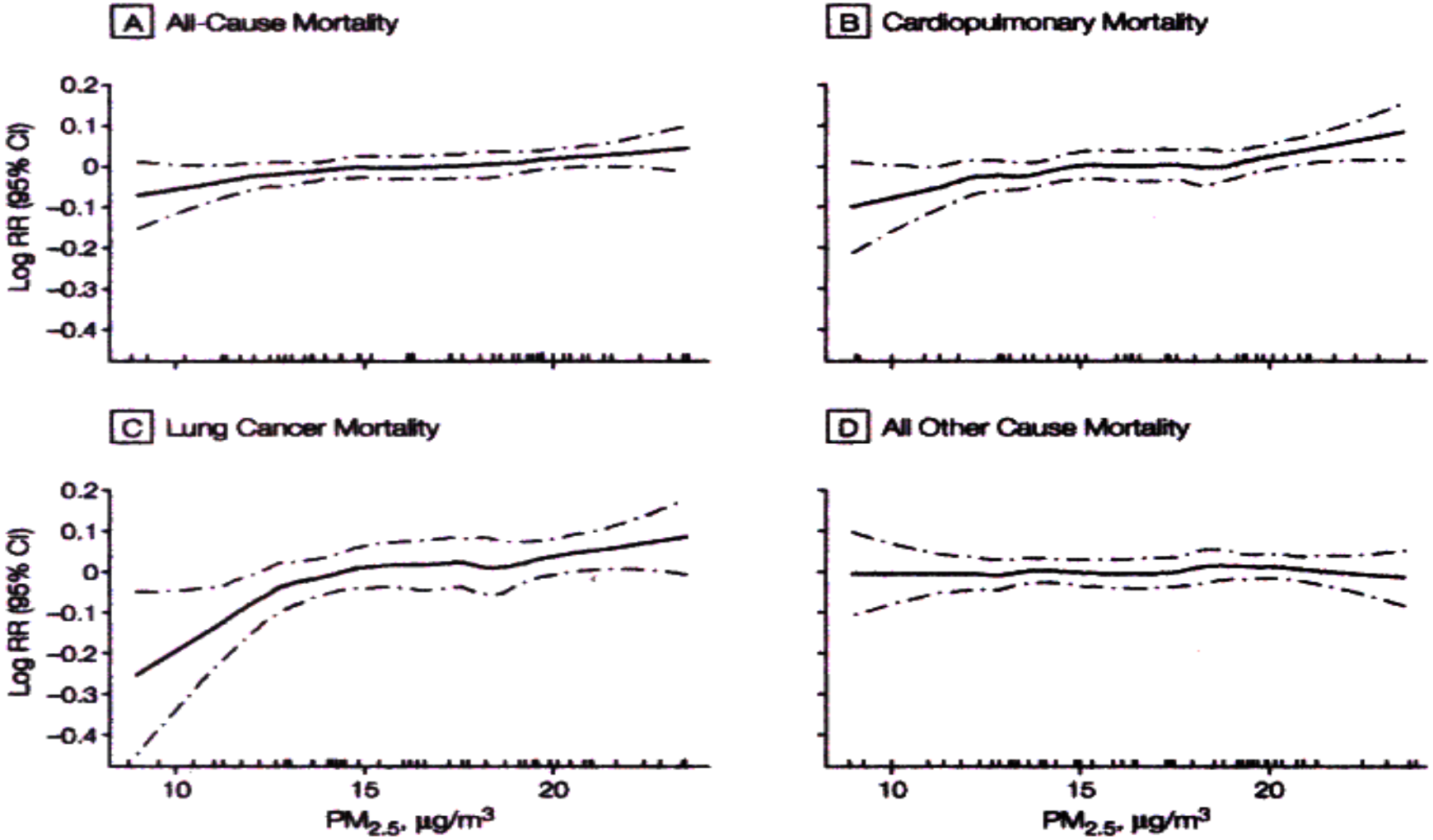
Long-term exposure and mortality

ORIGINAL CONTRIBUTION

Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution

POPE ET AL, JAMA 2002

Figure 2. Nonparametric Smoothed Exposure Response Relationship



Vertical lines along x-axes indicate rug or frequency plot of mean fine particulate pollution; $PM_{2.5}$, mean fine particles measuring less than 2.5 µm in diameter; RR, relative risk; and CI, confidence interval.

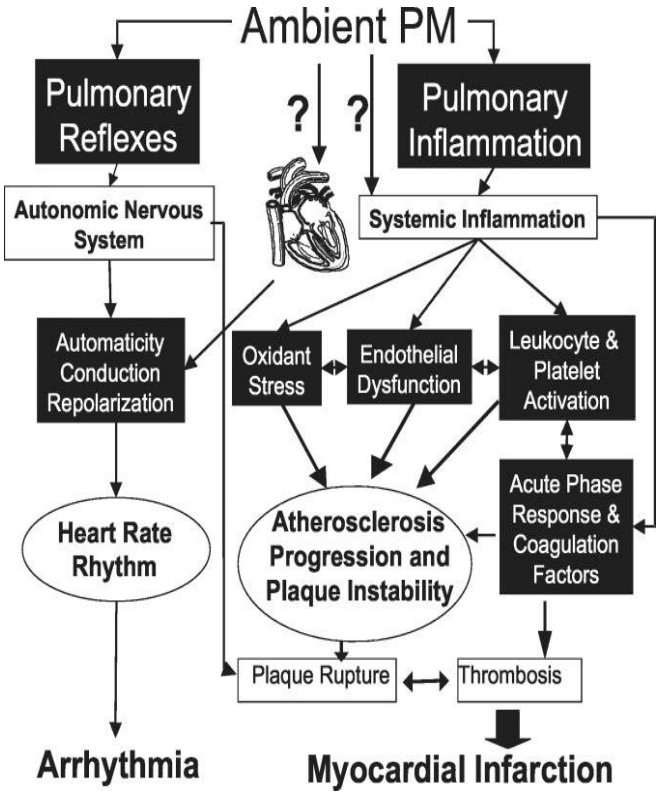
Adjusted mortality relative risks (RR) associated with 10μg/m^3 change in $PM_{2.5}$*

(Pope et al, 2002)

Cause of mortality	RR (95% CI)
All cause	1.06 (1.02 – 1.11)
Lung cancer	1.14 (1.04 – 1.23)
Cardiopulmonary	1.09 (1.03 – 1.16)
All other cause	1.01 (0.95 – 1.06)

*Adjusted for age, sex, race, smoking, education, marital status, body mass, alcohol consumption, occupational exposure, diet.

Possible biological mechanisms linking PM with cardiovascular diseases



Brook et al, 2004. AHA

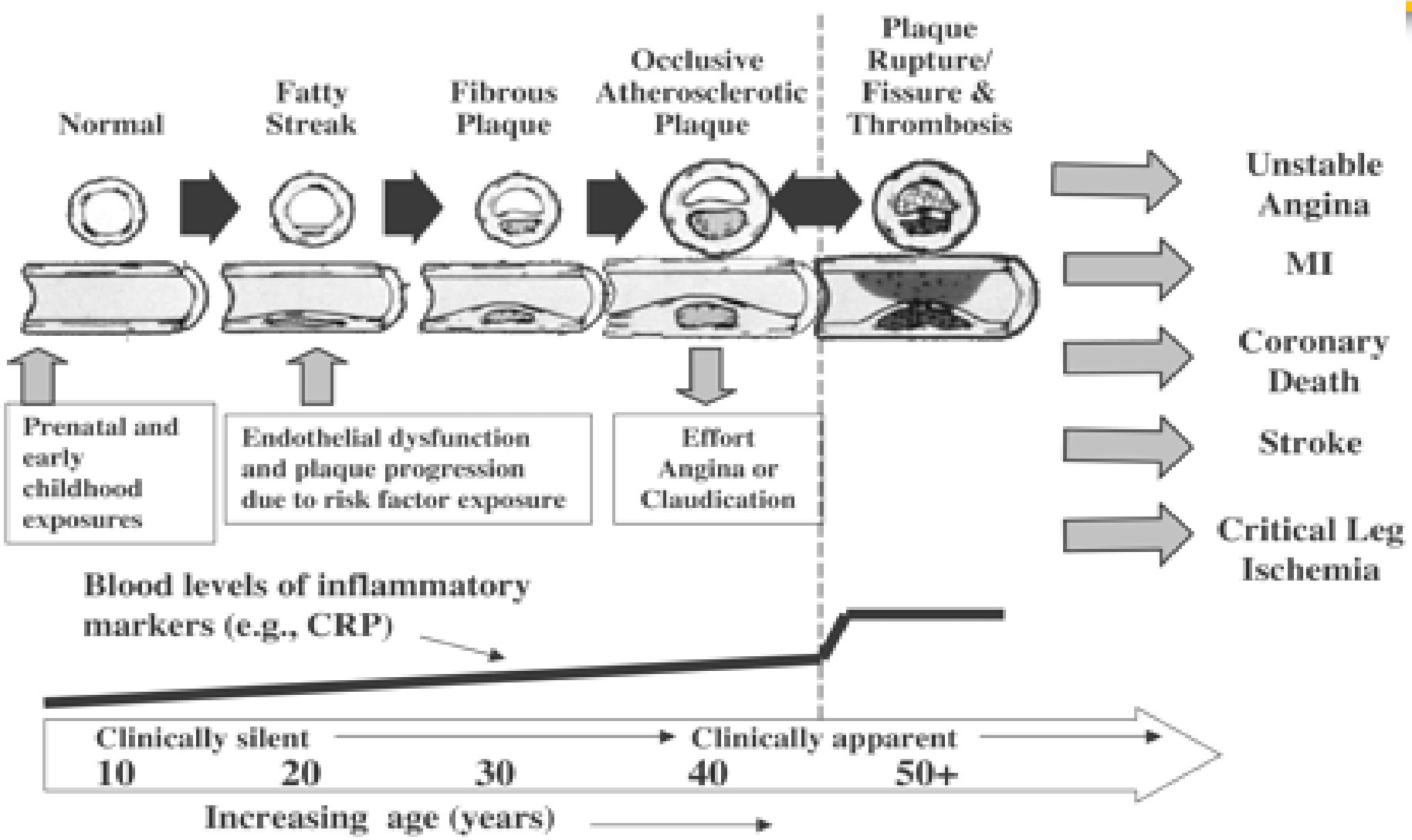
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 13, 2007 VOL. 357 NO. 11

Ischemic and Thrombotic Effects of Dilute Diesel-Exhaust Inhalation in Men with Coronary Heart Disease

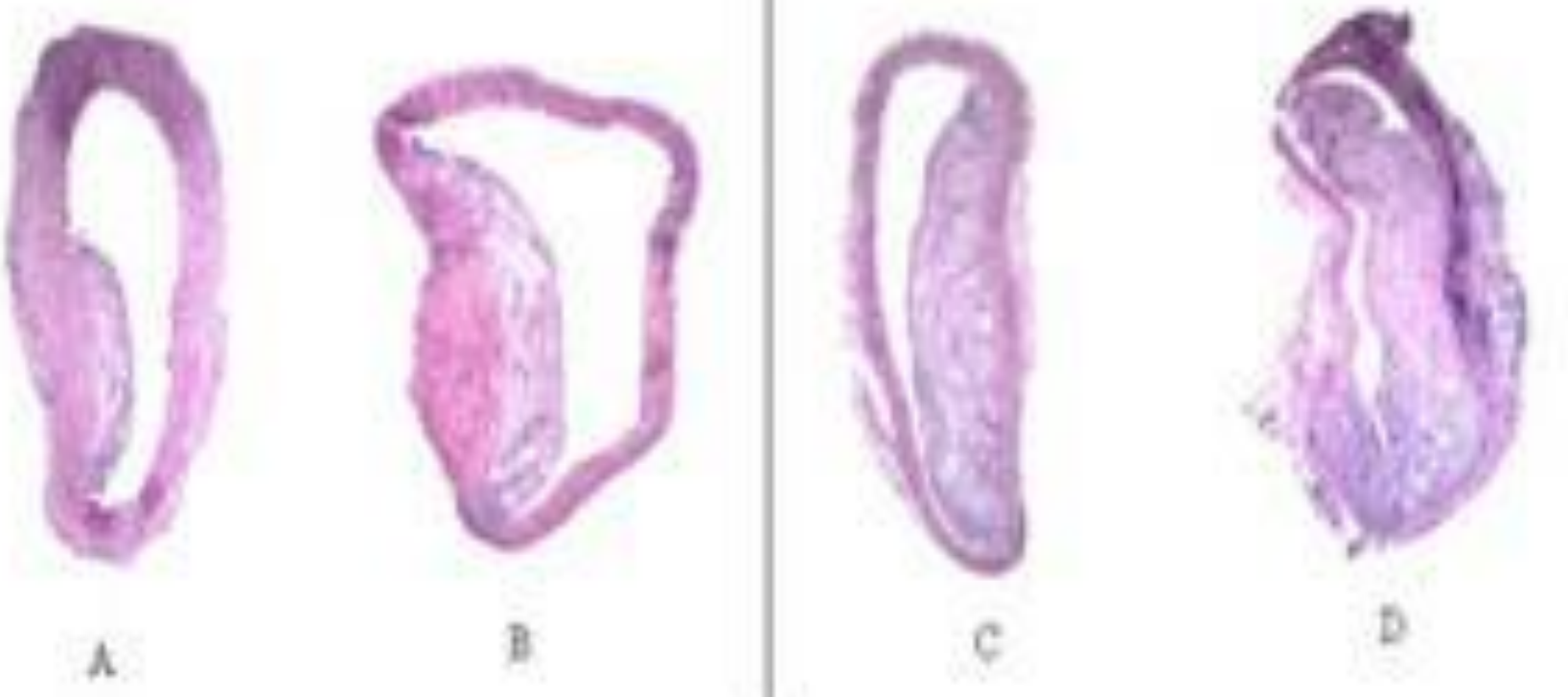
Nicholas L. Mills, M.D., Håkan Törnqvist, M.D., Manuel C. Gonzalez, M.D., Elen Vink, B.Sc., Simon D. Robinson, M.D., Stefan Söderberg, M.D., Ph.D., Nicholas A. Boon, M.D., Ken Donaldson, Ph.D., Thomas Sandström, M.D., Ph.D., Anders Blomberg, M.D., Ph.D., and David E. Newby, M.D., Ph.D.

Atherosclerosis: A Progressive Process



Diet, air pollution and atheriosclerosis

Mice on normal diet ***Mice on high-fat diet***



Filtered air ***PM2.5*** ***Filtered air*** ***PM2.5***

Long-term Air Pollution Exposure and Acceleration of Atherosclerosis… Sun et al. JAMA.2005; 294: 3003-3010.

Recent statements and publications on air pollution

World Health Organization

68th World Health Assembly

Media centre

World Health Assembly closes, passing resolutions on air pollution and epilepsy

New release

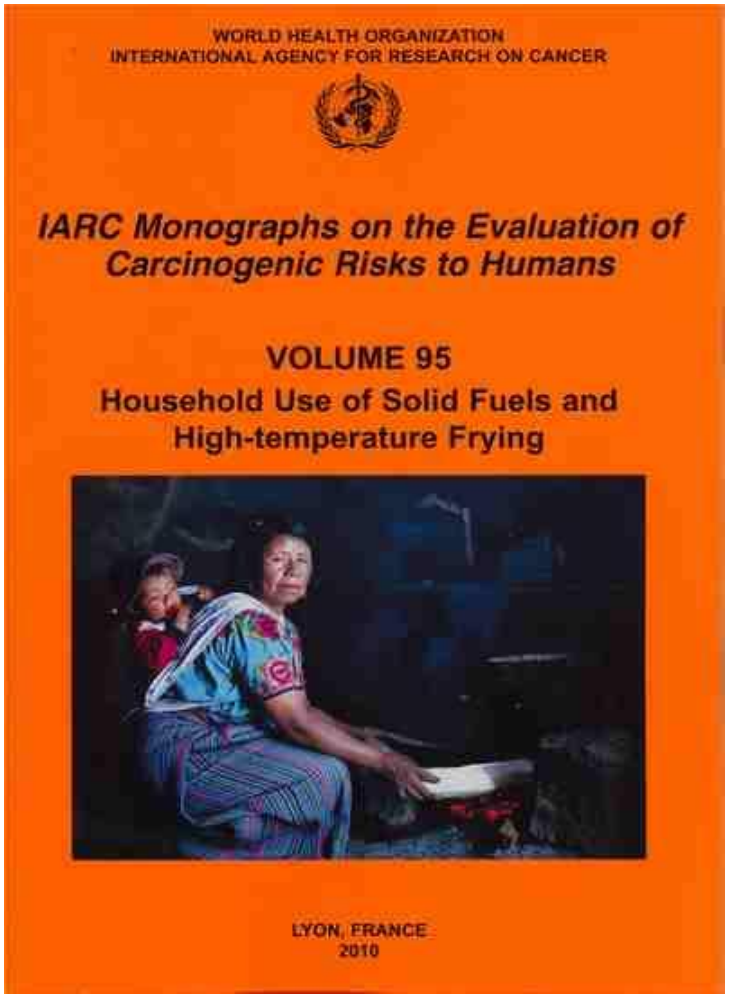
May 26, 2015

26 MAY 2015 ¦ GENEVA - The World Health Assembly closed today, with Director-General Dr Margaret Chan noting that it had passed several “landmark resolutions and decisions”. Three new resolutions were passed today: one on air pollution, one on epilepsy and one laying out the next steps in finalizing a framework of engagement with non-State actors.

Air pollution

Delegates at the World Health Assembly adopted a resolution to address the health impacts of air pollution – the world’s largest single environmental health risk. Every year 4.3 million deaths occur from exposure to indoor air pollution and 3.7 million deaths are attributable to outdoor air pollution. This was the first time the Health Assembly had debated the topic.

IARC Monographs



International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 213

12 June 2012

IARC: DIESEL ENGINE EXHAUST CARCINOGENIC

Lyon, France, June 12, 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as **carcinogenic to humans (Group 1)**, based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

INDOOR EMISSIONS FROM HOUSEHOLD COMBUSTION OF COAL

Indoor combustion of coal was considered by a previous IARC Working Group in 2006 (IARC, 2010a). Since that time, new data have become available, these have been incorporated into the *Monograph*, and taken into consideration in the present evaluation.

1. Exposure Data

1.1 Constituents of coal emissions from household use of coal

1.1.1 Types and forms of coal

Coal is a highly variable fuel, which ranges from high heating-value anthracite through

1.1.2 Constituents of coal emissions

When using small and simple combustion devices such as household cooking and heating stoves, coals are difficult to burn without substantial emission of pollutants principally due to the difficulty of completely pre-mixing the fuel and air during burning. Consequently, a substantial fraction of the fuel carbon is converted to prod-

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IARC Monographs

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 221

17 October 2013

IARC: Outdoor air pollution a leading environmental cause of cancer deaths

Lyon/Geneva, 17 October 2013 – The specialized cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced today that it has classified outdoor air pollution as *carcinogenic to humans* (Group 1).[1]

After thoroughly reviewing the latest available scientific literature, the world's leading experts convened by the IARC Monographs Programme concluded that there is *sufficient evidence* that exposure to outdoor air pollution causes lung cancer (Group 1). They also noted a positive association with an increased risk of bladder cancer.

Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as *carcinogenic to humans* (Group 1).

The IARC evaluation showed an increasing risk of lung cancer with increasing levels of exposure to particulate matter and air pollution. Although the composition of air pollution and levels of exposure can vary dramatically between locations, the conclusions of the Working Group apply to all regions of the world.

International Agency for Research on Cancer

12 June 2012

GENIC

xperts, the International anization (WHO), today d on sufficient evidence

USEHOLD OF COAL

ng Group in 2006 ave been incorpo- valuation.

1. Exposure Data

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Coal is a highly variable fuel, which ranges from high heating-value anthracite through

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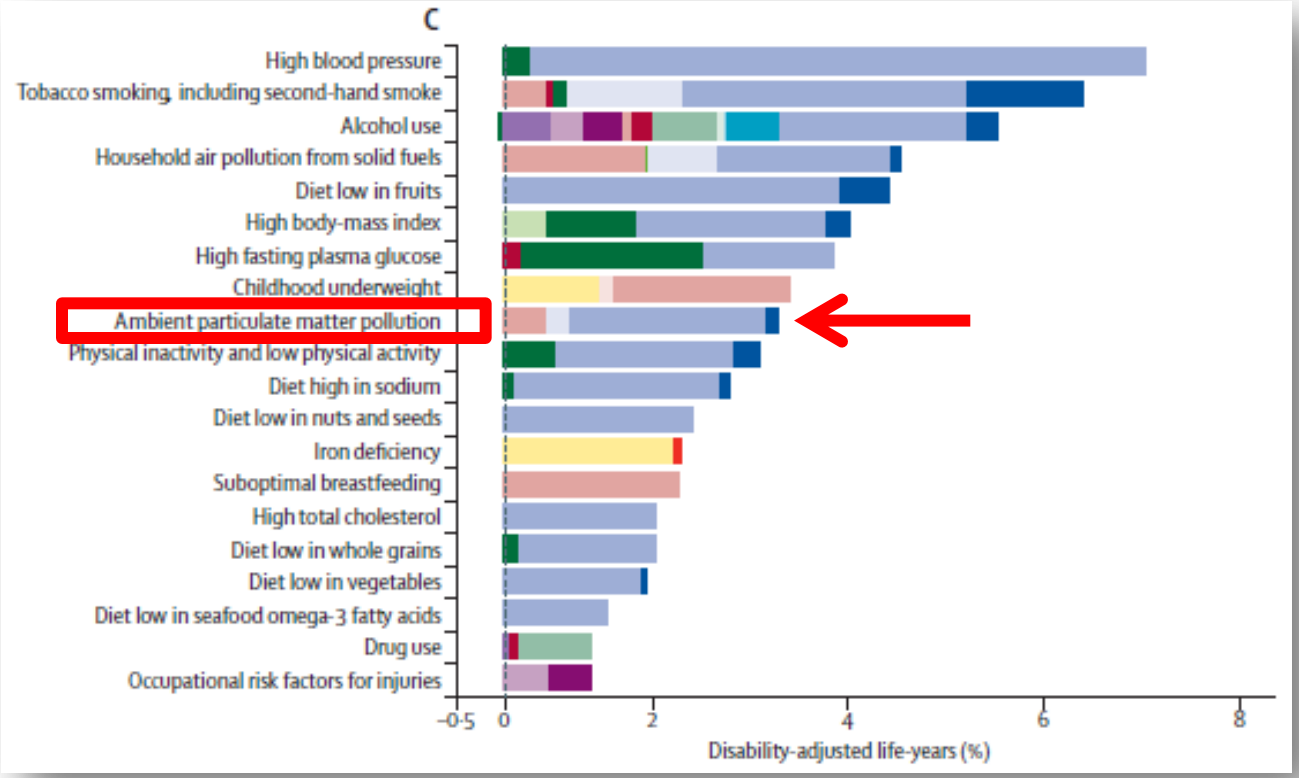
GBD 2010: Air pollution is a major risk factor for public health

A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010

Lancet, 2012



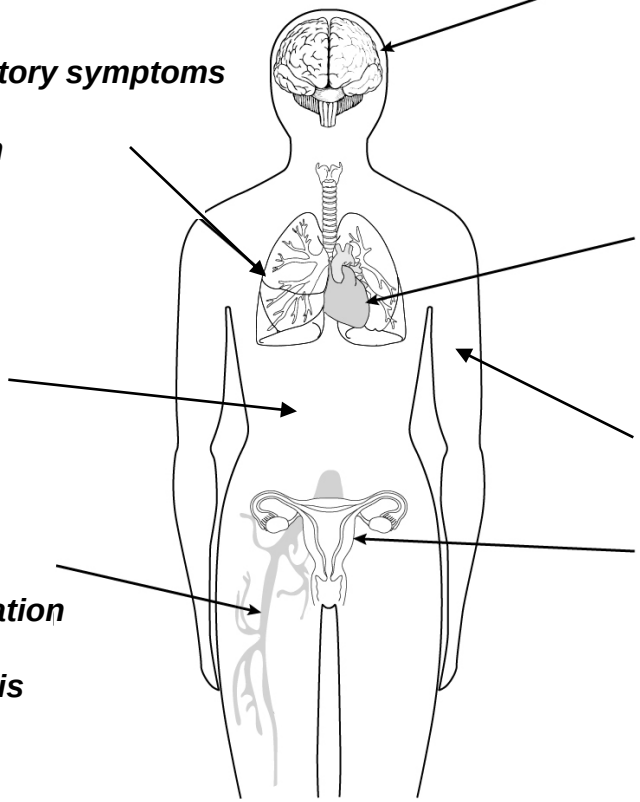
Fonte: Lancet 2012

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*

Joint ERS / ATS statement (ERJ, 2016)

Original Article

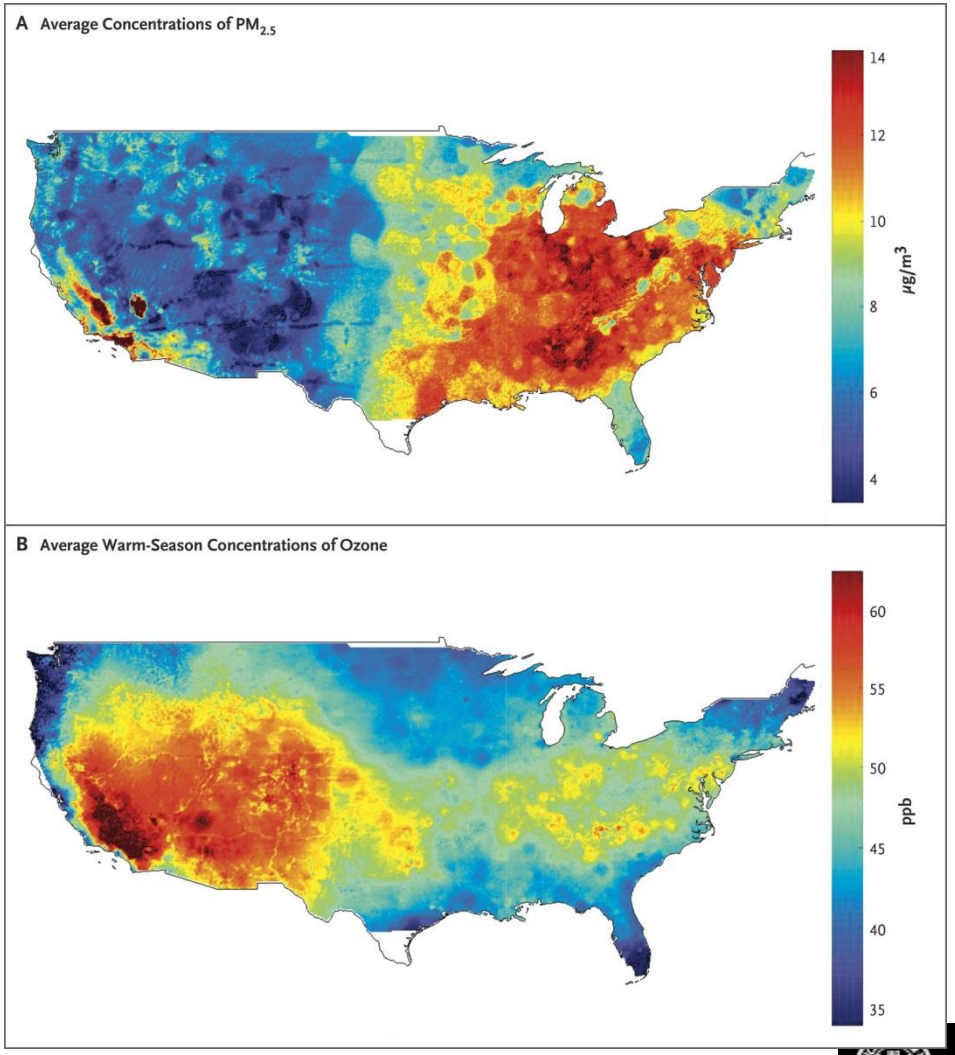
Air Pollution and Mortality in the Medicare Population

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 June 2017

The NEW ENGLAND JOURNAL of MEDICINE

Average $PM_{2.5}$ and Ozone Concentrations in the Continental United States, 2000 through 2012.



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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 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.*

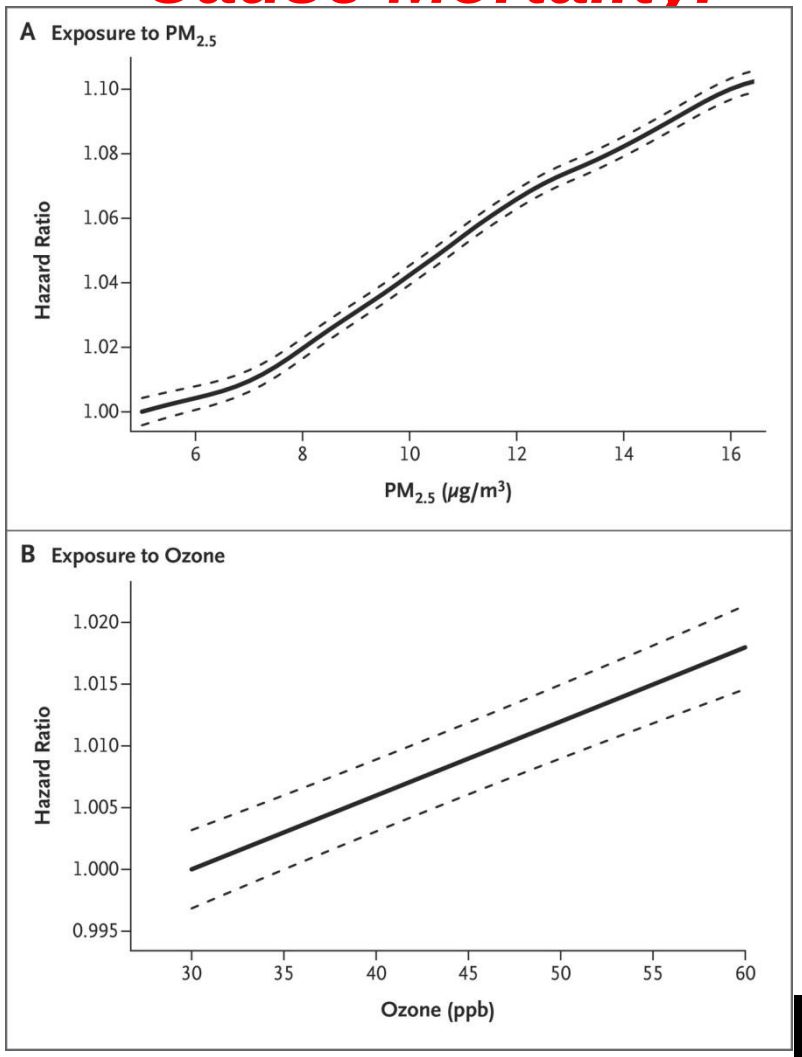
Model	$PM_{2.5}$	Ozone
	hazard ratio (95% CI)	
Two-pollutant analysis		
Main analysis	1.073 (1.071–1.075)	1.011 (1.010–1.012)
Low-exposure analysis	1.136 (1.131–1.141)	1.010 (1.009–1.011)
Analysis based on data from nearest monitoring site (nearest-monitor analysis)†	1.061 (1.059–1.063)	1.001 (1.000–1.002)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

* Hazard ratios and 95% confidence intervals were calculated on the basis of an increase of 10 µg per cubic meter in exposure to $PM_{2.5}$ and an increase of 10 ppb in exposure to ozone.

† Daily average monitoring data on $PM_{2.5}$ and ozone were obtained from the Environmental Protection Agency Air Quality System. Daily ozone concentrations were averaged from April 1 through September 30 for the computation of warm-season averages. Data on $PM_{2.5}$ and ozone levels were obtained from the nearest monitoring site within 50 km. If there was more than one monitoring site within 50 km, the nearest site was chosen. Persons who lived more than 50 km from a monitoring site were excluded.

‡ For the single-pollutant analysis, model specifications were the same as those used in the main analysis, except that ozone was not included in the model when the main effect of $PM_{2.5}$ was estimated and $PM_{2.5}$ was not included in the model when the main effect of ozone was estimated.

Concentration–Response Function of the Joint Effects of Exposure to $PM_{2.5}$ and Ozone on All-Cause Mortality.



The NEW ENGLAND JOURNAL of MEDICINE

The Lancet, May 2017

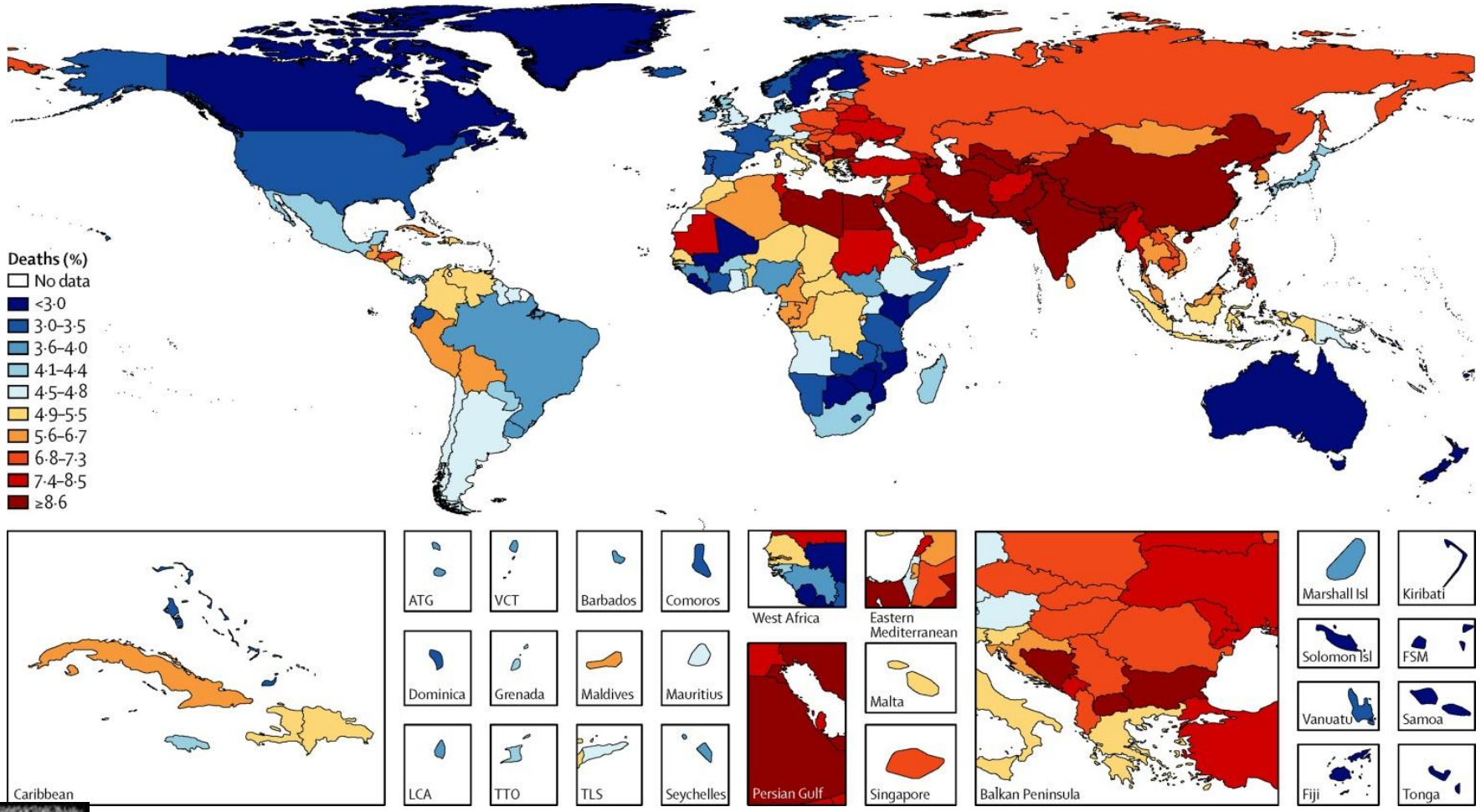
Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015

Aaron J Cohen, Michael Brauer*, Richard Burnett, H Ross Anderson, Joseph Frostad, Kara Estep, Kalpana Balakrishnan, Bert Brunekreef, Lalit Dandona, Rakhi Dandona, Valery Feigin, Greg Freedman, Bryan Hubbell, Amelia Jobling, Haidong Kan, Luke Knibbs, Yang Liu, Randall Martin, Lidia Morawska, C Arden Pope III, Hwashin Shin, Kurt Straif, Gavin Shaddick, Matthew Thomas, Rita van Dingenen, Aaron van Donkelaar, Theo Vos, Christopher J L Murray, Mohammad H Forouzanfar†*

Findings Ambient $PM_{2.5}$ was the fifth-ranking mortality risk factor in 2015. Exposure to $PM_{2.5}$ caused 4·2 million (95% uncertainty interval [UI] 3·7 million to 4·8 million) deaths and 103·1 million (90·8 million 115·1 million) disability-adjusted life-years (DALYs) in 2015, representing 7·6% of total global deaths and 4·2% of global DALYs, 59% of these in east and south Asia. Deaths attributable to ambient $PM_{2.5}$ increased from 3·5 million (95% UI 3·0 million to 4·0 million) in 1990 to 4·2 million (3·7 million to 4·8 million) in 2015. Exposure to ozone caused an additional 254 000 (95% UI 97 000–422 000) deaths and a loss of 4·1 million (1·6 million to 6·8 million) DALYs from chronic obstructive pulmonary disease in 2015.

4.2 million deaths attributable to PM2.5 in 2015

Deaths attributable to ambient particulate matter pollution in 2015



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