Recenti acquisizioni sugli effetti e l'impatto dell'inquinamento atmosferico sulla salute

Francesco Forastiere

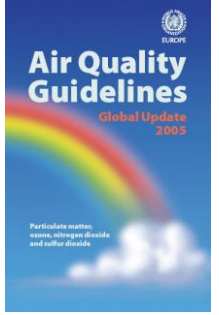
CNR-IBIM, Palermo, Italy; Imperial College, London, UK
Member of the GDG WHO Air Quality Guidelines

fran.forastiere@gmail.com

Outline

- WHO Air Quality Guidelines
- Effetti a breve termine
- Effetti lungo termine
- Stime di Impatto

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

Update of WHO global AQG

- To provide updated numerical concentration limits (i.e. guidelines) and, where possible, an indication of the shape of the concentration-response function for a number of ambient air pollutants, for relevant averaging times and in relation to critical health outcomes

- To provide a qualitative recommendation on the relation between exposure to desert dust and adverse health outcomes

Systematic Reviews

- **The update of the WHO Global Air Quality Guidelines**
  - Approach to assessing the certainty of evidence from systematic reviews informing WHO global air quality guidelines
  - **Three systematic reviews already published: Environmental International 2020**

Short-term exposure to particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), and ozone (O_3) and all-cause and cause-specific mortality: Systematic review and *meta*-analysis

Pablo Orellano [a], Julieta Reynoso [b], Nancy Quaranta [c, d], Ariel Bardach [e], Agustin Ciapponi [e]

Long-term exposure to PM and all-cause and cause-specific mortality: A systematic review and meta-analysis

Jie Chen, Gerard Hoek

Short-term exposure to carbon monoxide and myocardial infarction: *A systematic review and meta-analysis*

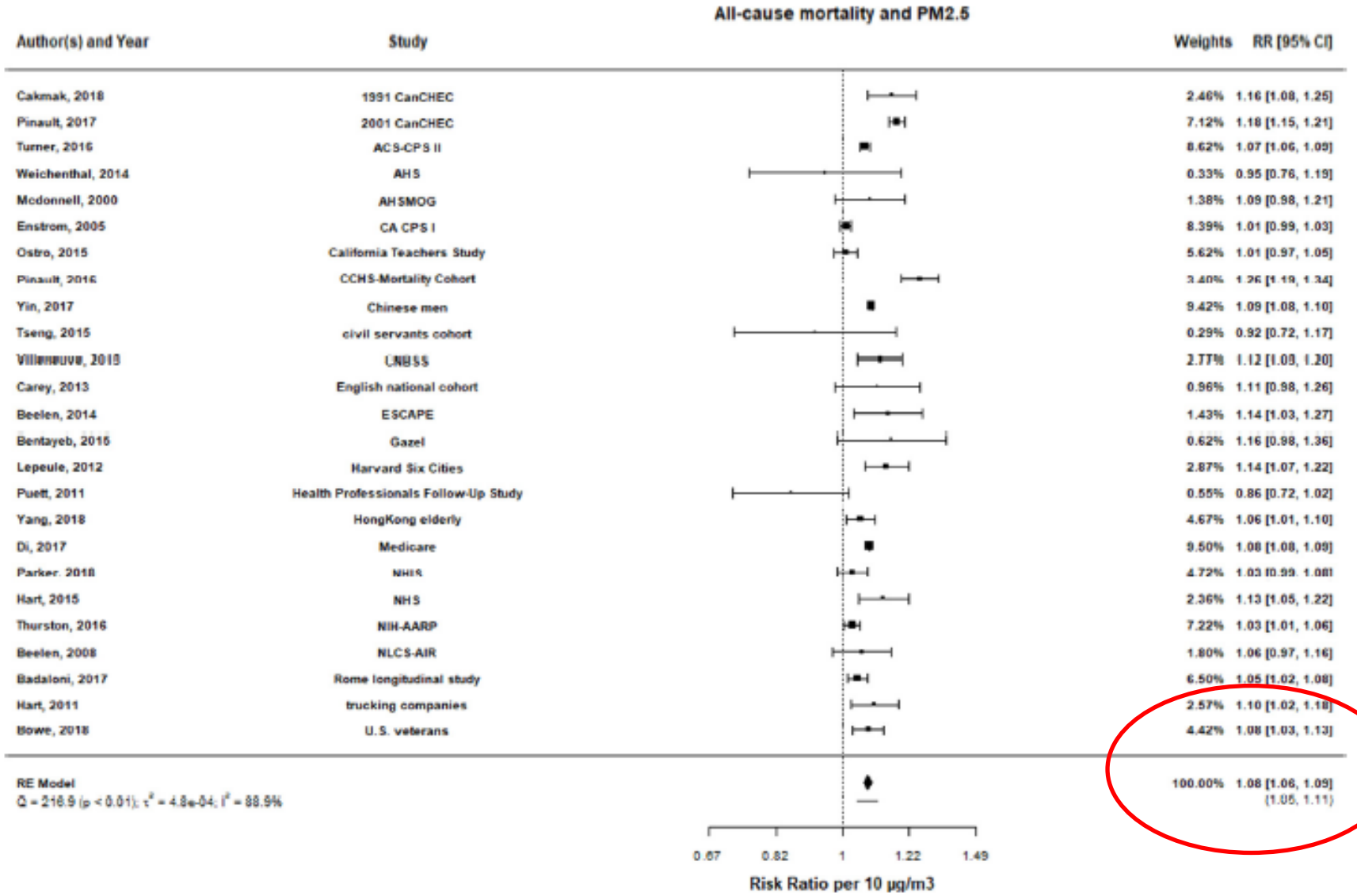
Kuan Ken Lee [a, 1], Nicholas Spath [a, 1], Mark R. Miller [a], Nicholas L. Mills [a, b], Anoop S.V. Shah [a, b]

Review article

Long-term exposure to PM and all-cause and cause-specific mortality: A systematic review and meta-analysis

Jie Chen*, Gerard Hoek

Env Int 2020



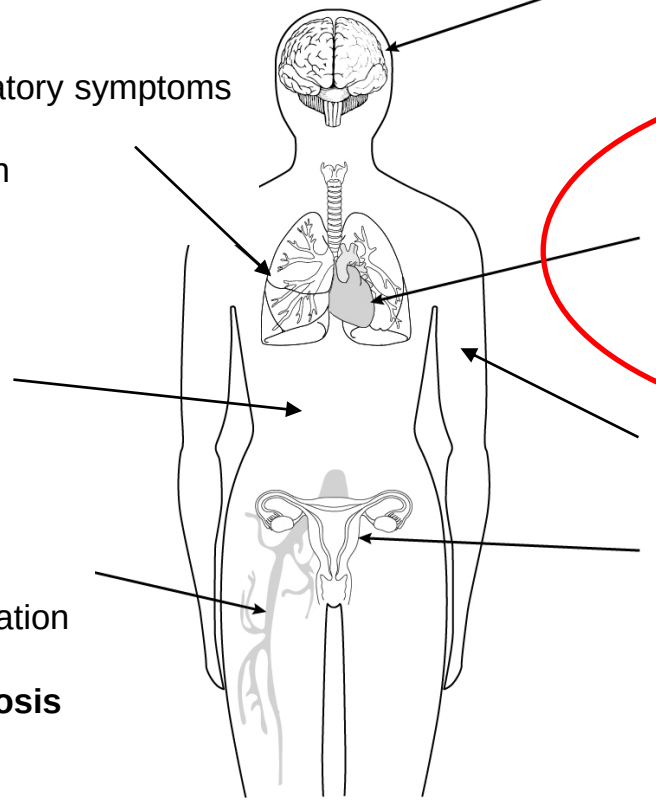
RR=1.08 per 10 ug/m³

Air pollution affects multiple organs immediately and has long-term consequences

- **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

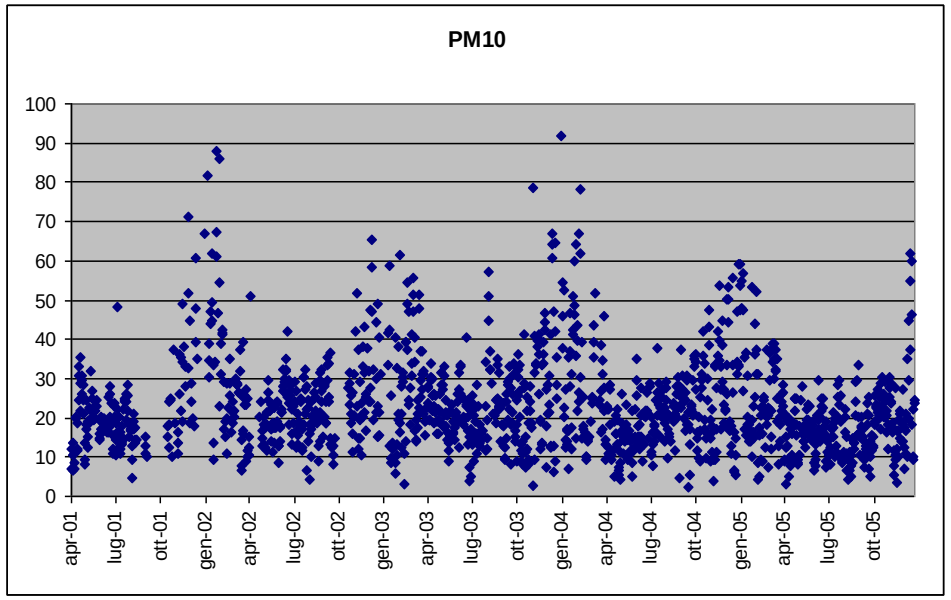
- **Premature Birth**
- **Decreased Birth Weight**
- Decreased foetal growth
- In uterine growth retardation
- Decreased sperm quality
- Preclampsia

Joint ERS / ATS statement ERJ 2017

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.

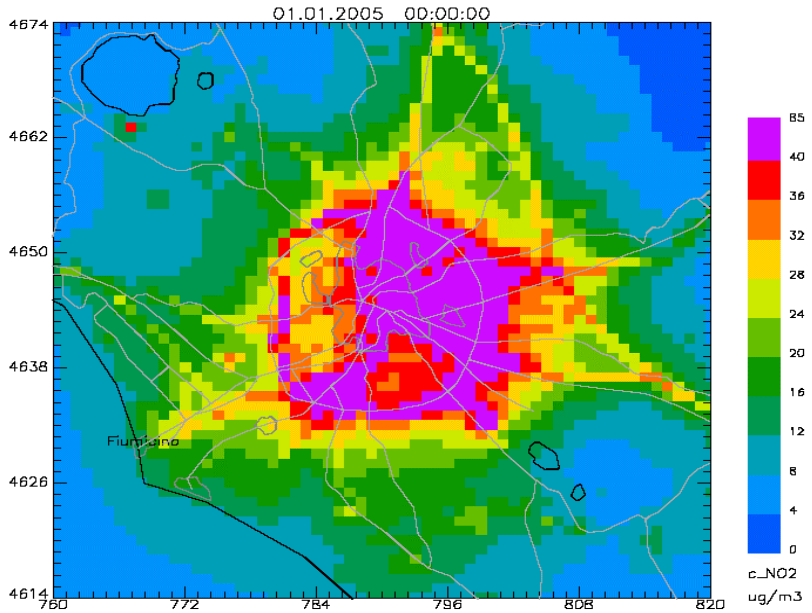


Acute effects

Temporal differences

Chronic effects

Spatial differences



DEP Lazio
Dipartimento di Epidemiologia
del Servizio Sanitario Regionale
Regione Lazio

ISPRA
Istituto Superiore per la Protezione
e la Ricerca Ambientale

OBIETTIVI

- Costruire un database nazionale con parametri spaziali e spazio-temporali per descrivere e stimare esposizioni ambientali multiple in Italia

- Stimare le concentrazioni giornaliere di PM_{10} e $PM_{2.5}$ su una griglia di 1 km^2 per l'intera Italia, per il periodo 2006-2015, usando molteplici fonti di dati, tra cui i dati satellitari

PROGETTO BEEP

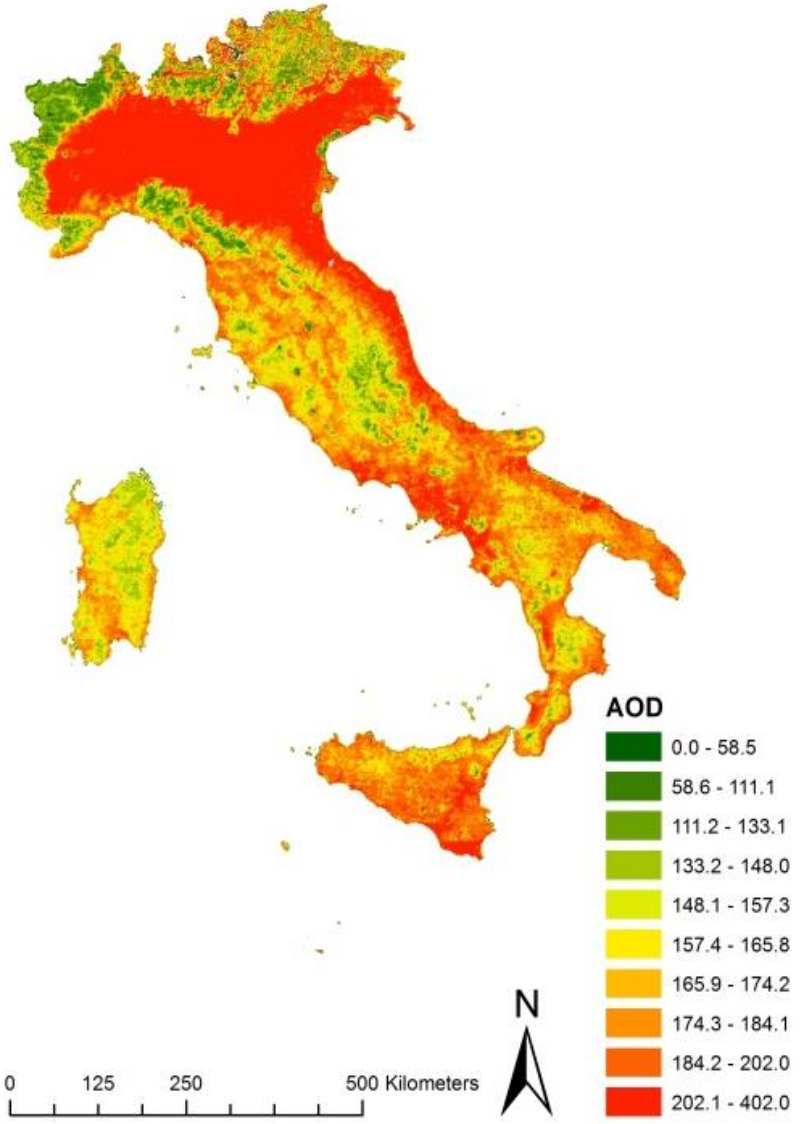
- Durata: 2 anni
- Partner
  - CNR-IBIM Palermo
  - DEP LAZIO Roma
  - INAIL
  - ARPA Emilia Romagna
  - SSR Emilia Romagna
  - CPO Torino
  - CNR-IPCF Pisa
  - ARES Puglia
  - DASOE Palermo
  - CNR-ISAC Roma

SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA

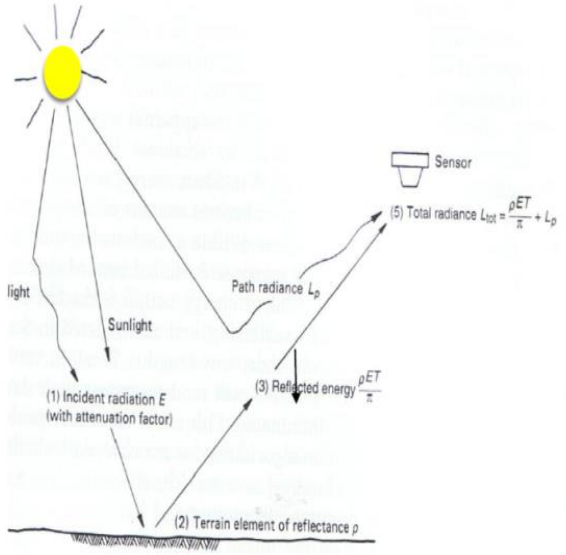
Regione Siciliana

INDICATORI SPAZIOTEMPORALI. Esempi:

Aerosol Optical Depth (AOD)



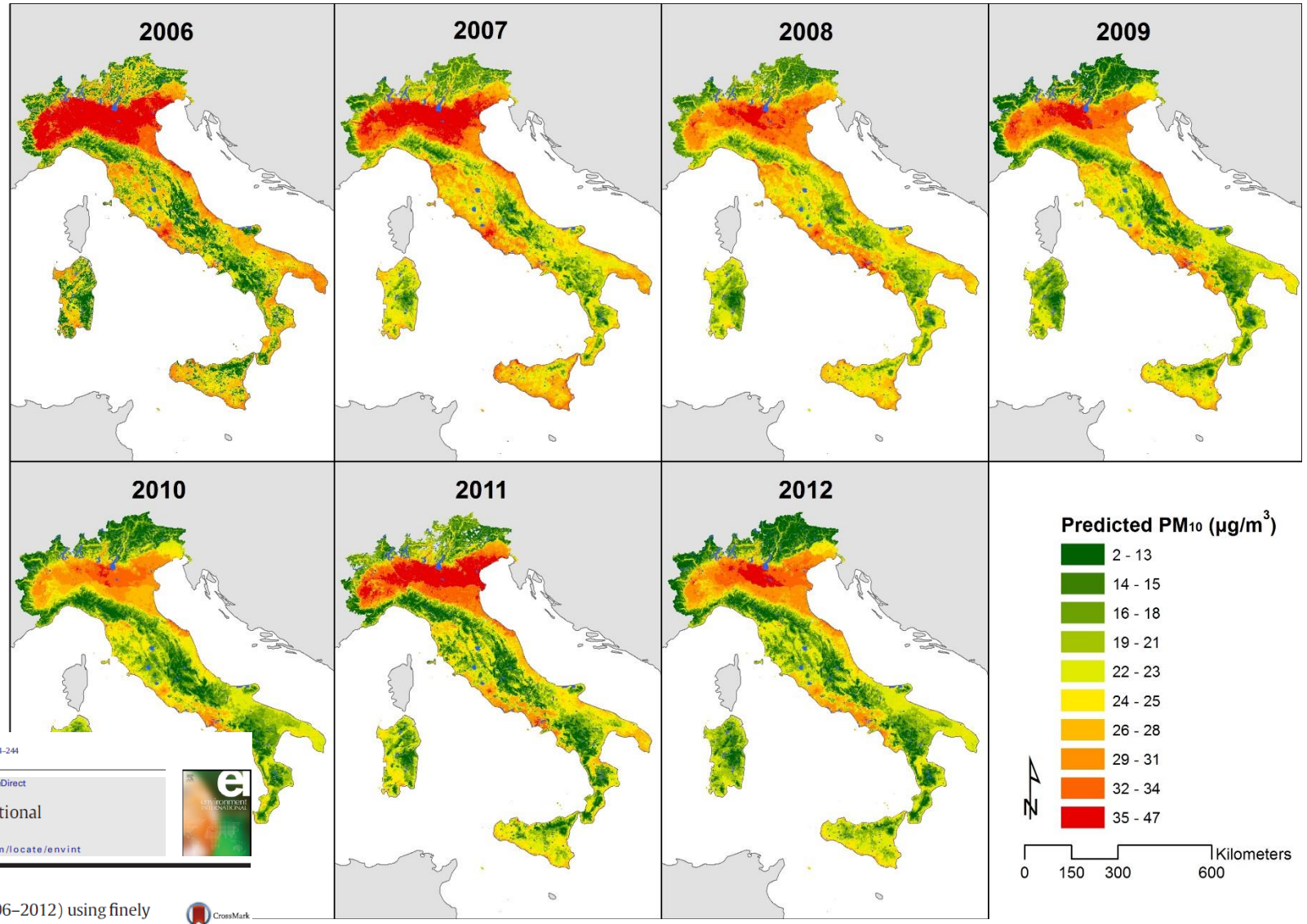
- Misura di aerosol distribuiti nella colonna d'aria
- Dato originale raccolto dal MODIS, un sensore a bordo dei satelliti NASA "Terra" e "Aqua", con risoluzione spaziale 10x10-km
- Dati 10x10 rielaborati secondo algoritmo MAIAC, con downscaling a 1-km^2 di risoluzione



Aerosol Optical Depth (AOD) or Aerosol Optical Thickness (AOT) expresses the quantity of light removed from a beam by scattering or absorption during its path through a medium.

Aerosol Optical Depth (AOD) → $\tau_\lambda = \int_{L_2}^{L_1} \beta_\lambda dL$

RISULTATI. Trend annuali



Environment International 99 (2017) 234–244

Contents lists available at ScienceDirect

Environment International

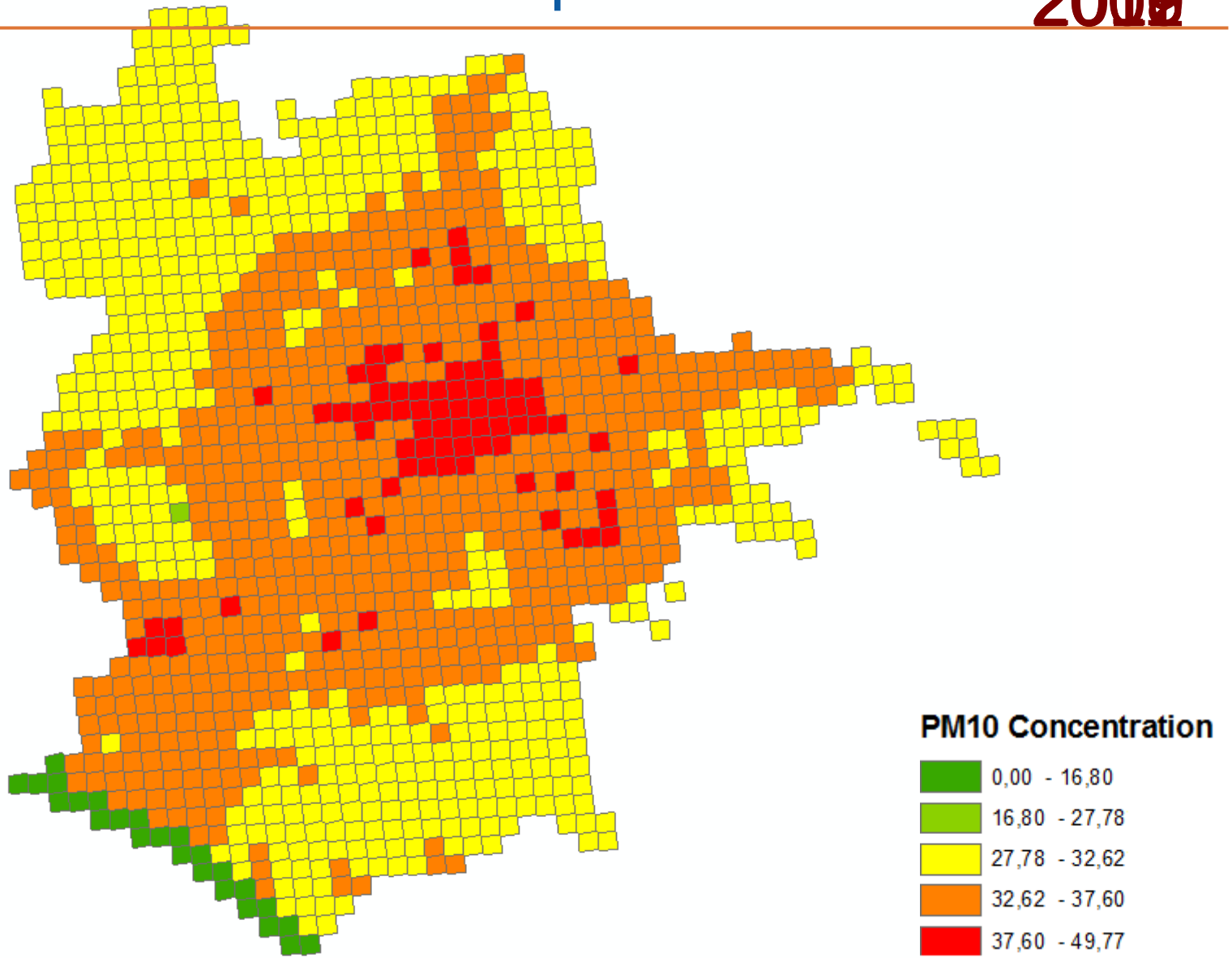
journal homepage: www.elsevier.com/locate/envint

Estimation of daily PM_{10} concentrations in Italy (2006–2012) using finely resolved satellite data, land use variables and meteorology

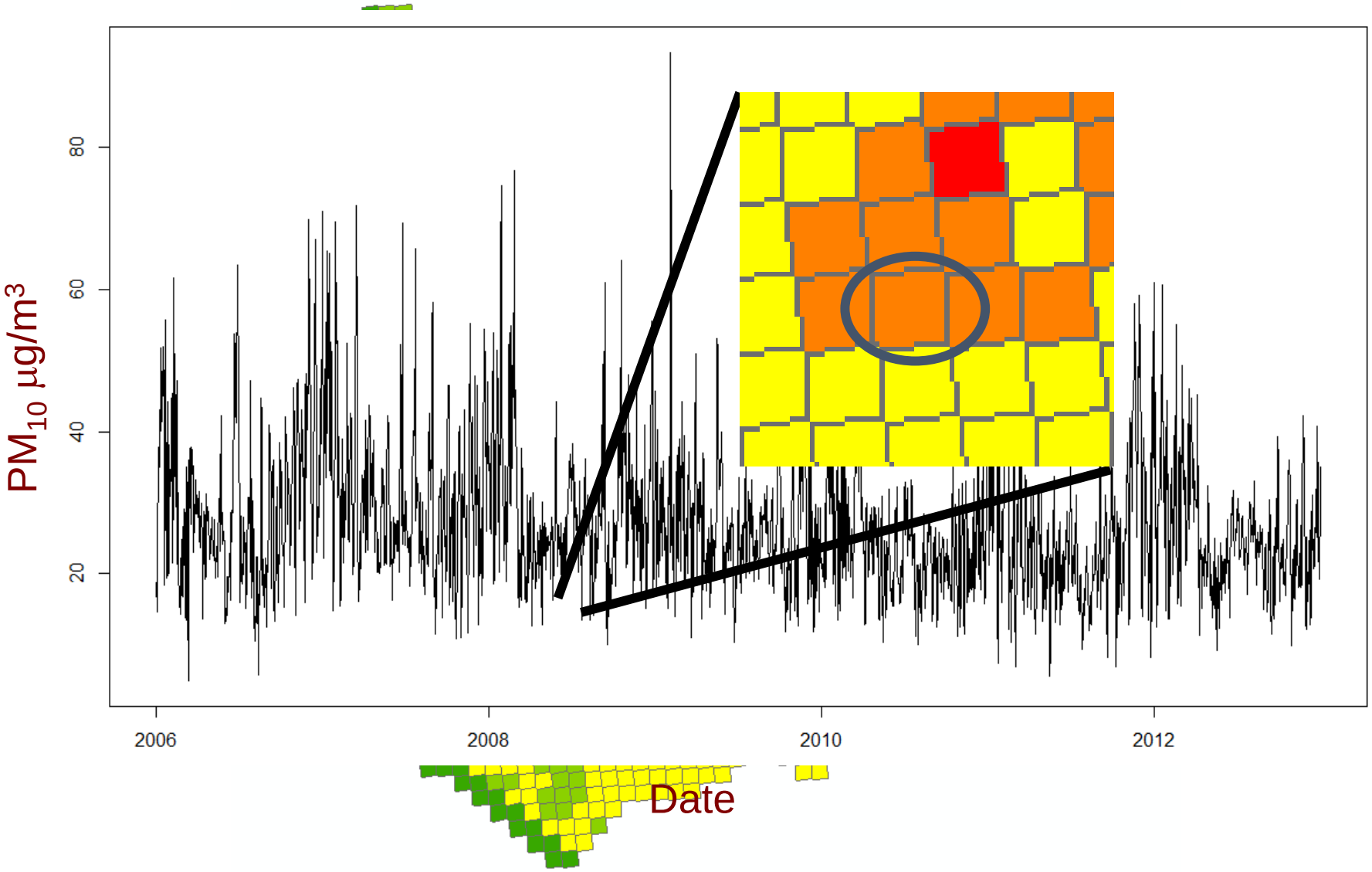
Massimo Stafoggia [a,b,*], Joel Schwartz [c], Chiara Badaloni [a], Tom Bellander [b,d], Ester Alessandrini [a], Giorgio Cattani [e], Francesca de' Donato [a], Alessandra Gaeta [e], Gianluca Leone [e], Alexei Lyapustin [f], Meytar Sorek-Hamer [g,h], Kees de Hoogh [i,j], Qian Di [c], Francesco Forastiere [a], Itai Kloog [h]

Esposizione. Contrasto spaziale

2005



Esposizione. Contrasto temporale



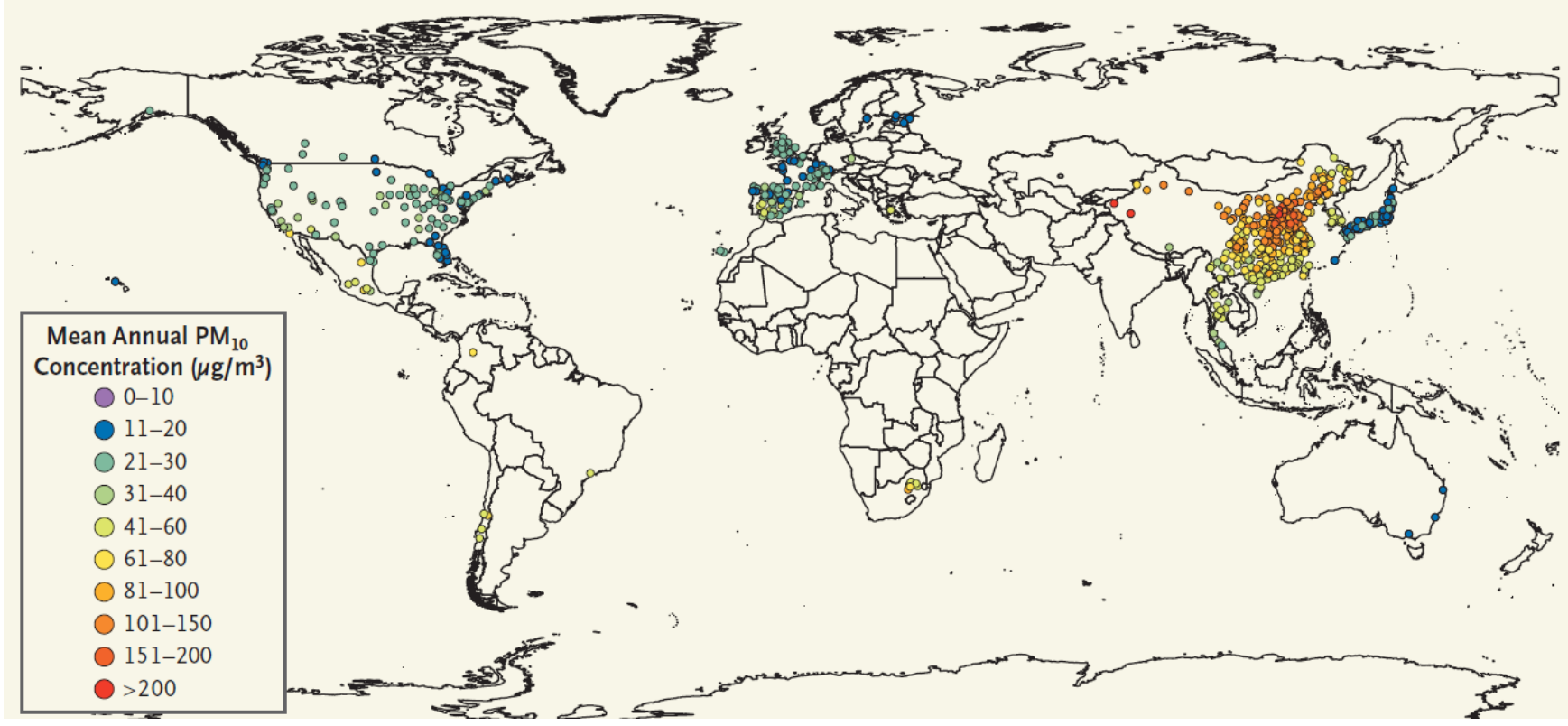
Short-term health effects

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 22, 2019 VOL. 381 NO. 8

Ambient Particulate Air Pollution and Daily Mortality in 652 Cities

C. Liu, R. Chen, F. Sera, A.M. Vicedo-Cabrera, Y. Guo, S. Tong, M.S.Z.S. Coelho, P.H.N. Saldiva, E. Lavigne, P. Matus, N. Valdes Ortega, S. Osorio Garcia, M. Pascal, M. Stafoggia, M. Scortichini, M. Hashizume, Y. Honda, M. Hurtado-Díaz, J. Cruz, B. Nunes, J.P. Teixeira, H. Kim, A. Tobias, C. Íñiguez, B. Forsberg, C. Åström,



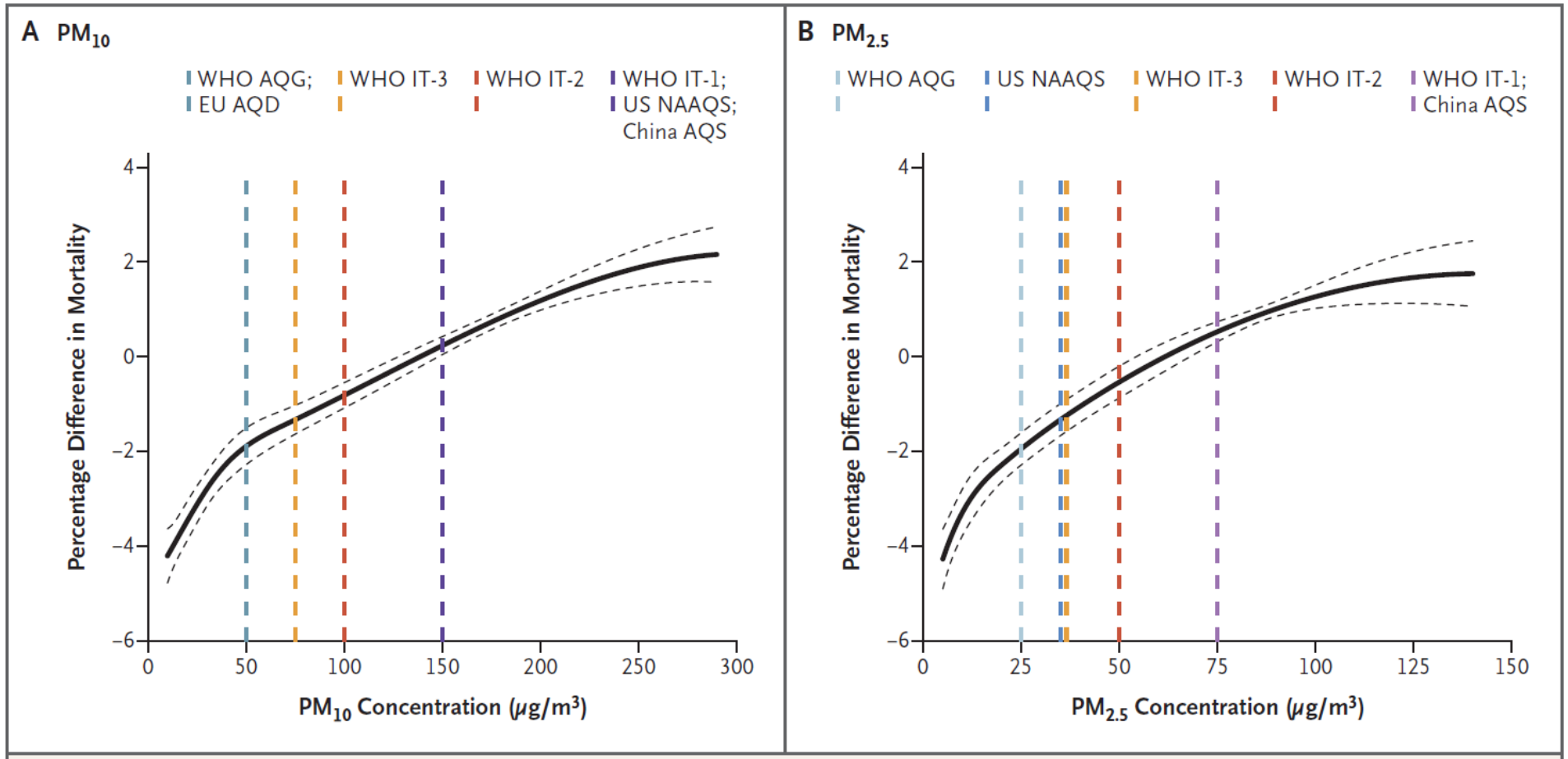


Figure 3. Pooled Concentration–Response Curves.

Short-term effects of particulate matter on cardiovascular morbidity in Italy. A national analysis (2013-2015)

Stafoggia et al (in press)

To estimate short-term effects of daily PM10 and PM2.5 on cardiovascular hospitalizations from specific causes

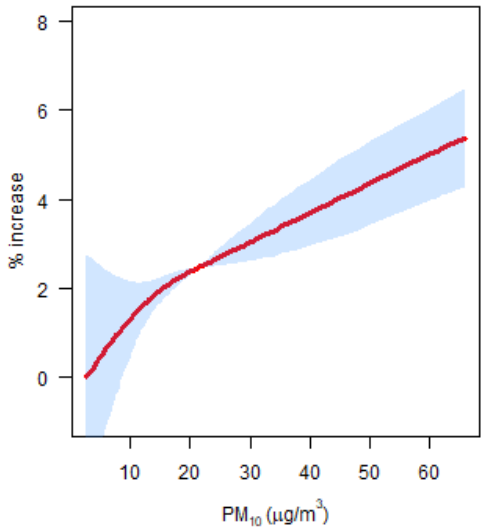
HOSPITALIZATIONS DATA

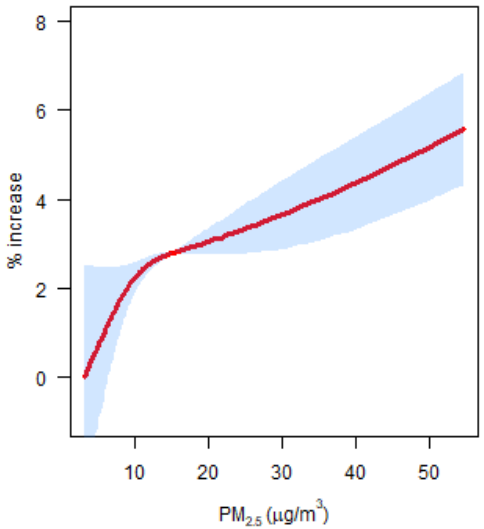
Disease	Total		Gender (%)		Age, years (%)			
	n	%	males	females	0-64	65-74	75-84	85+
All cardiovascular diseases	2,154,810	100	54	46	22	21	34	23
Cardiac diseases	1,470,370	68	56	44	23	22	33	22
Hypertension	72,391	3	43	57	20	17	34	29
Ischemic heart diseases	511,027	24	67	33	34	26	27	13
Acute myocardial infarction	321,768	15	66	34	34	24	27	15
Arrhythmias	200,207	9	52	48	24	24	34	17
Heart failure	471,042	22	49	51	9	16	39	36
Cerebrovascular diseases	542,671	25	49	51	18	20	36	26
Hemorrhagic stroke	57,223	3	52	48	21	20	36	22
Ischemic stroke	329,702	15	49	51	17	21	36	26

Disease (ICD-9 code)	Lag (days)	**PM_{10}** % IR (95% CI)	**$PM_{2.5}$** % IR (95% CI)
Total cardiovascular diseases	0-1	**0.42 (0.27, 0.57)**	**0.64 (0.42, 0.85)**
	0-5	**0.55 (0.32, 0.77)**	**0.97 (0.67, 1.27)**
Cardiac diseases	0-1	**0.58 (0.40, 0.77)**	**0.86 (0.60, 1.13)**
	0-5	**0.79 (0.52, 1.07)**	**1.32 (0.97, 1.68)**
Ischemic heart diseases	0-1	**0.52 (0.22, 0.81)**	**0.98 (0.22, 1.74)**
	0-5	**0.43 (0.01, 0.85)**	**0.84 (0.29, 1.39)**
Myocardial infarction	0-1	**0.62 (0.17, 1.07)**	**0.90 (0.29, 1.50)**
	0-5	0.28 (-0.24, 0.80)	**0.77 (0.05, 1.49)**
Arrhytmias	0-1	0.23 (-0.25, 0.72)	0.27 (-0.45, 0.99)
	0-5	0.30 (-0.40, 1.00)	0.39 (-0.52, 1.30)
Atrial fibrillation	0-1	0.79 (-0.05, 1.65)	**1.25 (0.26, 2.26)**
	0-5	**1.03 (0.10, 1.97)**	**1.44 (0.15, 2.74)**
Heart failure	0-1	**1.15 (0.82, 1.48)**	**1.74 (1.23, 2.24)**
	0-5	**1.70 (1.28, 2.13)**	**2.66 (2.09, 3.23)**
Cerebrovascular diseases	0-1	-0.05 (-0.32, 0.23)	-0.07 (-0.44, 0.31)
	0-5	-0.09 (-0.44, 0.25)	-0.03 (-0.49, 0.44)
Ischemic stroke	0-1	0.26 (-0.09, 0.62)	0.29 (-0.19, 0.76)

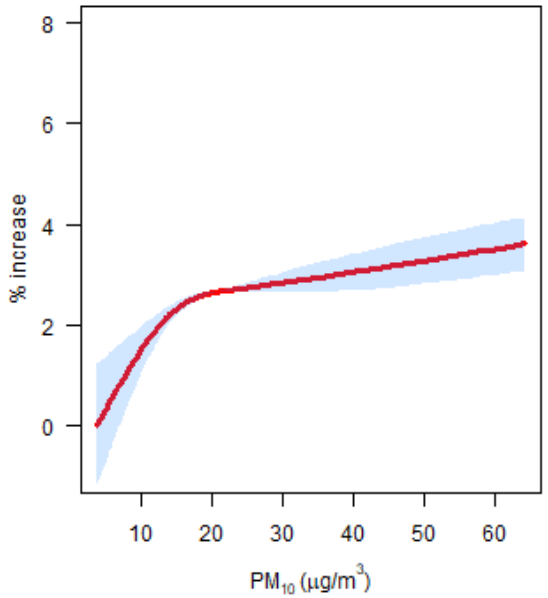
Exposure-response functions

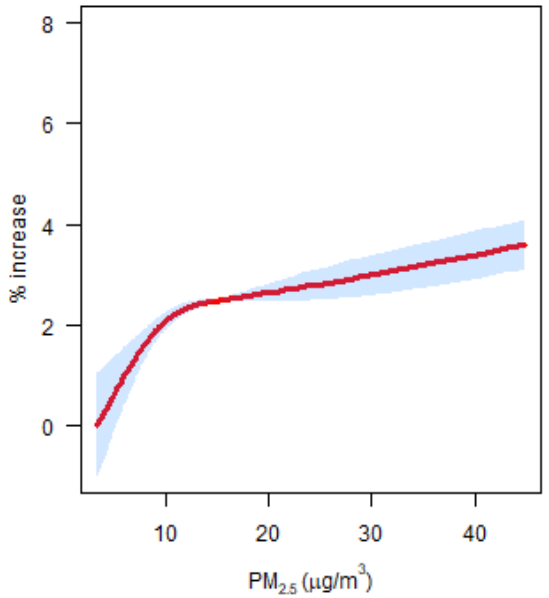
Heart failure



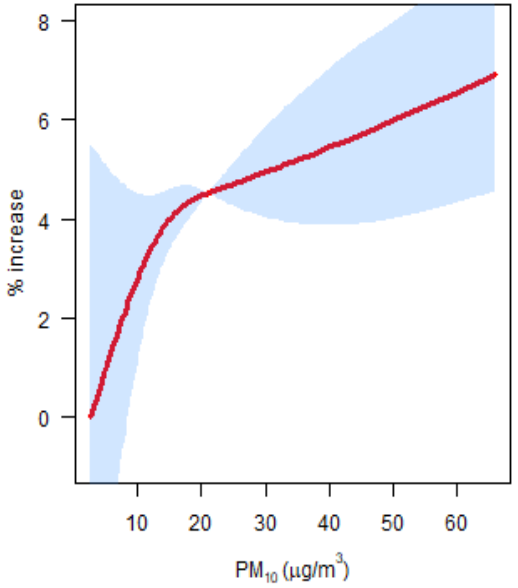


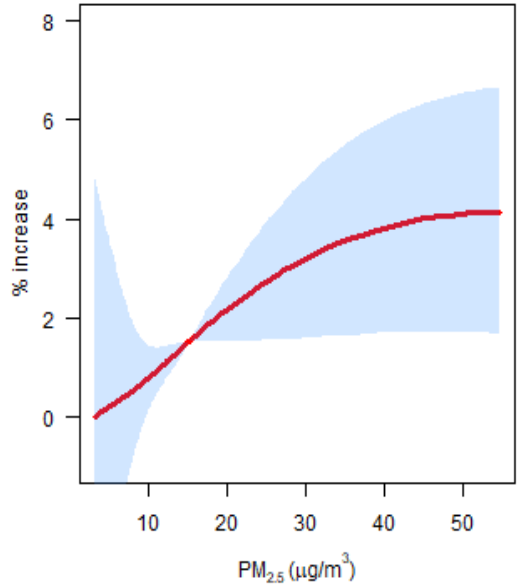
Cardiovascular diseases





Atrial fibrillation



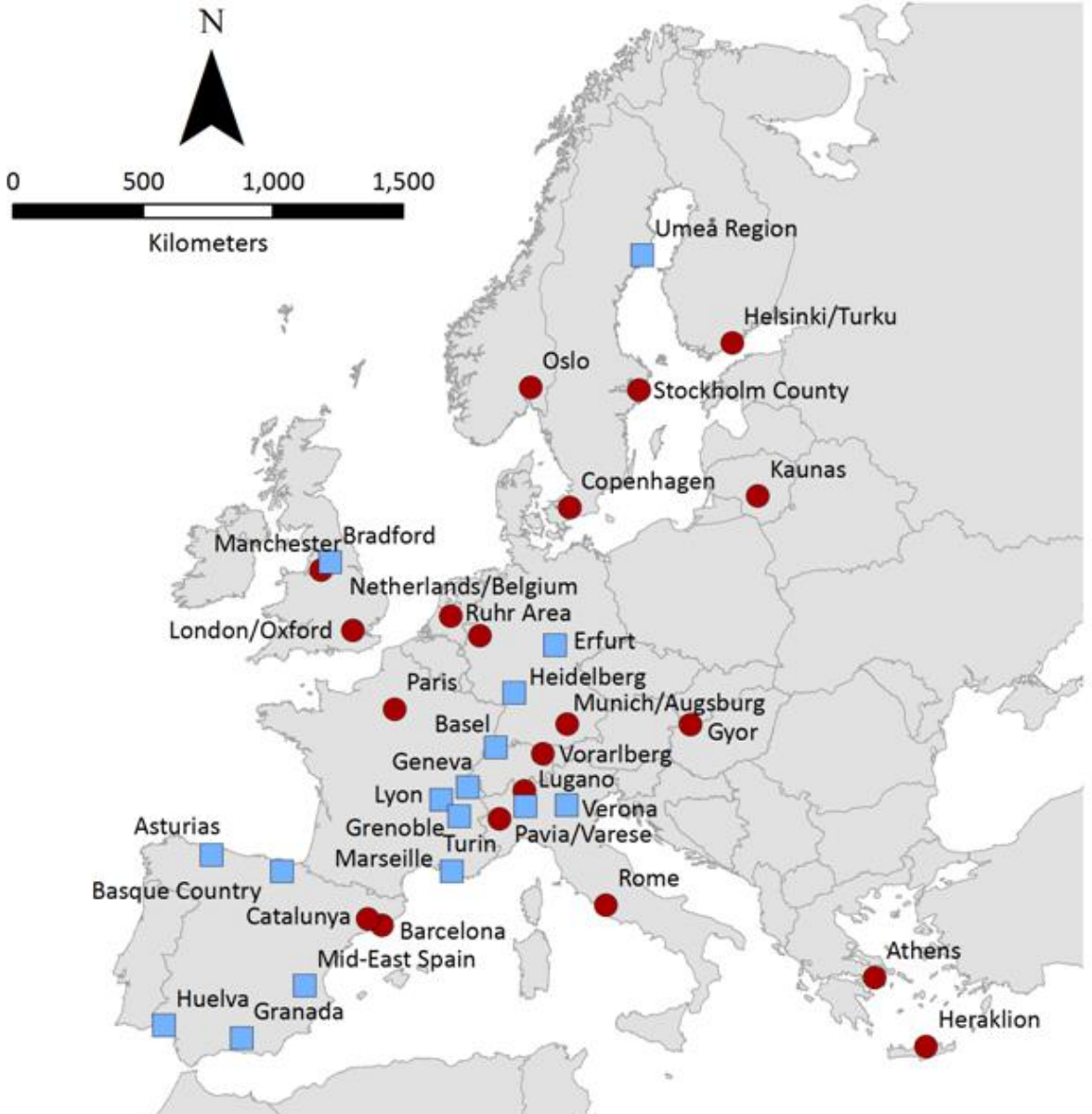


Long-term health effects

ESCAPE study areas in EUROPE

PM+NOx

NOx only

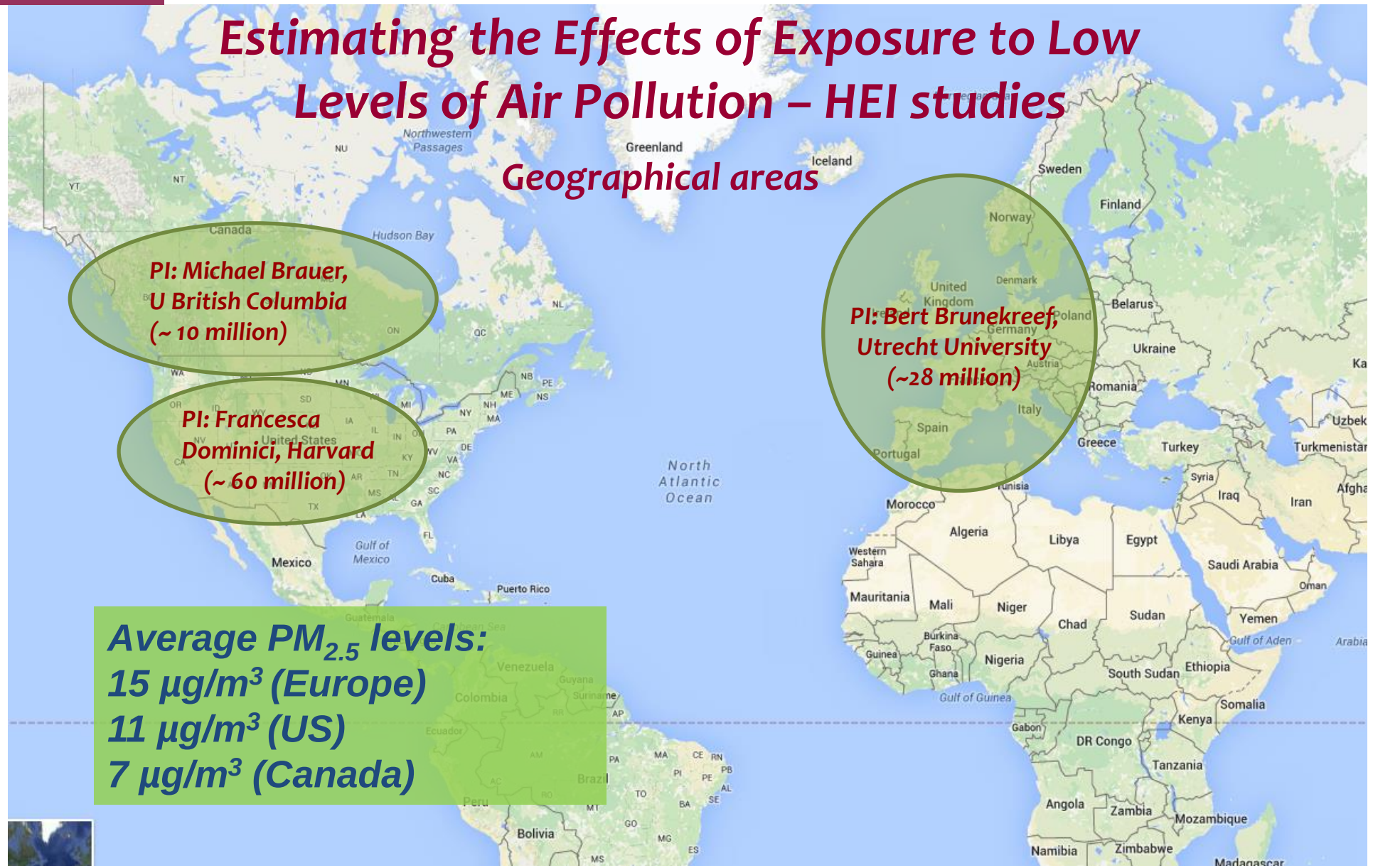


The ESCAPE project

	PM_{10} (10 ug/m^3)	$PM_{2.5}$ (5 ug/m^3)
Non accidental mortality	1.04 (1.00–1.09)	1.07 (1.02–1.13)
CV mortality	1.02 (0.92–1.14)	0,99 (0.91–1.08)
Incidence of acute coronary events	1.12 (1.04-1.28)	1.13 (0.98-1.30)
Incidence of stroke	1.02 (0.90-1.16)	1.19 (0.88-1.62)
Lung cancer incidence	1.22 (1.03–1.45)	1.18 (0.96–1.46)

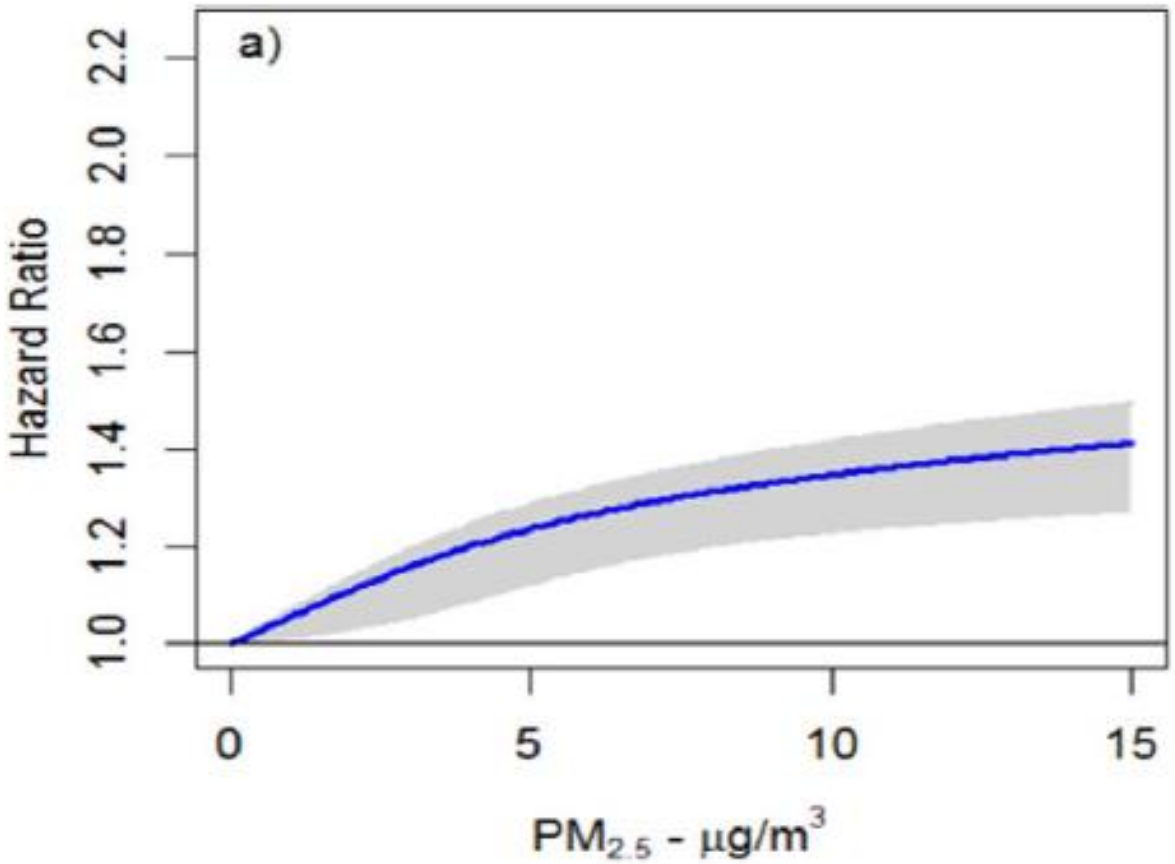
Estimating the Effects of Exposure to Low Levels of Air Pollution – HEI studies

Geographical areas



Associations between fine particulate matter and mortality in the 2001 Canadian Census Health and Environment Cohort

Pinault, Environ Res 2017



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.

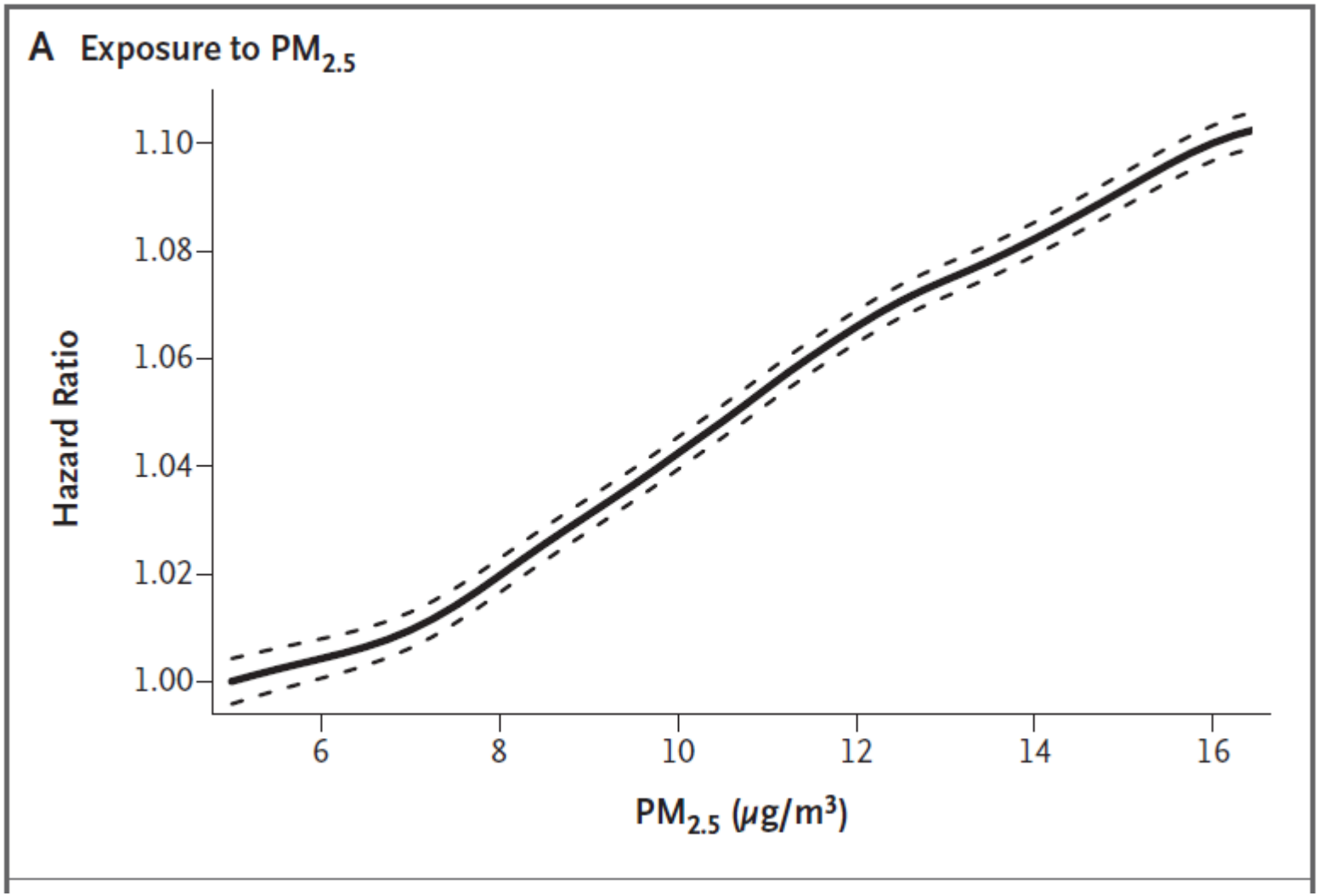
NEJM June 2017

The NEW ENGLAND JOURNAL of MEDICINE

Air Pollution and Mortality in the Medicare Population

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 JUNE 29, 2017 VOL. 376 NO. 26

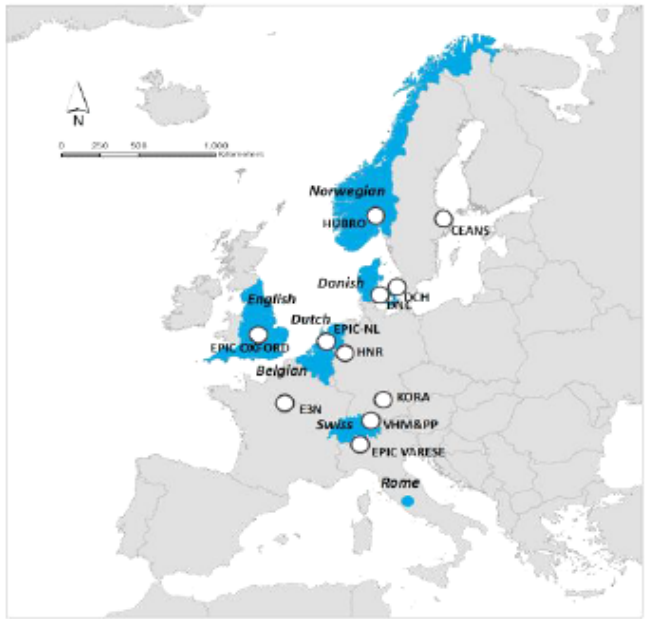
2017



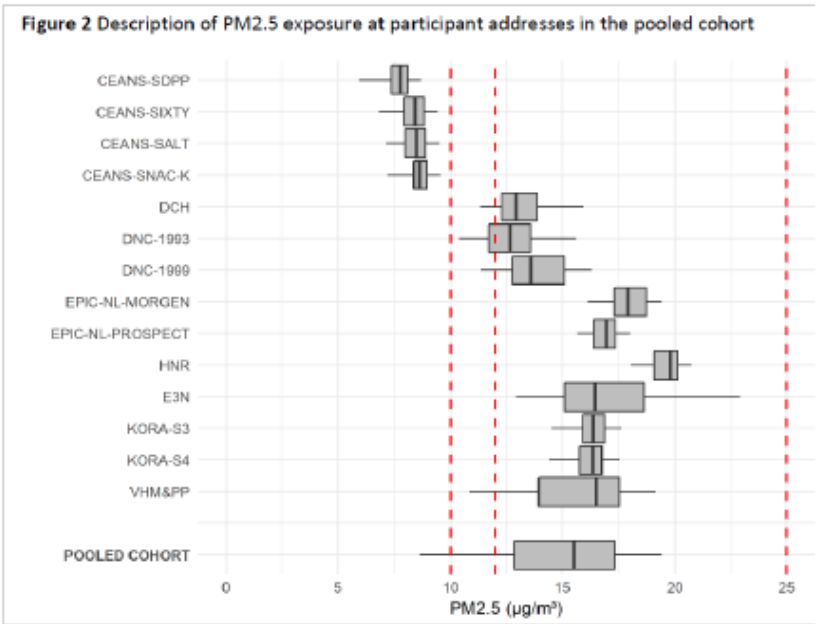
ELAPSE: Effects of Low-Level Air Pollution: a Study in Europe

- Mortality, lung cancer incidence, CVD events, respiratory disease
- Advanced exposure modeling combining LUR, CTM, AIRBASE, satellite observations
- Modeling for PM2.5, NO2, BC, and O3 with high resolution

- Two arms of the study:
  - Pooling of several well-examined European cohorts (ESCAPE)
  - ~ 380,000 subjects
  - Seven large administrative/national cohorts in UK, NO, DK, IT, NL, CH, B
  - ~ 35,000,000 subjects, no pooling



PM2.5 long term exposure pooled cohort



Cox PH models | Pooled cohort

	Mortality HRs *(N=325,367)*	
	Natural	**CVD**
PM2.5 *(per 5 µg/m^3)*	1.13 (1.11, 1.16)	1.14 (1.10, 1.18)
NO_2 *(per 10 µg/m^3)*	1.09 (1.07, 1.10)	1.09 (1.06, 1.12)
BC *(per 0.5*10^{-5}/m)*	1.08 (1.06, 1.10)	1.09 (1.06, 1.12)
O_3 *(per 10 µg/m^3)*	0.90 (0.88, 0.91)	0.89 (0.85, 0.92)

Full and subset anaylses – natural cause mortality

Pooled cohort

Table 7 Hazard ratios for associations between air pollution and **natural-cause mortality** in subset analysis

Pollutant	Subset	N	HR (95% CI)
PM2.5 per 5 µg/m3	Full dataset	325,367	1.130 (1.106, 1.155)

Full and subset anaylses – natural cause mortality

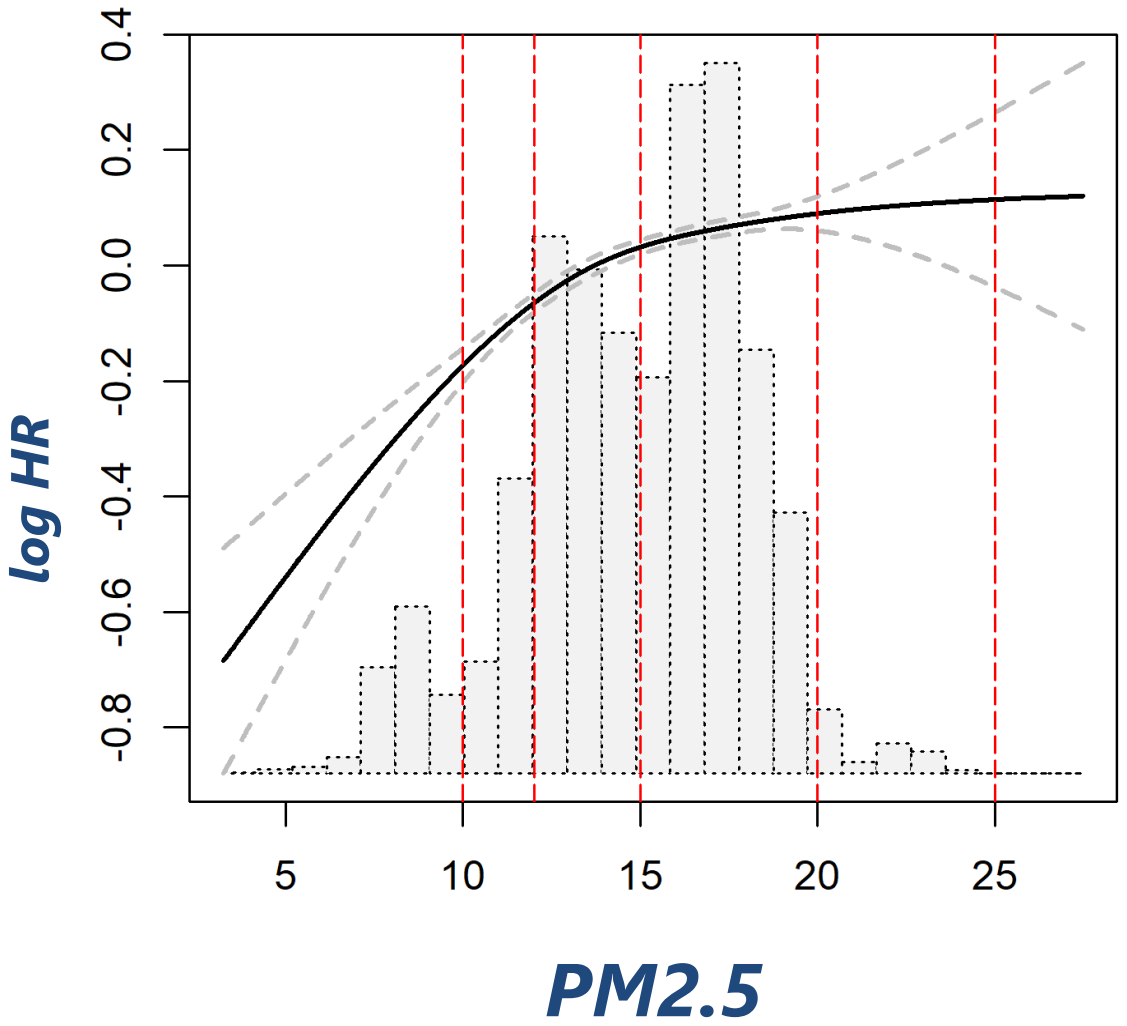
Pooled cohort

Table 7 Hazard ratios for associations between air pollution and **natural-cause mortality** in subset analysis

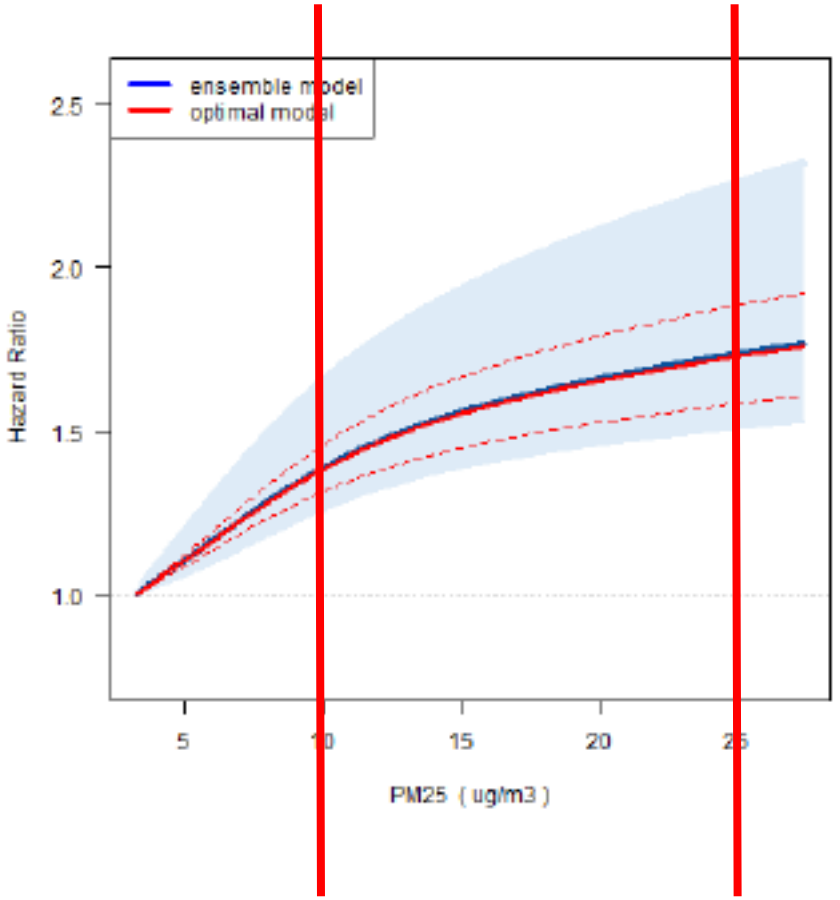
Pollutant	Subset	N	HR (95% CI)
PM2.5 per 5 µg/m3	Full dataset	325,367	1.130 (1.106, 1.155)
	< 25 µg/m^3	325,339	1.131 (1.107, 1.155)
	< 20 µg/m^3	316,540	1.138 (1.113, 1.164)
	< 15 µg/m^3	151,250	1.257 (1.193, 1.324)
	< 12 µg/m^3	52,528	1.296 (1.140, 1.474)
	< 10 µg/m^3	25,422	1.146 (0.931, 1.410)

Natural splines (3 df) | Pooled cohort

Natural mortality

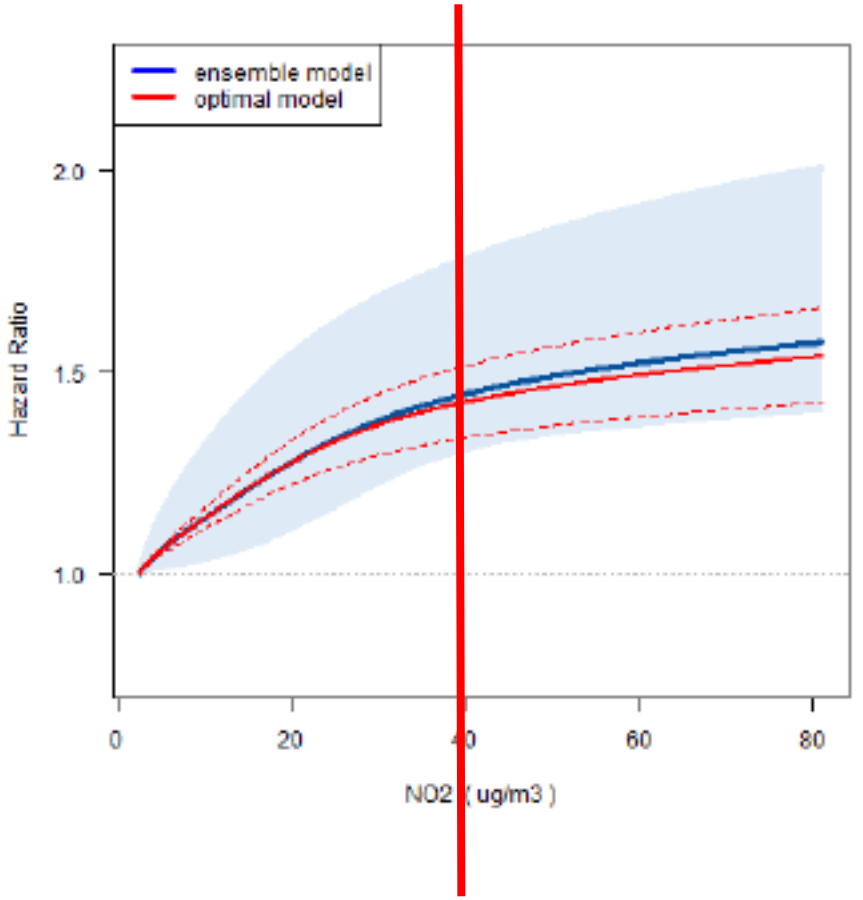


Natural cause mortality



WHO Guideline

EU Limit value



EU Limit value and WHO Guideline

- No threshold
- Results stable in two-pollutant models
- Estimates higher than currently used in burden of disease calculations
- These effects occur below EU limits

Impact assessment

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

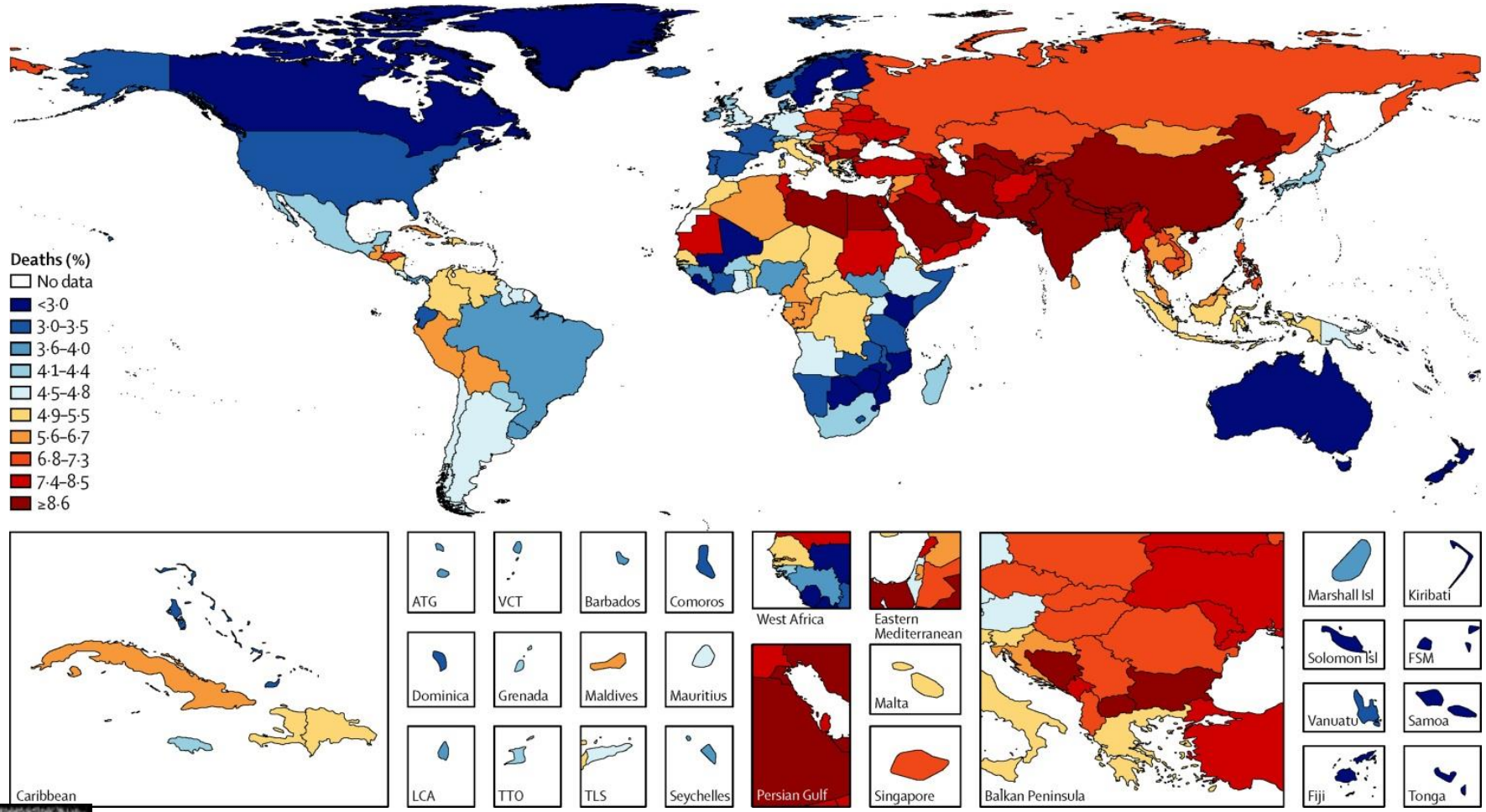
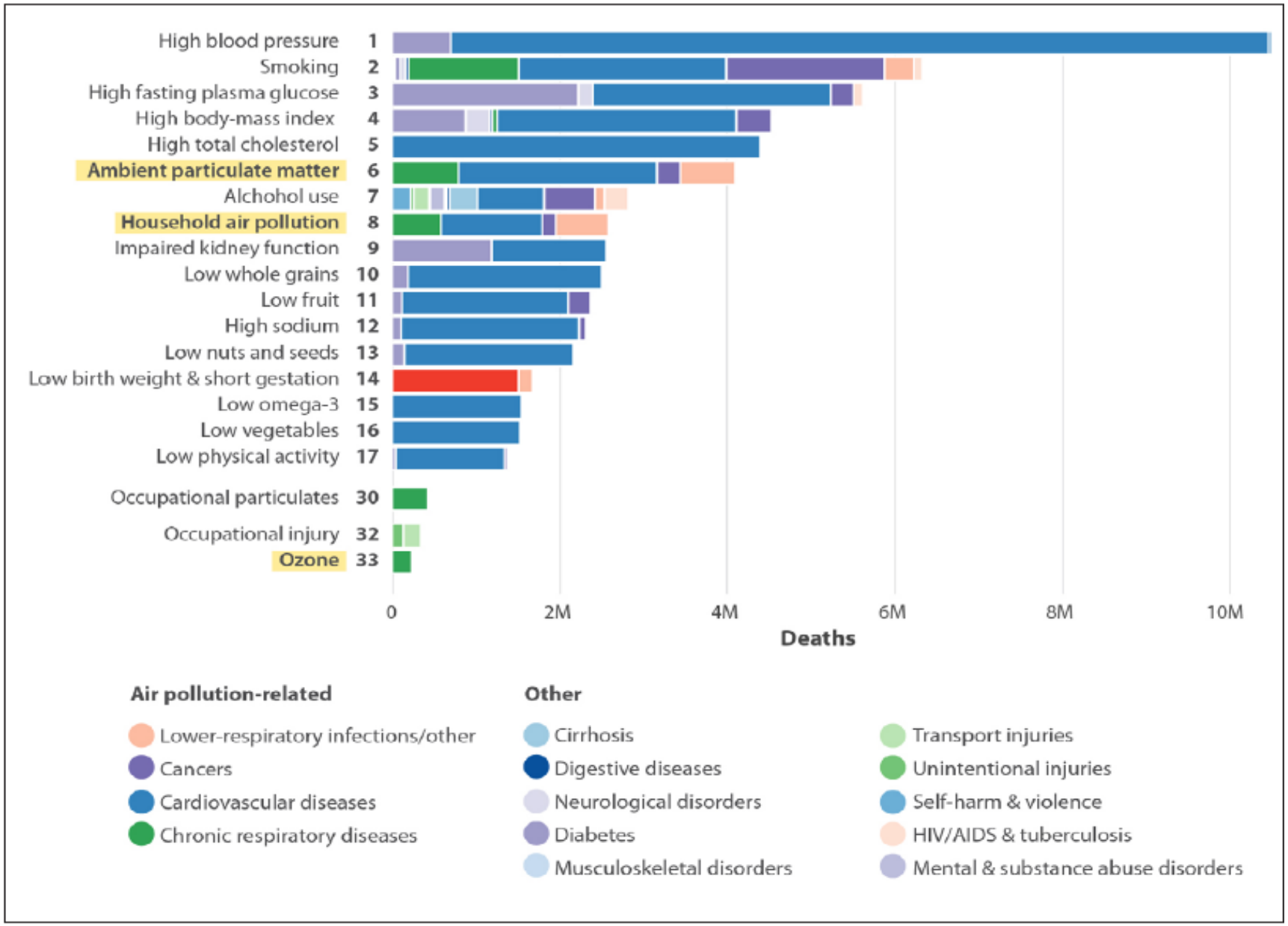
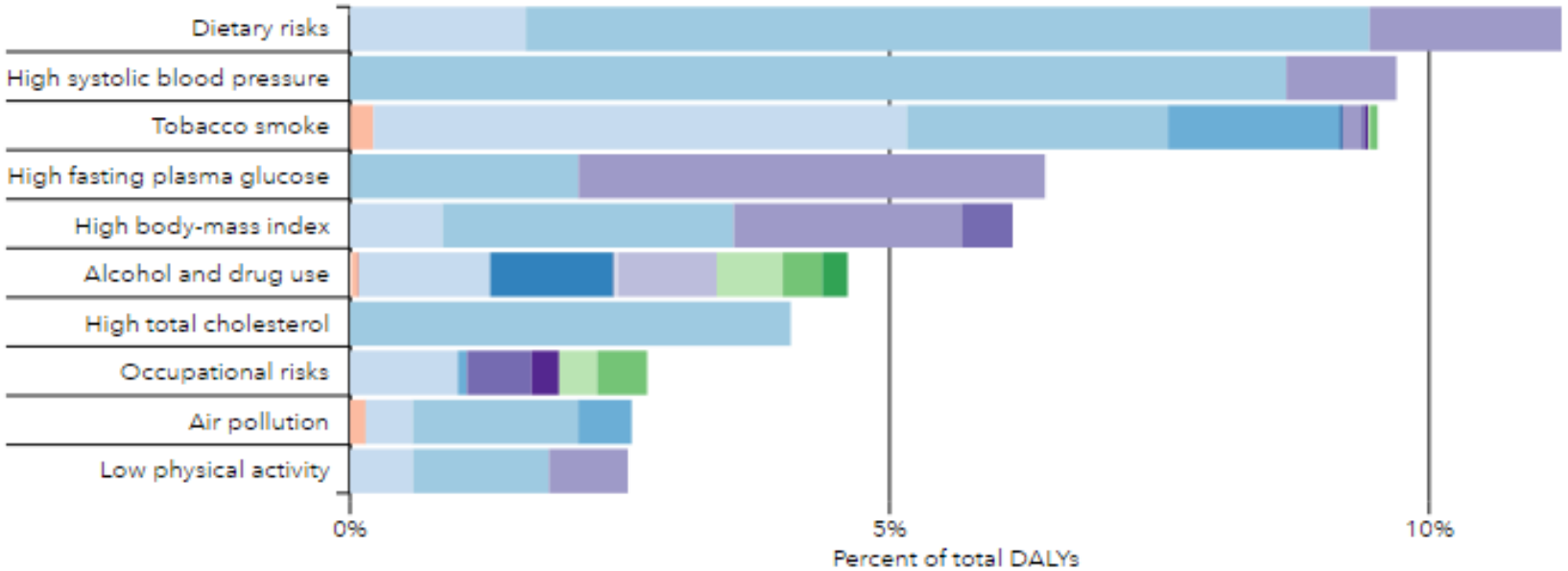


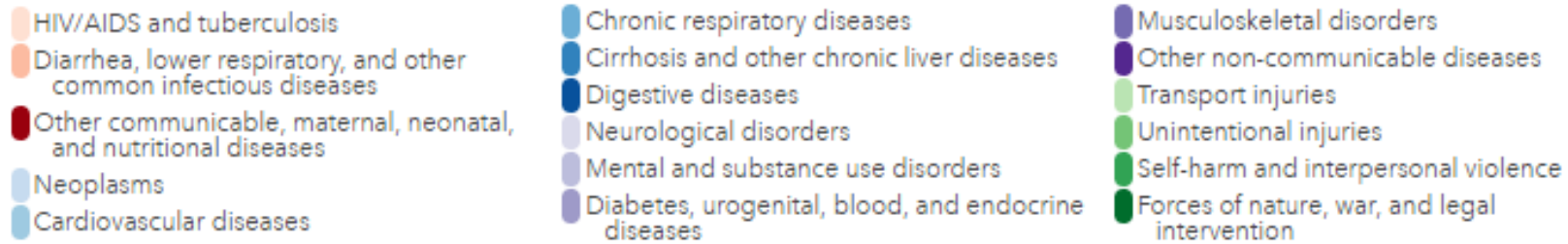
Figure 1. Global ranking of risk factors by total number of deaths from all causes for all ages and both sexes in 2016.



GBD 2015 Italy

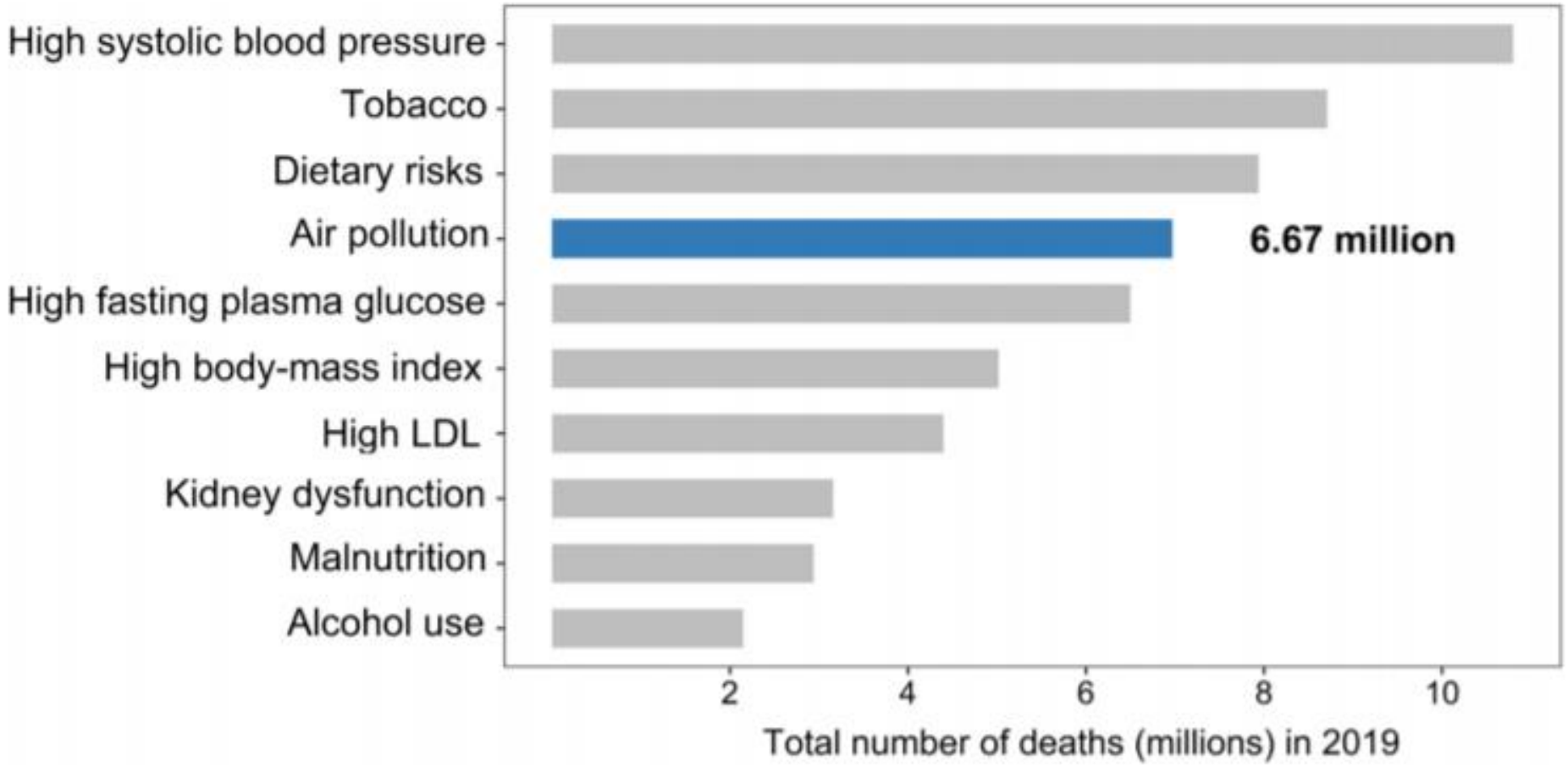
What risk factors drive the most death and disability combined?





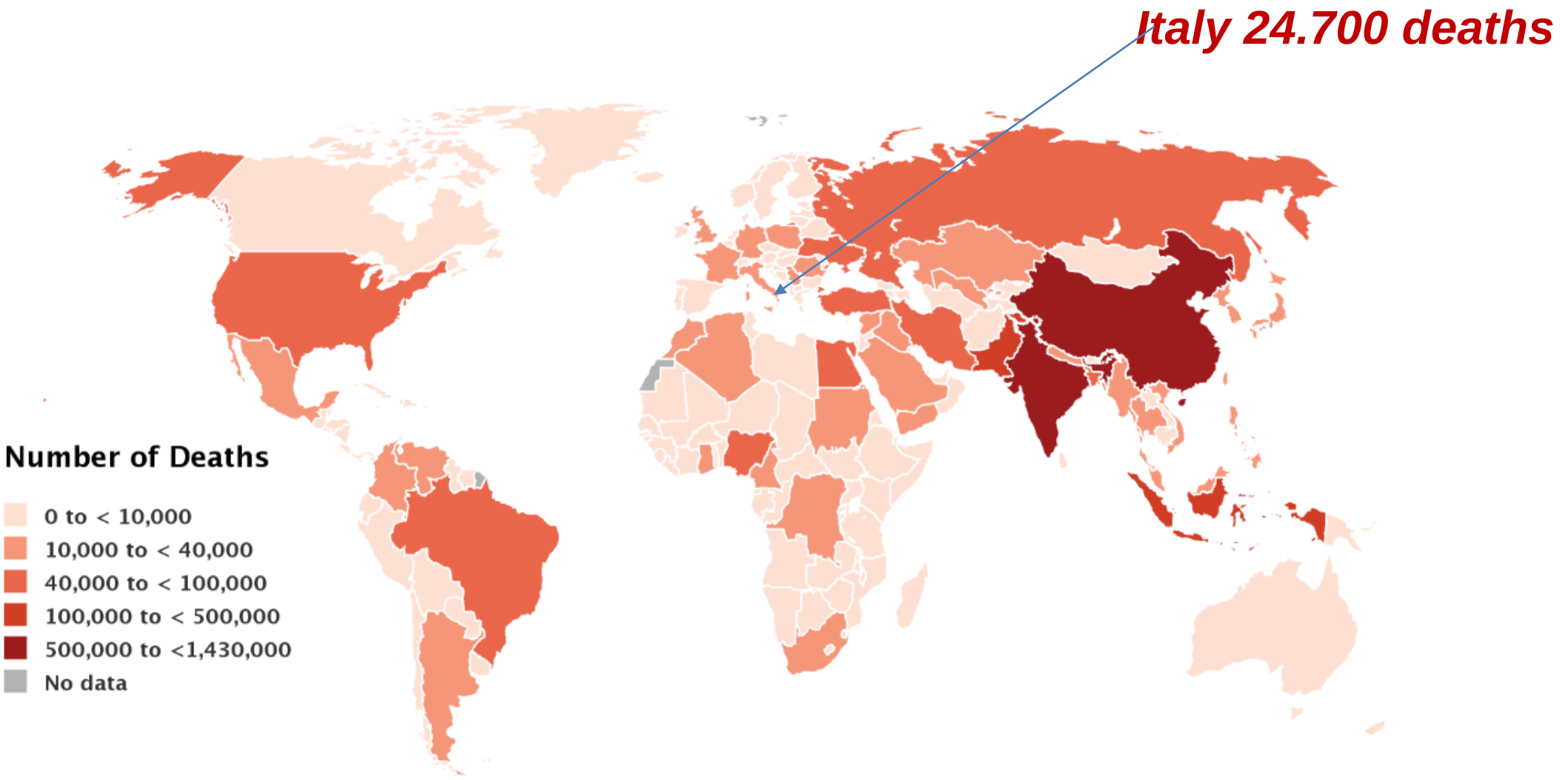
Top 10 causes of DALYs with key risk factors, 2015

FIGURE 1 Global ranking of risk factors by total number of deaths from all causes in 2019.



GBD 2019, Lancet 2020

Number of Deaths Attributable to PM2.5 in 2019



Next Generation EU (che in Italia ci ostiniamo a chiamare Recovery Fund)

1. **Fonti rinnovabili**
2. **Consumi energetici**
3. **Mobilità sostenibile**
4. **Riconversione industriale**
5. **Adattamento al clima dei territori:**
6. **Sostegno alla ricerca pubblica e privata**
7. **Rafforzare il modello agroecologico**

Si chiama Next Generation EU, non Old Generation

FRIDAYS FOR FUTURE ITALIA


We can't solve problems by using the same kind of thinking we used when we created them.
Albert Einstein
World Health Organization
Europe
“Citizens are entitled to clean air, just like clean water and safe food”.
WHO Air Quality Guidelines 2000