CITIZENS CONFERENCE BRUSSELS – 12 December 2020

Luchtverontreiniging en gezondheid

Pollution de l'air et santé

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23 November 2020

European Environment Agency

Better air quality has led to a significant reduction of premature deaths over the past decade in Europe. However, the European Environment Agency's (EEA) latest official data show that almost all Europeans still suffer from air pollution, leading to about 400,000 premature deaths across the continent.

https://www.eea.europa.eu/highlights/marked-improvement-in-europes-air

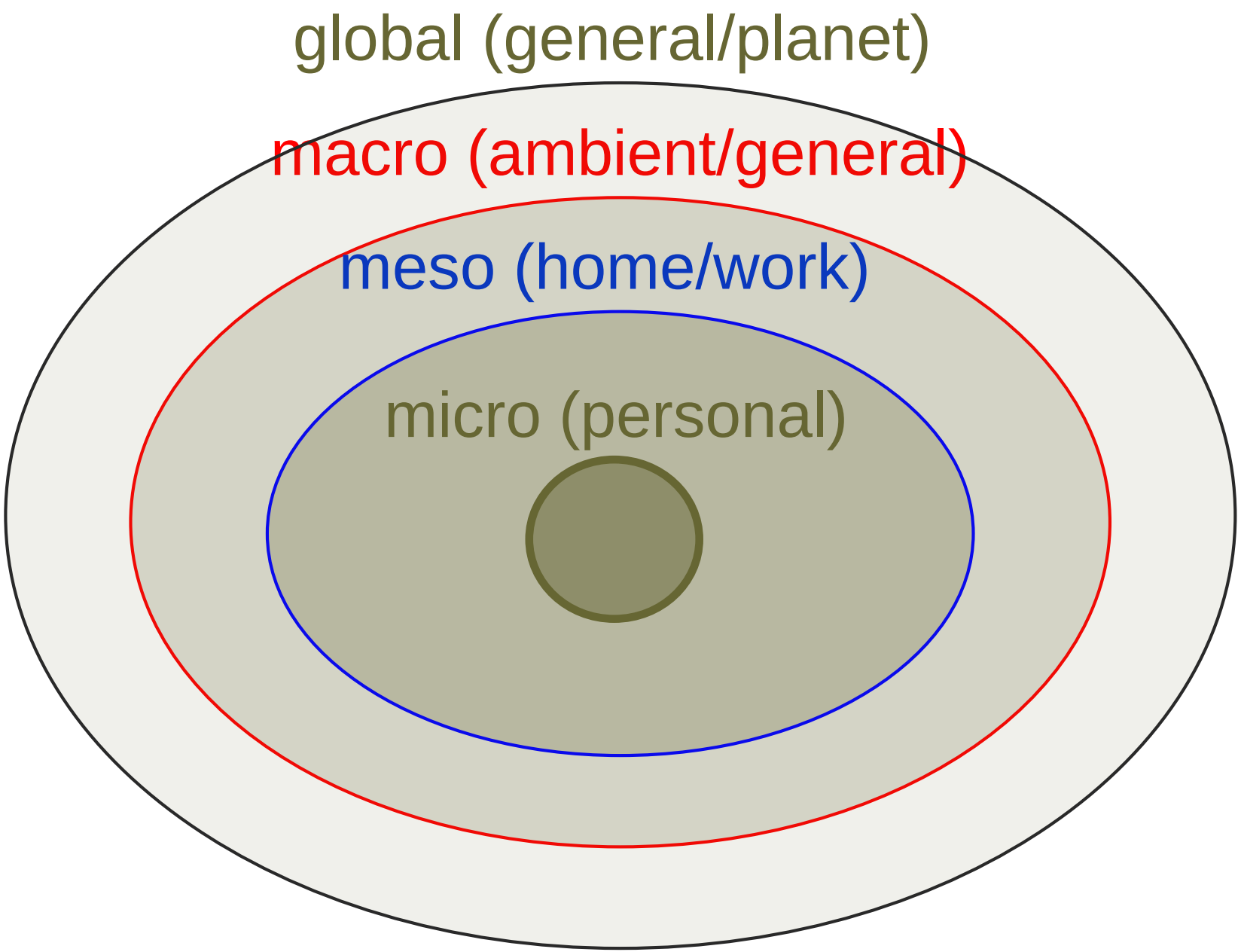
- The new EEA analysis is based on the latest official air quality data from more than 4 000 monitoring stations across Europe in **2018**.

- The EEA's 'Air quality in Europe — 2020 report' shows that six Member States exceeded the European Union's limit value for fine particulate matter ($PM_{2.5}$) in 2018: Bulgaria, Croatia, Czechia, Italy, Poland, and Romania. Only four countries in Europe — Estonia, Finland, Iceland and Ireland — had fine particulate matter concentrations that were below the World Health Organization's (WHO) stricter guideline values. The EEA report notes that there remains a gap between EU's legal air quality limits and WHO guidelines, an issue that the European Commission seeks to address with a revision of the EU standards under the Zero Pollution Action Plan.

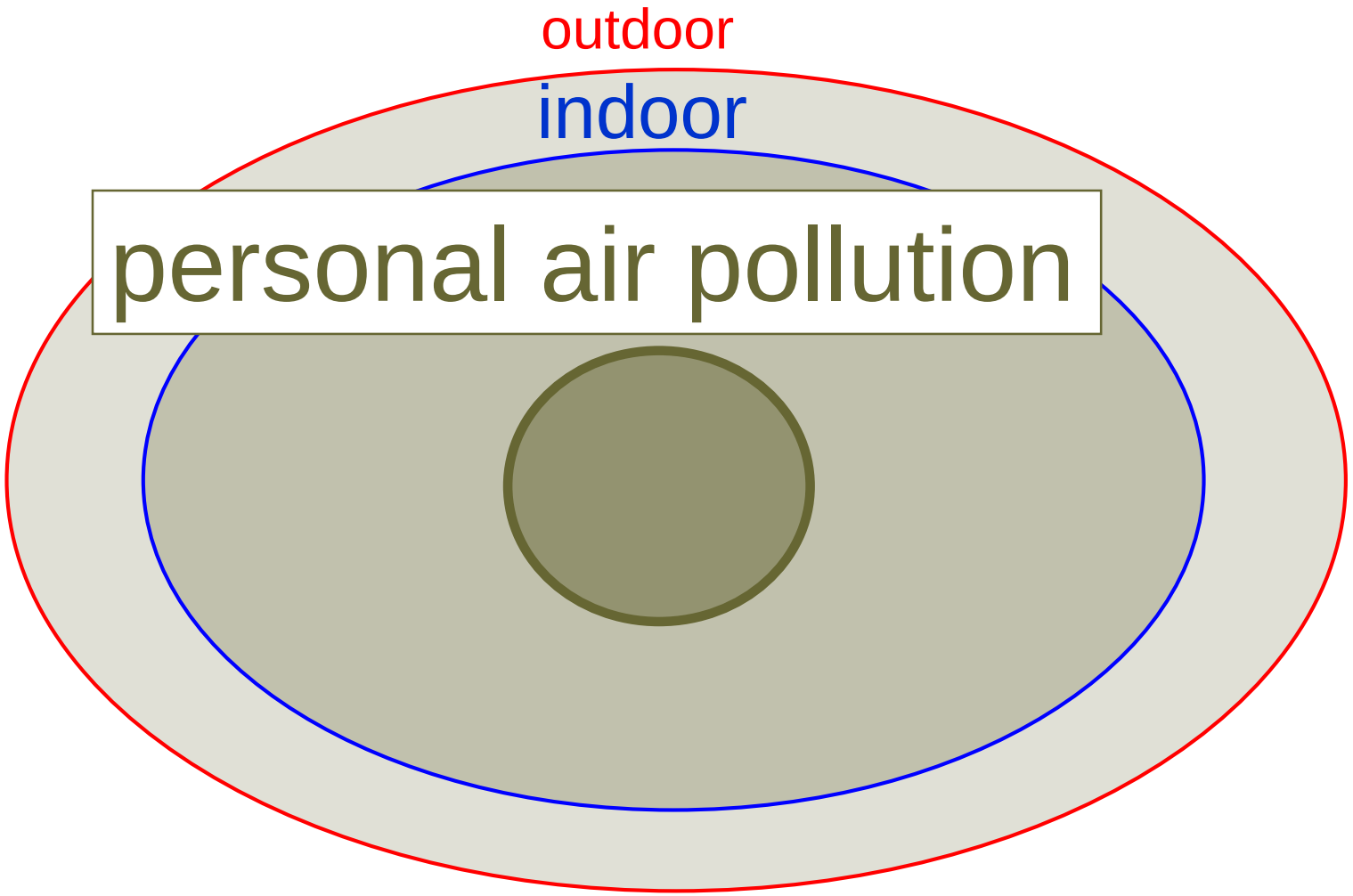
- Exposure to fine particulate matter caused about 417,000 premature deaths in 41 European countries in 2018, according to the EEA assessment. About 379,000 of those deaths occurred in EU-28 where 54,000 and 19,000 premature deaths were attributed to nitrogen dioxide (NO_2) and ground-level ozone (O_3), respectively. (The three figures are separate estimates and the numbers should not be added together to avoid double counting.)

“Air pollution”

Environment



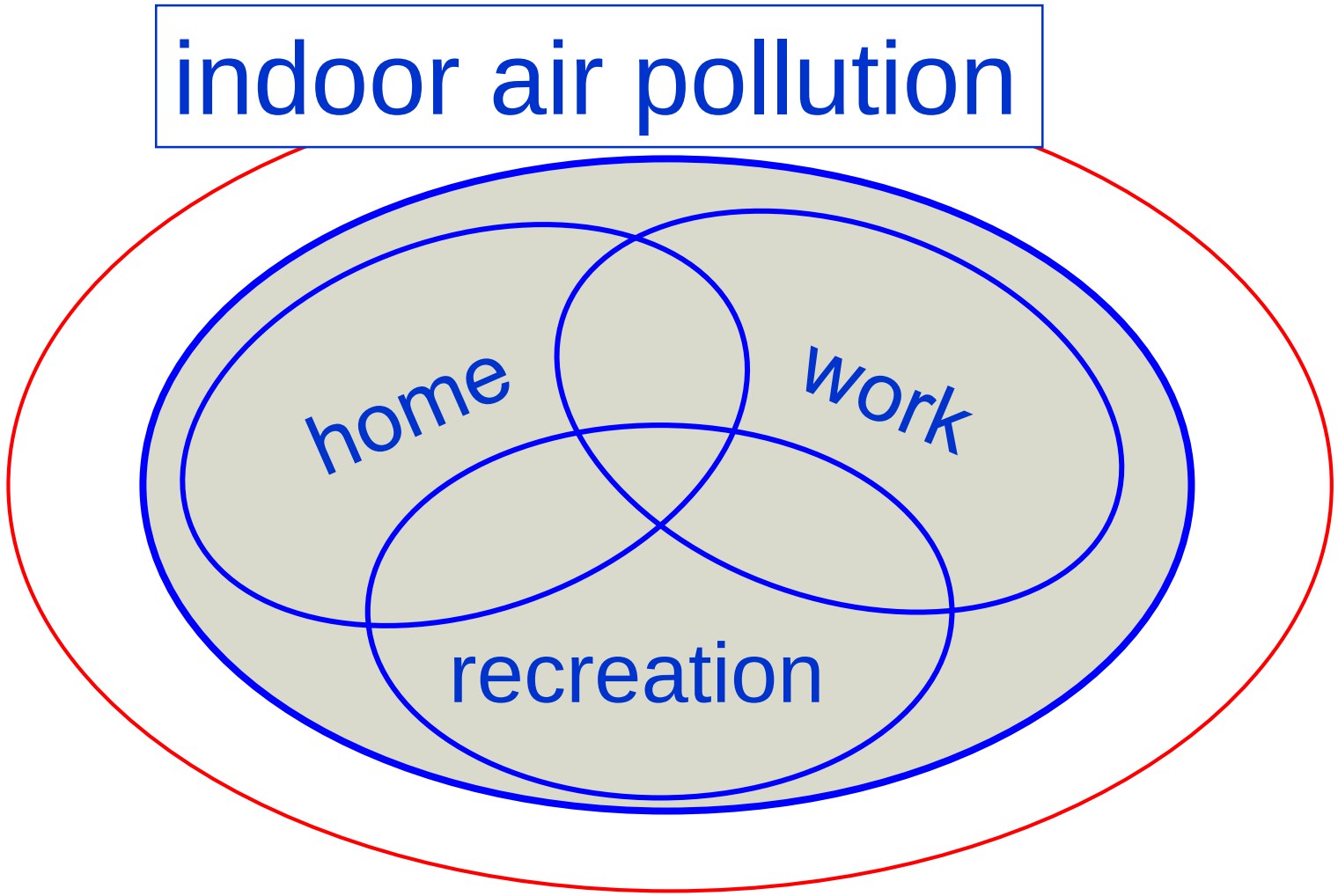
Air pollution



Tobacco smoking

DIY = do it yourself

Meso-environment



Macro-environment

outdoor/general pollution

Health effects

Air pollution and adverse health effects

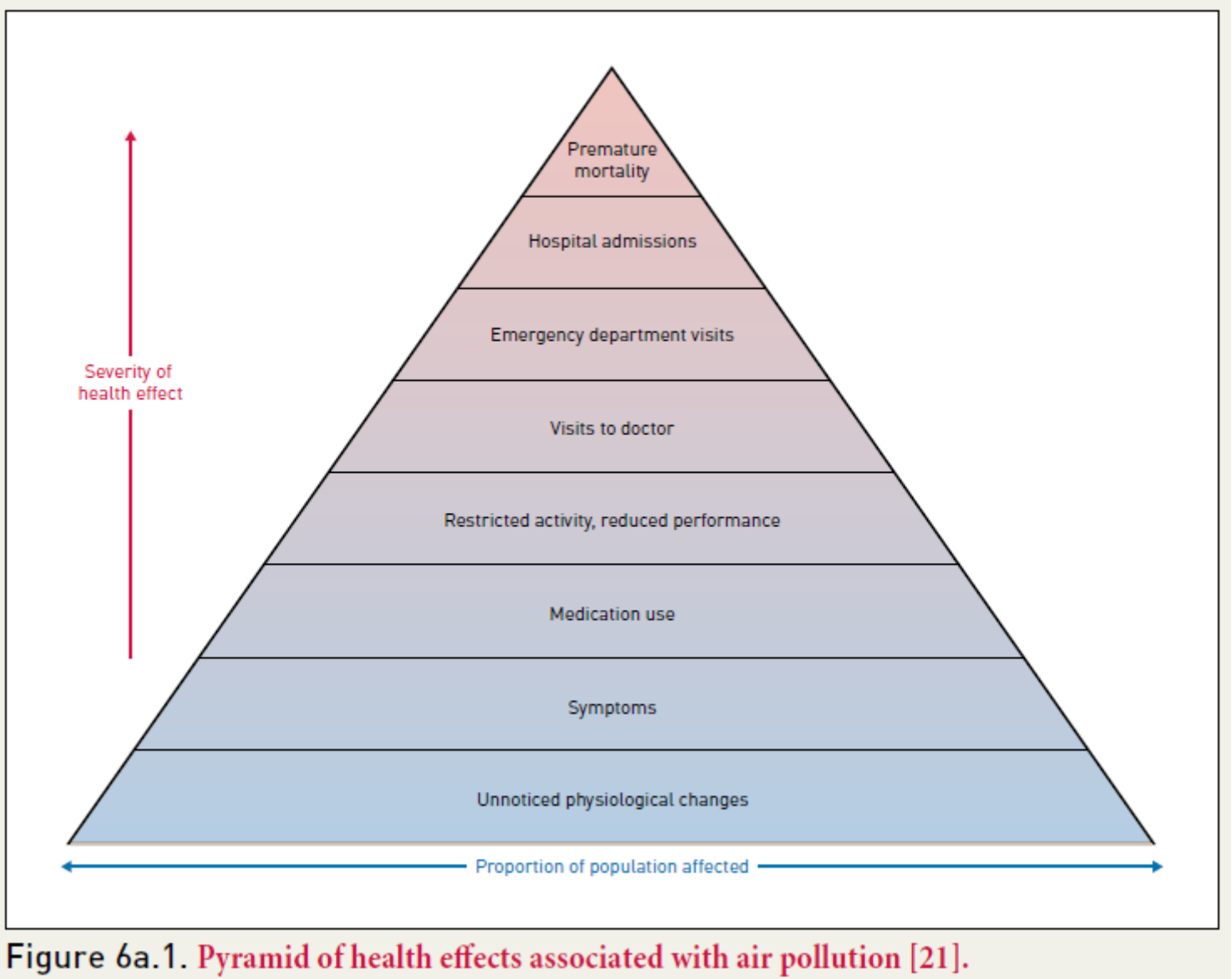


Figure 6a.1. Pyramid of health effects associated with air pollution [21].

deaths

hospital admissions

primary care visits

medication use

symptoms

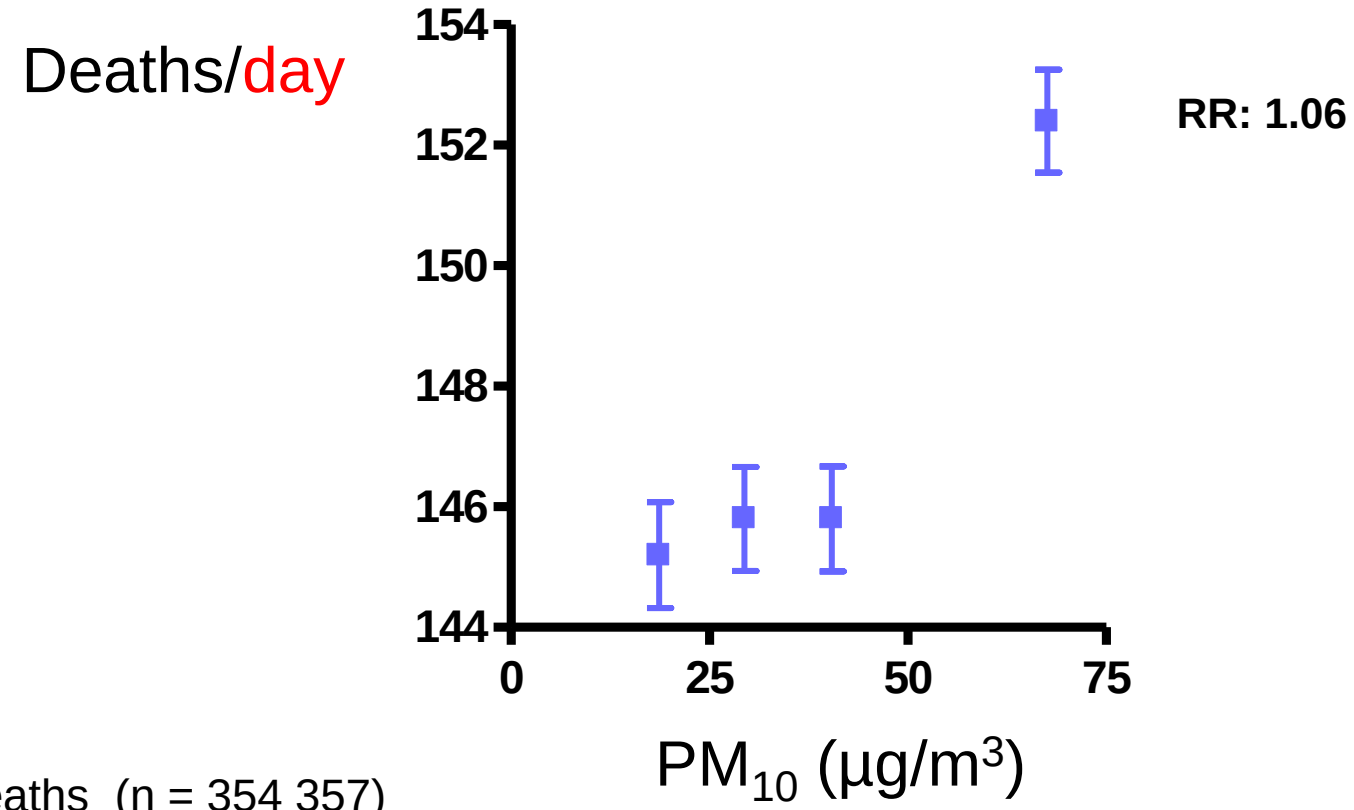
growth & development

http://www.ersnet.org/images/stories/pdf/web-AQ2010-ENG.pdf

Premature mortality

Short term effects of pollutant particles

Daily mortality *vs* quartiles of PM_{10} Flanders, 1997-2003



non-traumatic deaths (n = 354 357)

Nawrot *et al*. J Epidemiol Comm Health 2007, 61, 146-9

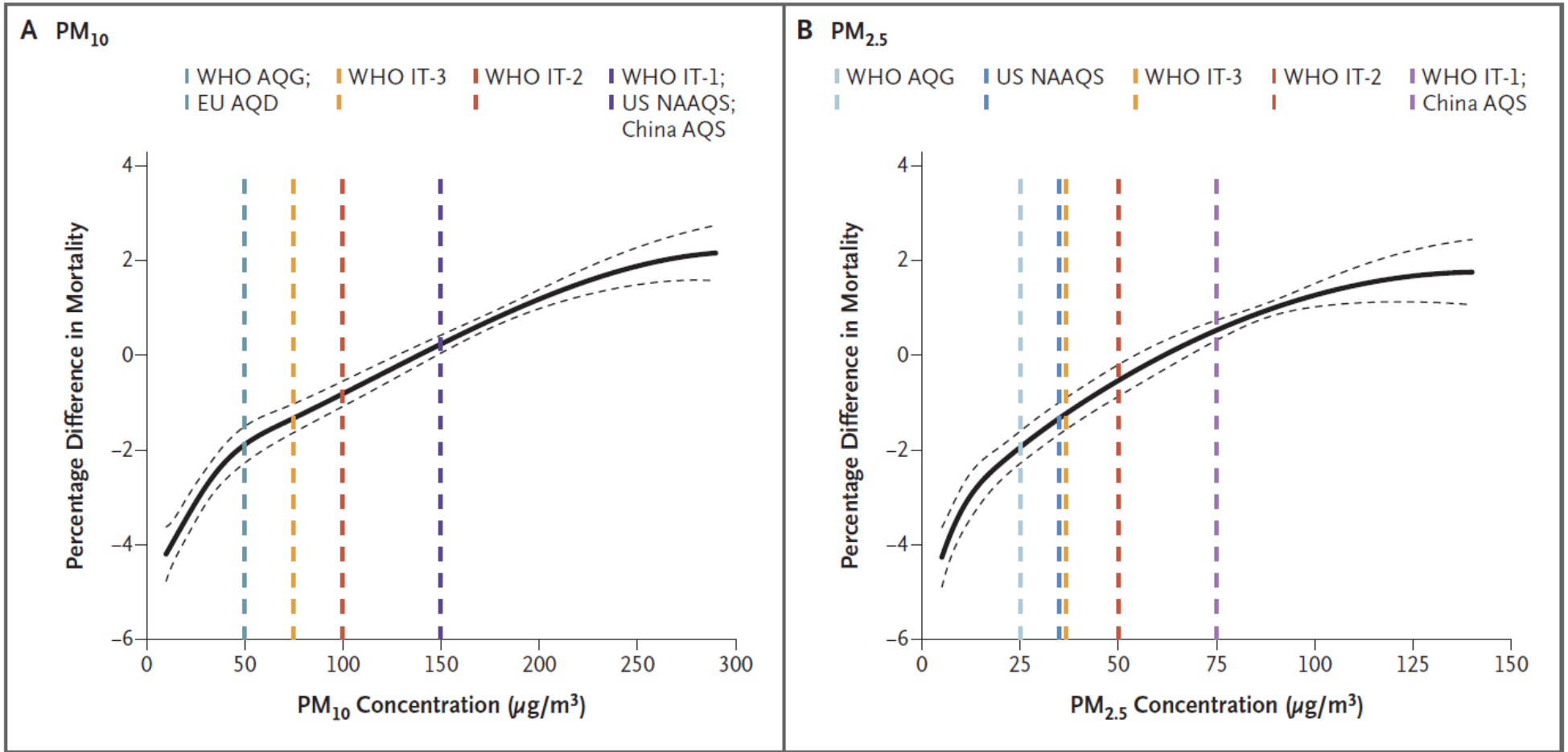
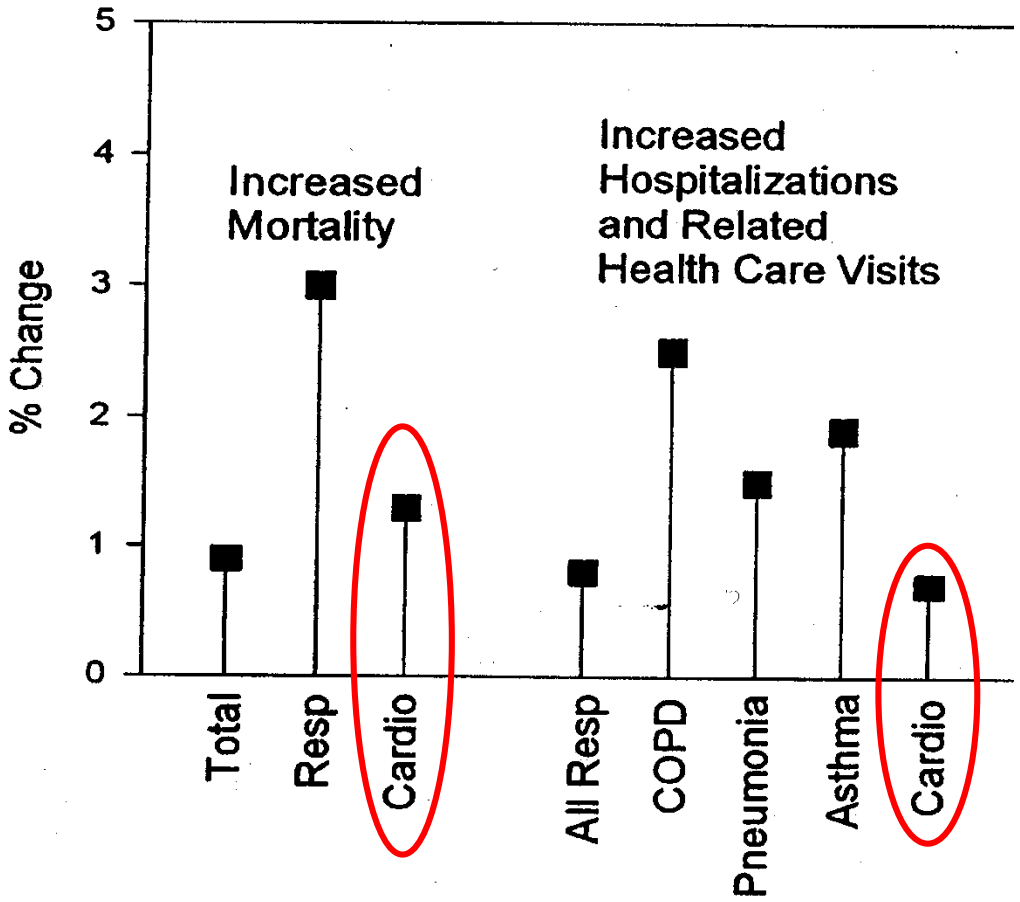


Figure 3. Pooled Concentration–Response Curves.

Shown are the pooled concentration–response curves for the associations of 2-day moving average concentrations of PM_{10} (Panel A) and $PM_{2.5}$ (Panel B) with daily all-cause mortality. The y axis represents the percentage difference from the pooled mean effect (as derived from the entire range of PM concentrations at each location) on mortality. Zero on the y axis represents the pooled mean effect, and the portion of the curve below zero denotes a smaller estimate than the mean effect. The dashed lines represent the air-quality guidelines or standards for 24-hour average concentrations of PM_{10} or $PM_{2.5}$ according to the World Health Organization Air Quality Guidelines (WHO AQG), WHO Interim Target 1 (IT-1), WHO Interim Target 2 (IT-2), WHO Interim Target 3 (IT-3), European Union Air Quality Directive (EU AQD), U.S. National Ambient Air Quality Standard (NAAQS), and China Air Quality Standard (AQS).

PM_{10} & mortality/morbidity (short term)

Stylized summary: % change per 10 μg/m^3 change in PM_{10}



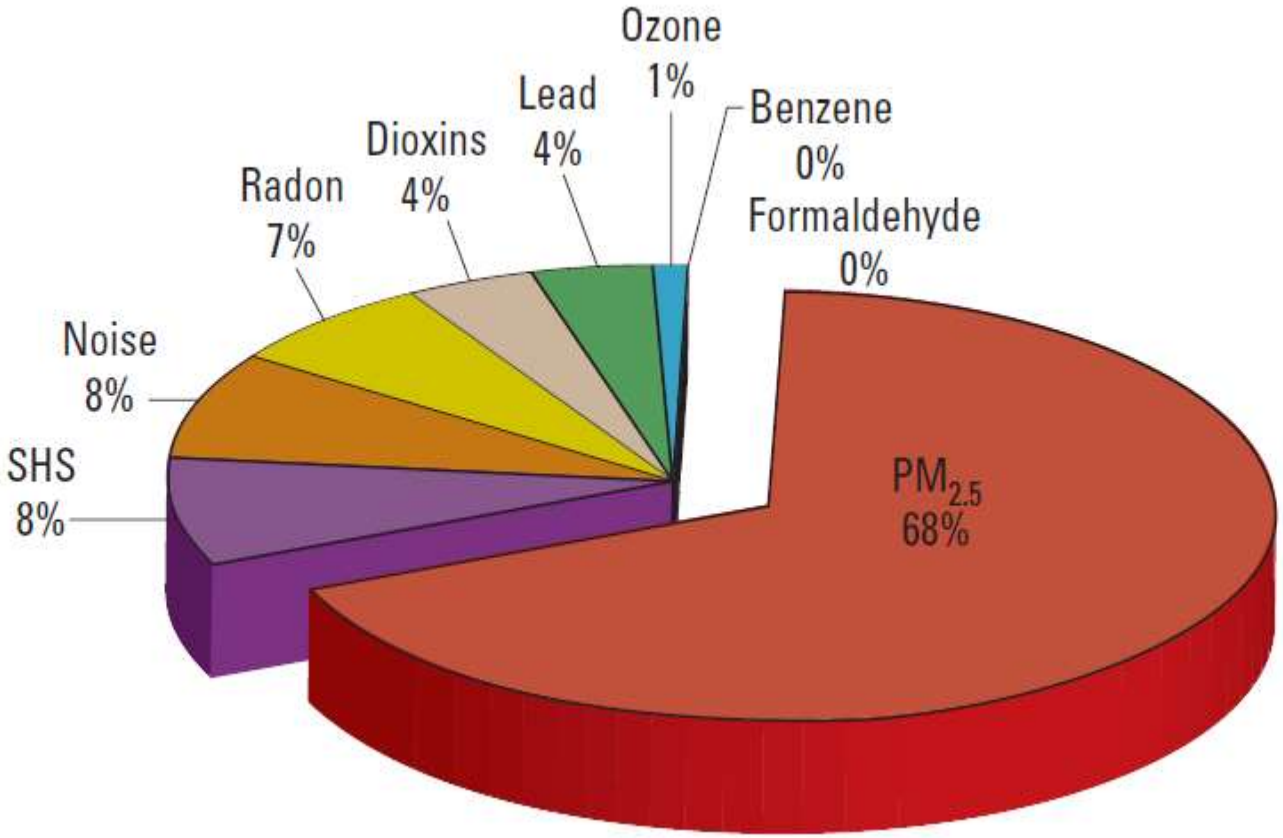
Pope, Ch.31 *in* Holgate *et al*. 1999

Long term effects of pollutant particles

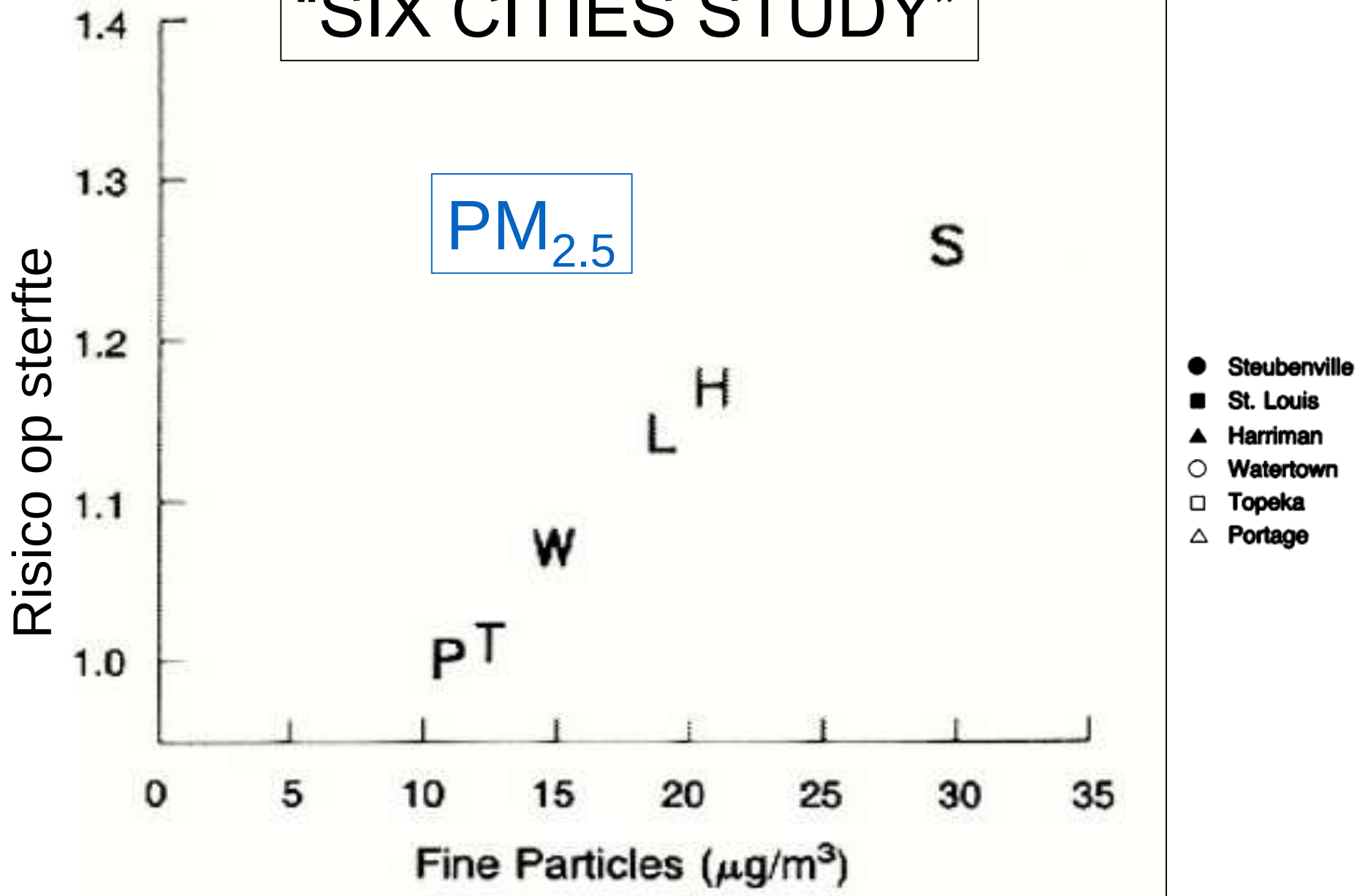
Environmental Burden of Disease in Europe: Assessing Nine Risk Factors in Six Countries (BE, FIN, FR, DE, IT, NL)

Otto Hänninen,[1] Anne B. Knol,[2] Matti Jantunen,[1] Tek-Ang Lim,[3] André Conrad,[4] Marianne Rappolder,[4] Paolo Carrer,[5] Anna-Clara Fanetti,[5] Rokho Kim,[6] Jurgen Buekers,[7] Rudi Torfs,[7] Ivano Iavarone,[8] Thomas Classen,[9] Claudia Hornberg,[9] Odile C.L. Mekel,[10] and the EBoDE Working Group

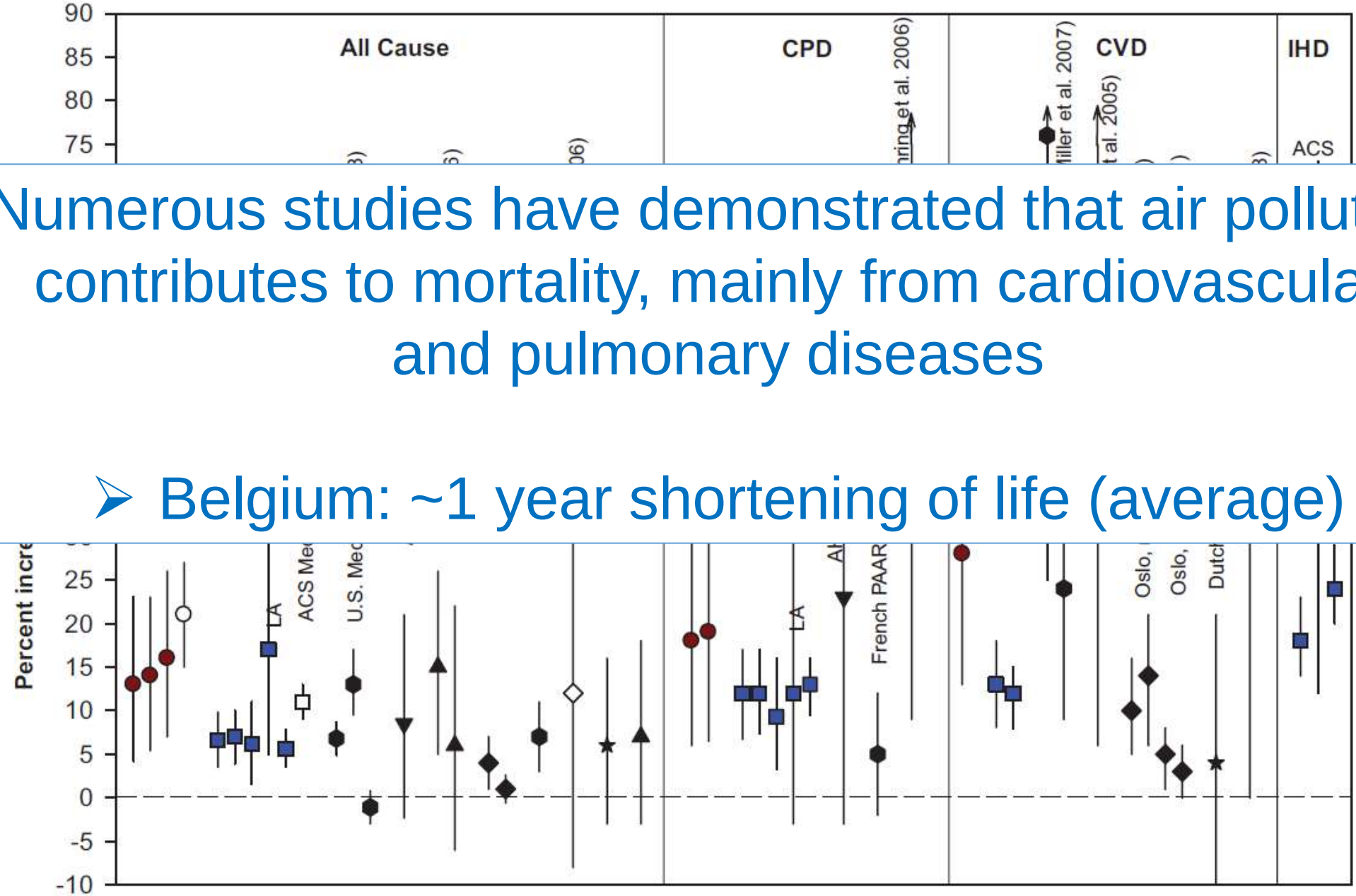
Environ Health Perspect 2014, 122, 439-446



“SIX CITIES STUDY”



Dockery *et al. N.Engl.J.Med*. 1993, 329, 1753-9



Numerous studies have demonstrated that air pollution contributes to mortality, mainly from cardiovascular and pulmonary diseases

- Belgium: ~1 year shortening of life (average)

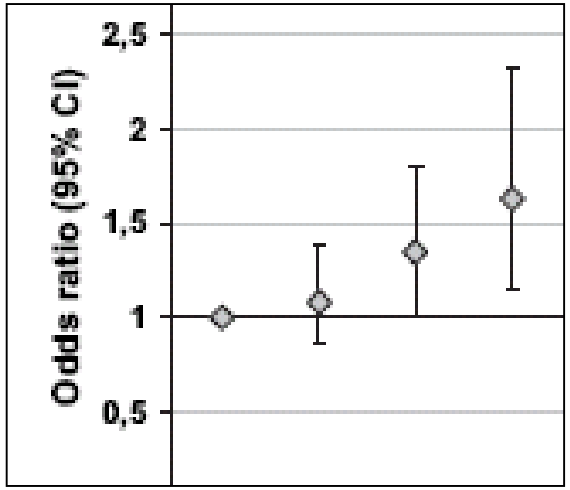
Figure 1. Risk estimates provided by several cohort studies per increment of 10 $\mu g/m^3$ in $PM_{2.5}$ or PM_{10}. CPD indicates cardiopulmonary disease; IHD, ischemic heart disease.

Brooks *et al. Circulation* 2010,121, 2331-78

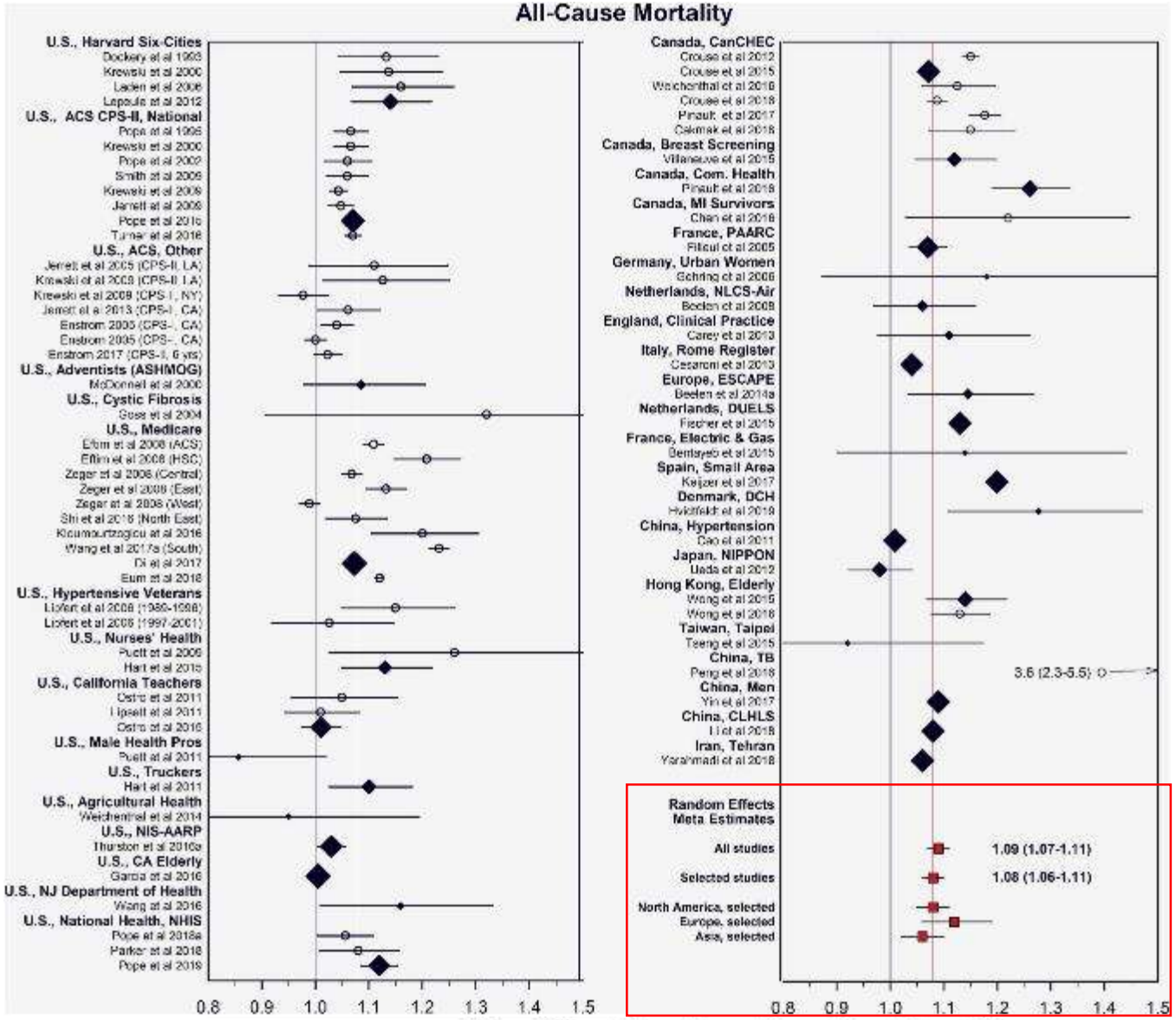
Pollution (long term) and CV morbidity

Hoffmann *et al.* Residential exposure to traffic is associated with coronary atherosclerosis. *Circulation* 2007, 116, 489-96

- Prospective cohort study, Germany:
  - 2000 - : 4494 persons, 45-74 y
  - Coronary artery calcification (CAC) by electron-beam CT
- Exposure: distance of residence to major roads
- OR for high CAC (> 75th percentile):
  - > 200 m from major road : 1 (reference)
  - 101-200 m : 1.08
  - 51-100 m : 1.34
  - < 50 m : 1.63



Environmental Research 183 (2020) 108924



ALL-CAUSE MORTALITY
per +10 µg/m³ in $PM_{2.5}$

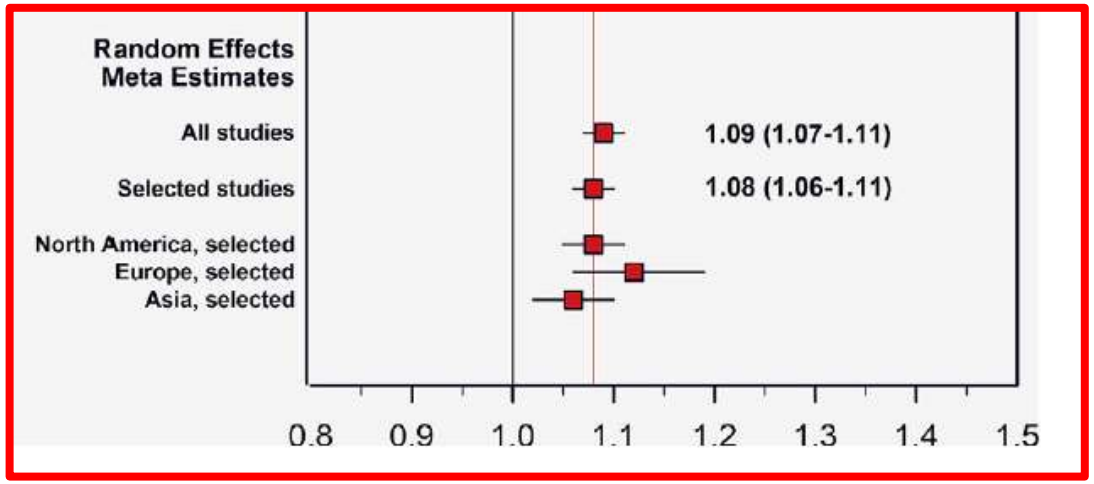
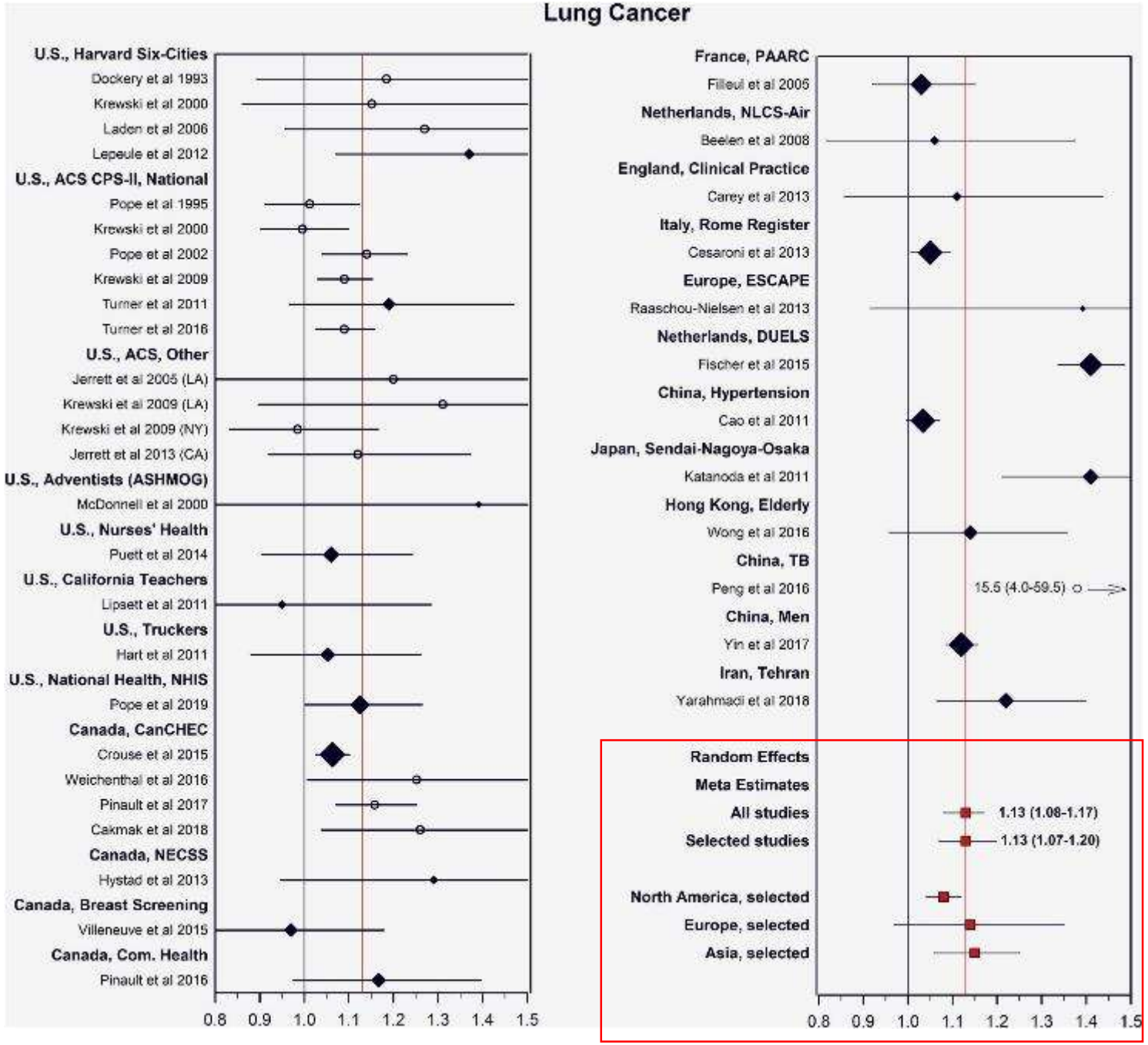
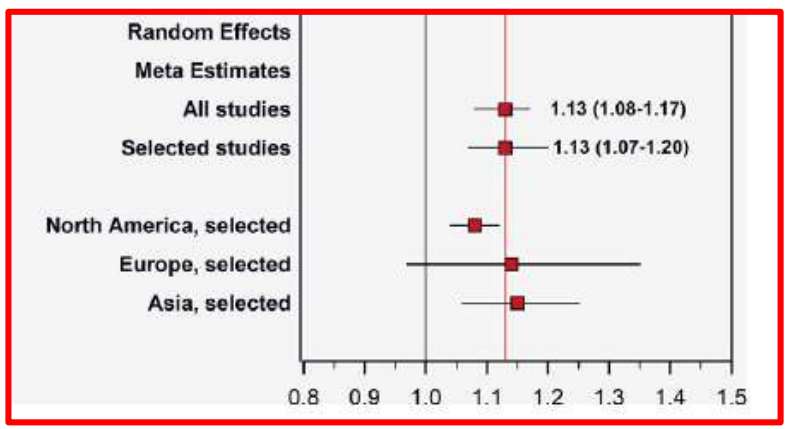


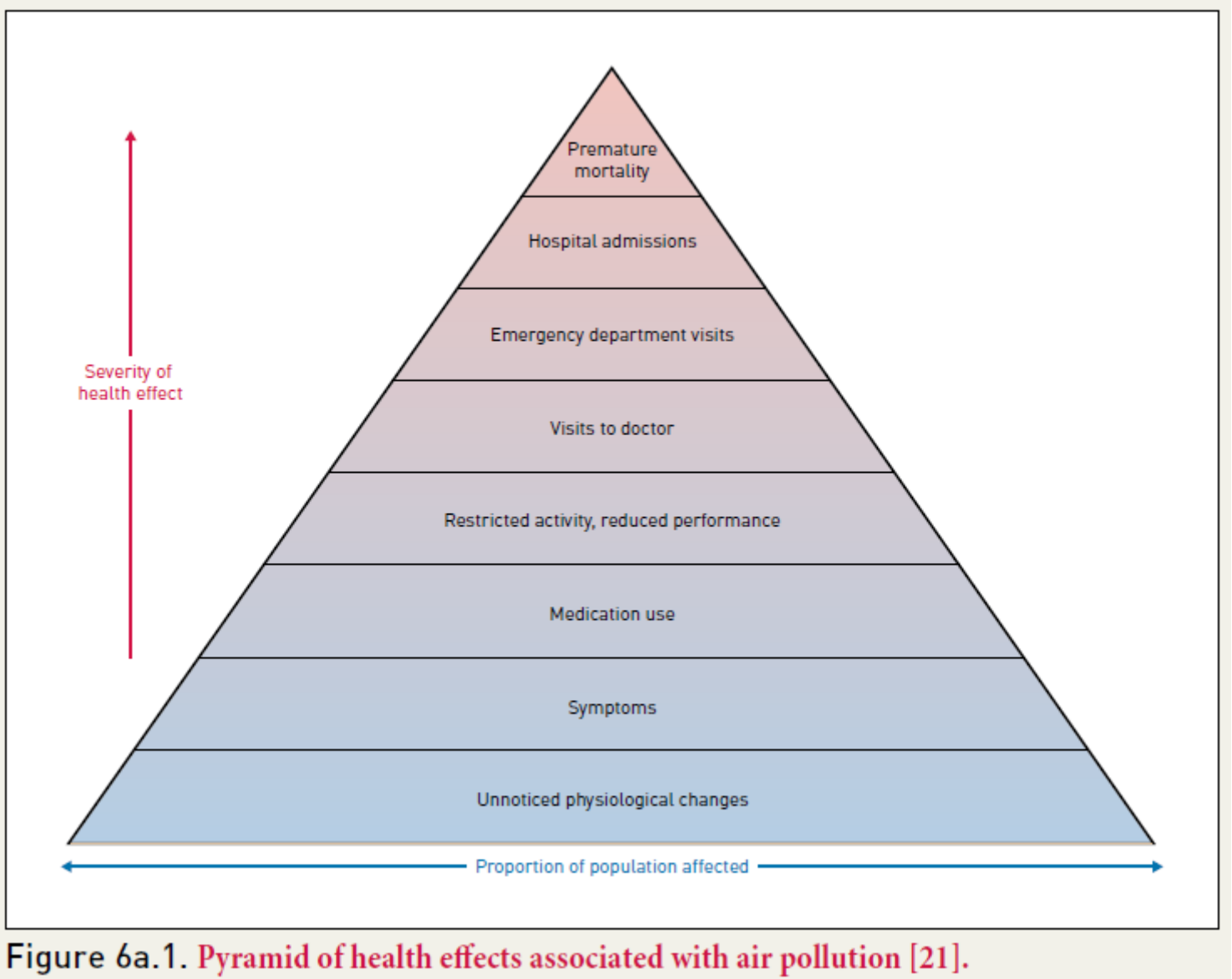
Fig. 1. Estimated adjusted HRs (and 95% CIs) for all-cause mortality per 10 µg/m³ elevation in $PM_{2.5}$ from multiple cohort studies. Black diamonds represent selected studies with the size of the diamond proportional to the relative weight in the random effect estimate using selected studies. The red squares represent random effects meta-estimates. The black line is a reference line at RR = 1. The red line is a reference line at RR equals the random effects meta-estimate using the selected studies (Enstrom, 2005, 2017, Jerrett et al., 2005, 2013; Peng et al., 2017). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



LUNG CANCER MORTALITY
per +10 µg/m^3 in $PM_{2.5}$



Air pollution and adverse health effects



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deaths

hospital admissions

primary care visits

medication use

symptoms

growth & development

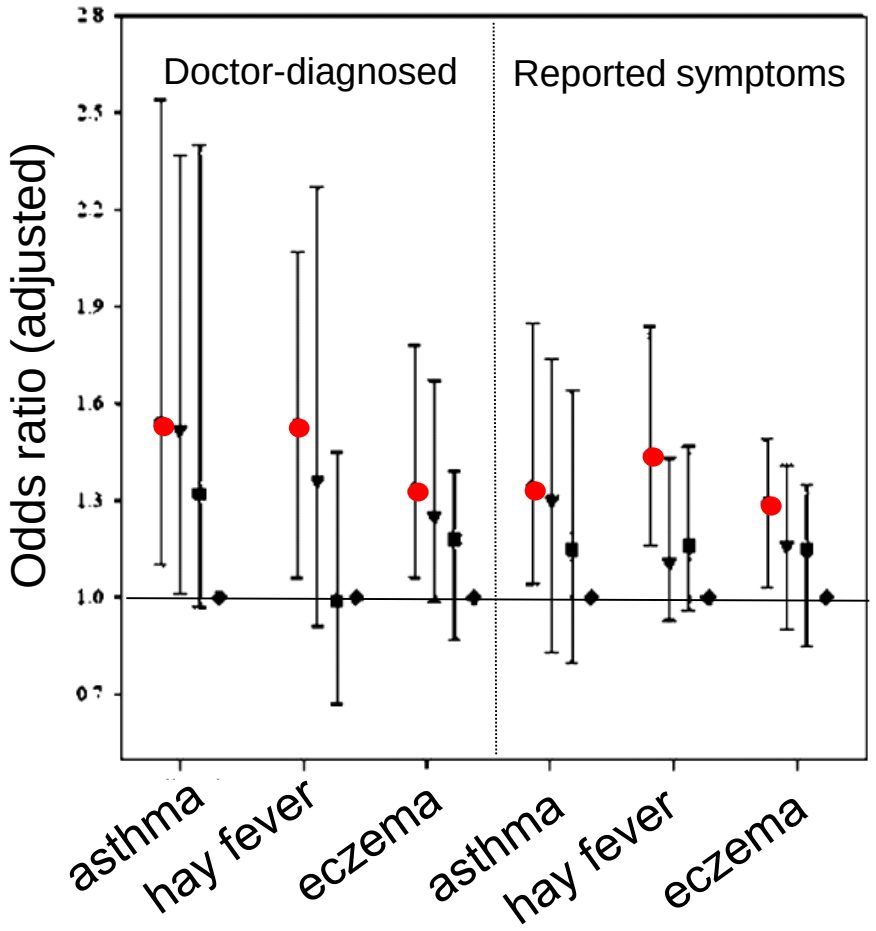
http://www.ersnet.org/images/stories/pdf/web-AQ2010-ENG.pdf

Diseases

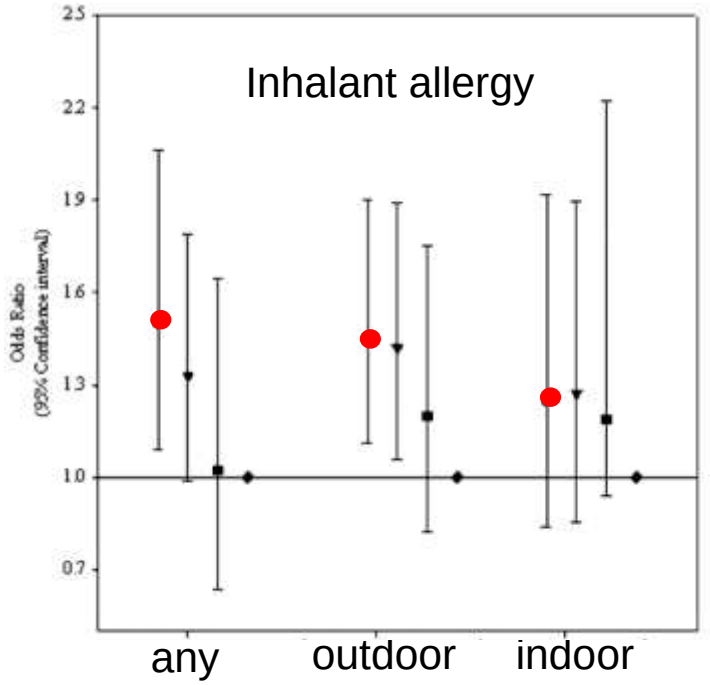
Medication use

Air pollution and asthma / allergy in children

Germany
2860 children 4 y + 3061 children 6 y



Distance from major road
- ● < 50 m
- ▲ 50-250 m
- ■ 250-1000 m
- ♦ > 1000 m



Morgenstern *et al. AJRCCM* 2008, 177, 1331-7

Eur Respir J 2019; 54: 1802194

https://doi.org/10.1183/13993003.02194-2018

Outdoor air pollution and the burden of childhood asthma across Europe

Haneen Khreis[1,2,3,4,9], Marta Cirach[2,3,4], Natalie Mueller[2,3,4], Kees de Hoogh[5,6], Gerard Hoek[7], Mark J. Nieuwenhuijsen[2,3,4] and David Rojas-Rueda[2,3,8,9]

Background: Emerging evidence suggests that air pollution may contribute to childhood asthma development. We estimated the burden of incident childhood asthma that may be attributable to outdoor nitrogen dioxide (NO_2), particulate matter ⩽2.5 µm in diameter ($PM_{2.5}$) and black carbon (BC) in Europe.

Methods: We combined country-level childhood incidence rates and pooled exposure–response functions with childhood (age 1–14 years) population counts, and exposure estimates at 1 540 386 1 km×1 km cells, across 18 European countries and 63 442 419 children. Annual average pollutant concentrations were obtained from a validated and harmonised European land-use regression model. We investigated two exposure reduction scenarios. For the first, we used recommended annual World Health Organization (WHO) air quality guideline values. For the second, we used the minimum air pollution levels recorded across 41 studies in the underlying meta-analysis.

Results: NO_2 ranged from 1.4 to 70.0 $\mu g \cdot m^{-3}$, with a mean of 11.8 $\mu g \cdot m^{-3}$. $PM_{2.5}$ ranged from 2.0 to 41.1 $\mu g \cdot m^{-3}$, with a mean of 11.6 $\mu g \cdot m^{-3}$. BC ranged from 0.003 to 3.7×10^{-5} m^{-1}, with a mean of 1.0×10^{-5} m^{-1}. Compliance with the NO_2 and $PM_{2.5}$ WHO guidelines was estimated to prevent 2434 (0.4%) and 66 567 (11%) incident cases, respectively. Meeting the minimum air pollution levels for NO_2 (1.5 $\mu g \cdot m^{-3}$), $PM_{2.5}$ (0.4 $\mu g \cdot m^{-3}$) and BC (0.4×10^{-5} m^{-1}) was estimated to prevent 135 257 (23%), 191 883 (33%) and 89 191 (15%) incident cases, respectively.

A significant proportion (up to 33%) of incident childhood asthma cases across Europe may be attributable to outdoor air pollution. These cases are largely preventable, underlying an urgent need to reduce children's exposure to NO_2, $PM_{2.5}$ and black carbon. http://bit.ly/36Fe5KN

Air pollution and sales of medication for asthma or COPD (Brussels 2005-2011)

Increase of NO_2 by 20.5 µg/m^3 → more inhalers sold

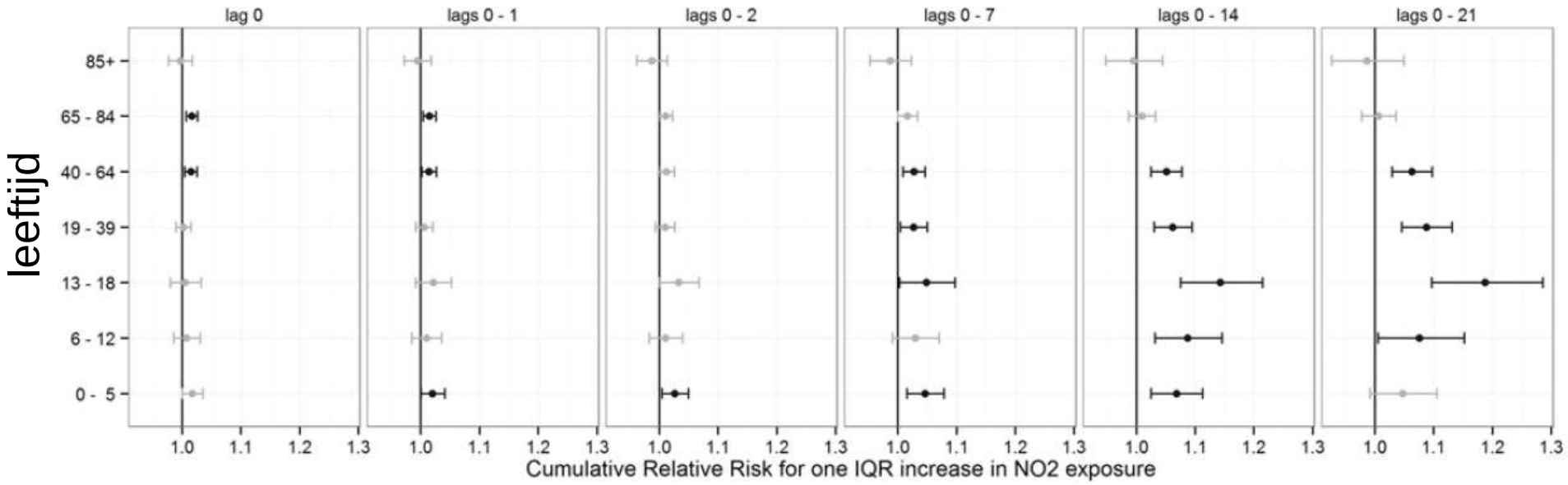


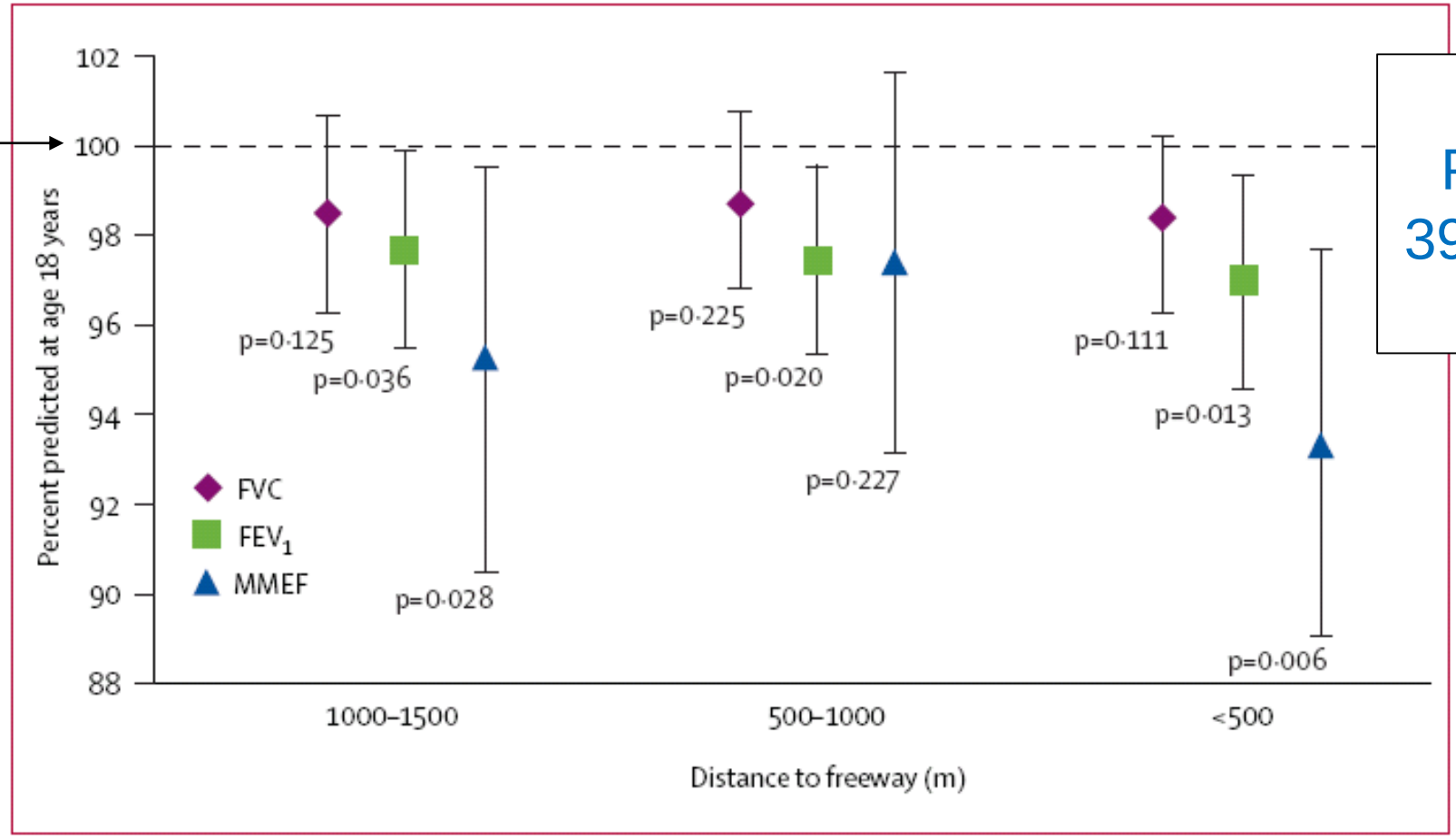
Fig. 4. Estimated cumulative relative risks (RR)* and their 95% confidence intervals of sales of asthma and COPD medication per IQR (20.5 µg/m^3) increase in the concentration of NO_2 in Brussels-Capital Region (Belgium) between the 1st of January 2005 and the 31st of December 2011, by age groups Estimates are adjusted for daily minimum temperature, average relative humidity, day of the week and influenza epidemics.

Casas *et al. Environ Int* 2016, 94, 576-82

Growth and development

Air pollution and growth of pulmonary function

> 1500m



California
Prospective study
3977 children (~10y)
8 year follow-up

Figure: **Percent-predicted lung function at age 18 years versus residential distance from a freeway**
The horizontal line at 100% corresponds to the referent group, children living >1500 m from a freeway.

Gauderman *et al. Lancet* 2007, 369, 571-7

Air pollution and growth of pulmonary function

Gauderman *et al. NEJM* 2015, 372, 905-13

Improvement in air quality → improvement in lung function

per 26.5 µg/m^3 ↓ in NO_2

growth of FEV_1 + 91.4 ml

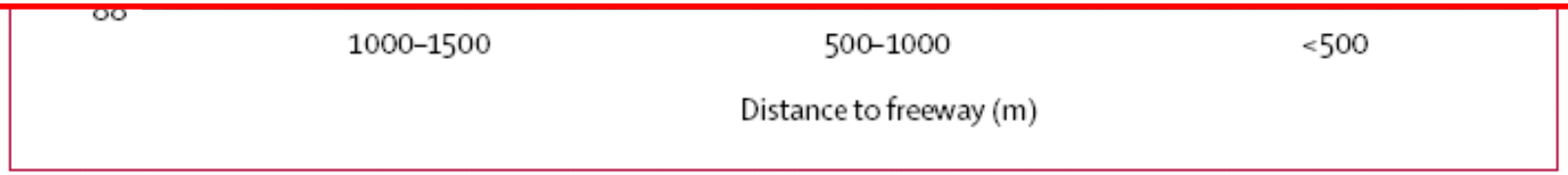
growth of FVC + 169 ml

> 150

tudy

~10y)

-up



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Gauderman *et al. Lancet* 2007, 369, 571-7

Air pollution and cognitive development

Barcelona
39 schools, 2715 children, 7-10 y,
4 tests of cognitive development over 1 year

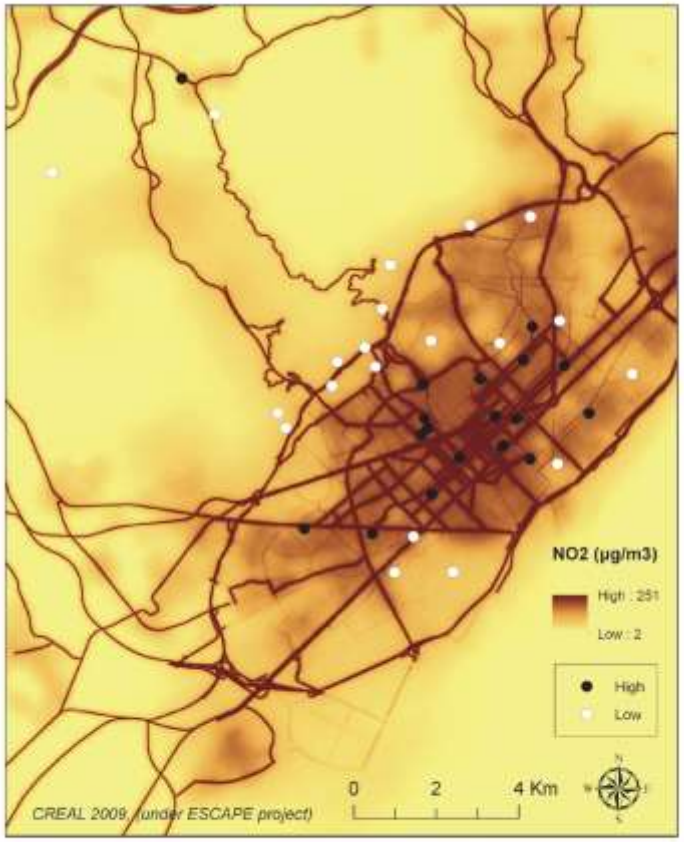


Fig 1. Map of Barcelona and the schools by high or low air pollution by design. Black dots indicate the locations of schools with high air pollution, and white dots indicate the locations of schools with low air pollution, based on NO_2 levels.

doi:10.1371/journal.pmed.1001792.g001

NO_2 µg/m^3

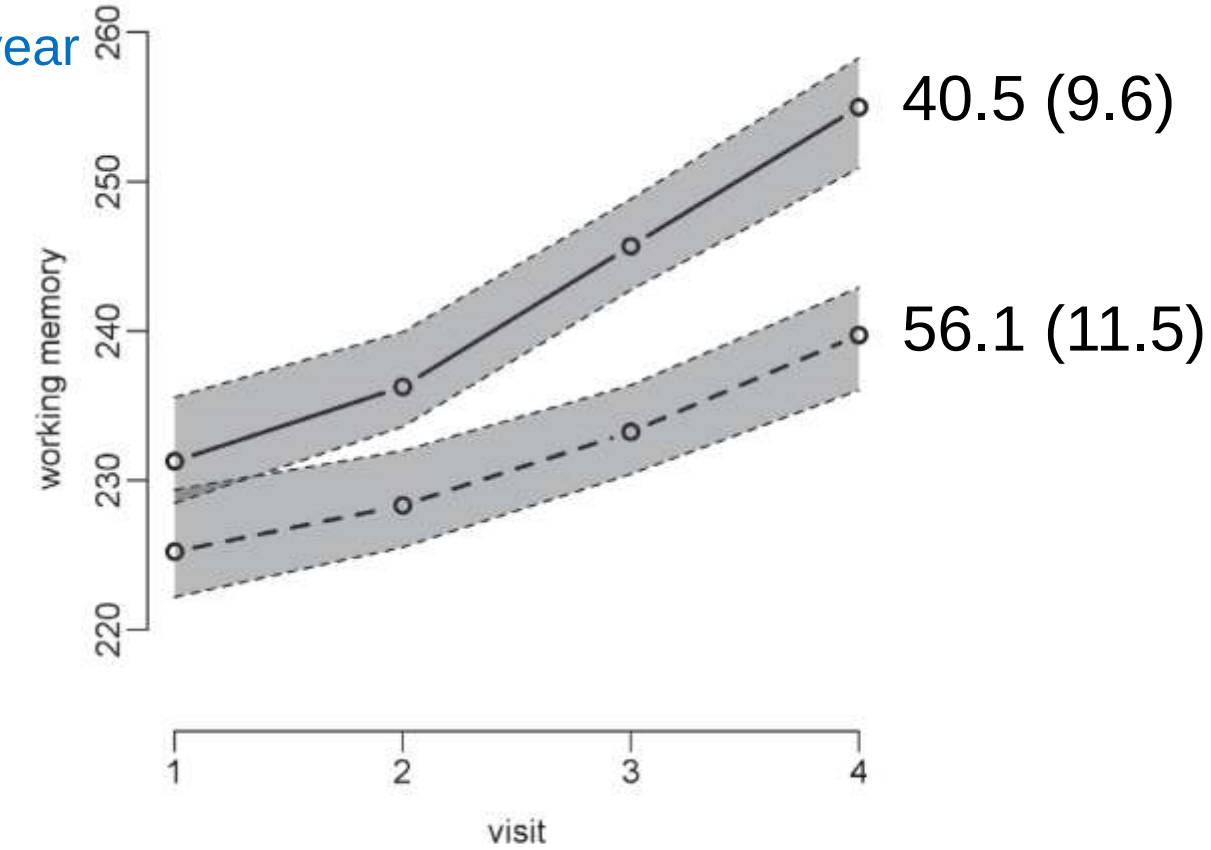


Fig 2. Working memory development by high- or low-traffic-air-pollution school. Dashed line = high traffic air pollution; continuous line = low traffic air pollution; gray shading indicates 95% CIs. Adjusted for age, sex, maternal education, residential neighborhood socioeconomic status, and air pollution exposure at home; school and individual as nested random effects in 2,715 children and 10,112 tests from 39 schools.

doi:10.1371/journal.pmed.1001792.g002

Sunyer *et al. PLOS Med* 2015, 12:e1001792

www.thelancet.com/planetary-health Published online October 19, 2020 https://doi.org/10.1016/S2542-5196(20)30227-8

Long-term effects of $PM_{2·5}$ on neurological disorders in the American Medicare population: a longitudinal cohort study

Liuhua Shi, Xiao Wu*, Mahdieh Danesh Yazdi, Danielle Braun, Yara Abu Awad, Yaguang Wei, Pengfei Liu, Qian Di, Yun Wang, Joel Schwartz, Francesca Dominici, Marianthi-Anna Kioumourtzoglou†, Antonella Zanobetti†*

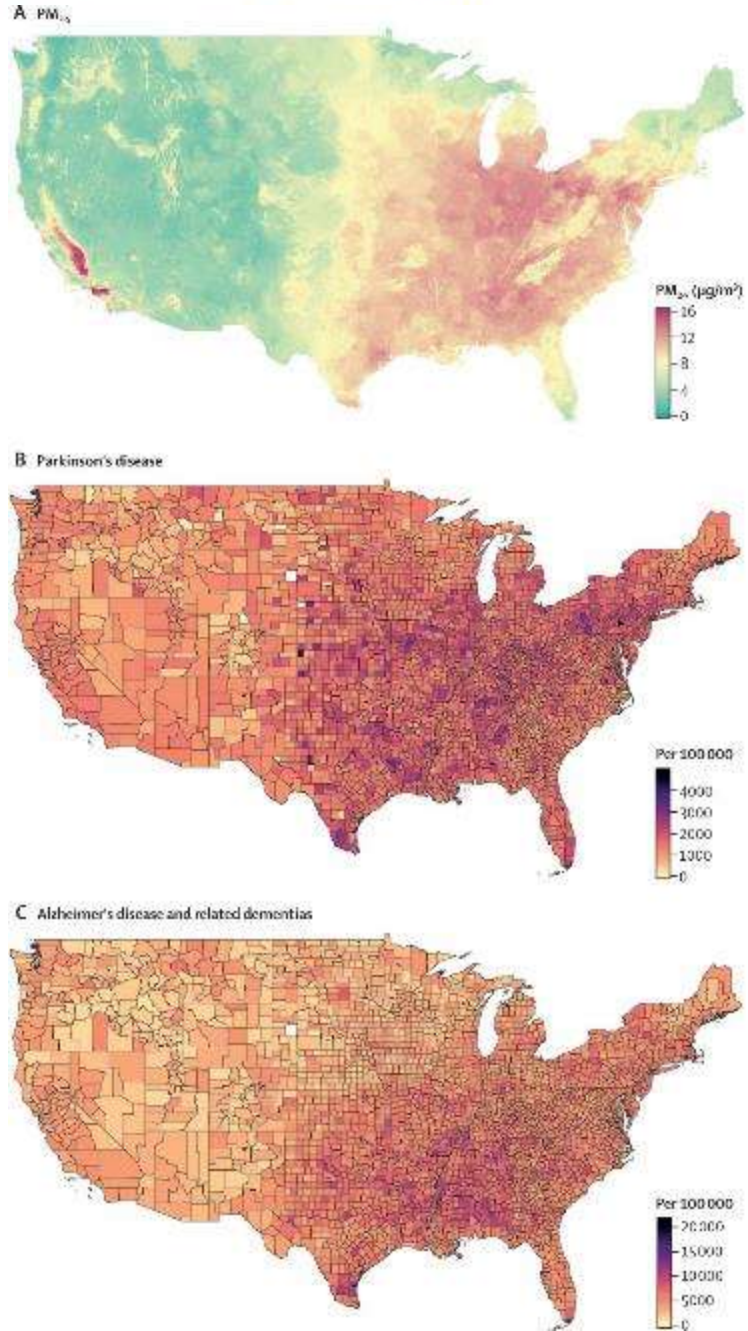
Summary

Background Accumulating evidence links fine particulate matter ($PM_{2·5}$) to premature mortality, cardiovascular disease, and respiratory disease. However, less is known about the influence of $PM_{2·5}$ on neurological disorders. We aimed to investigate the effect of long-term $PM_{2·5}$ exposure on development of Parkinson's disease or Alzheimer's disease and related dementias.

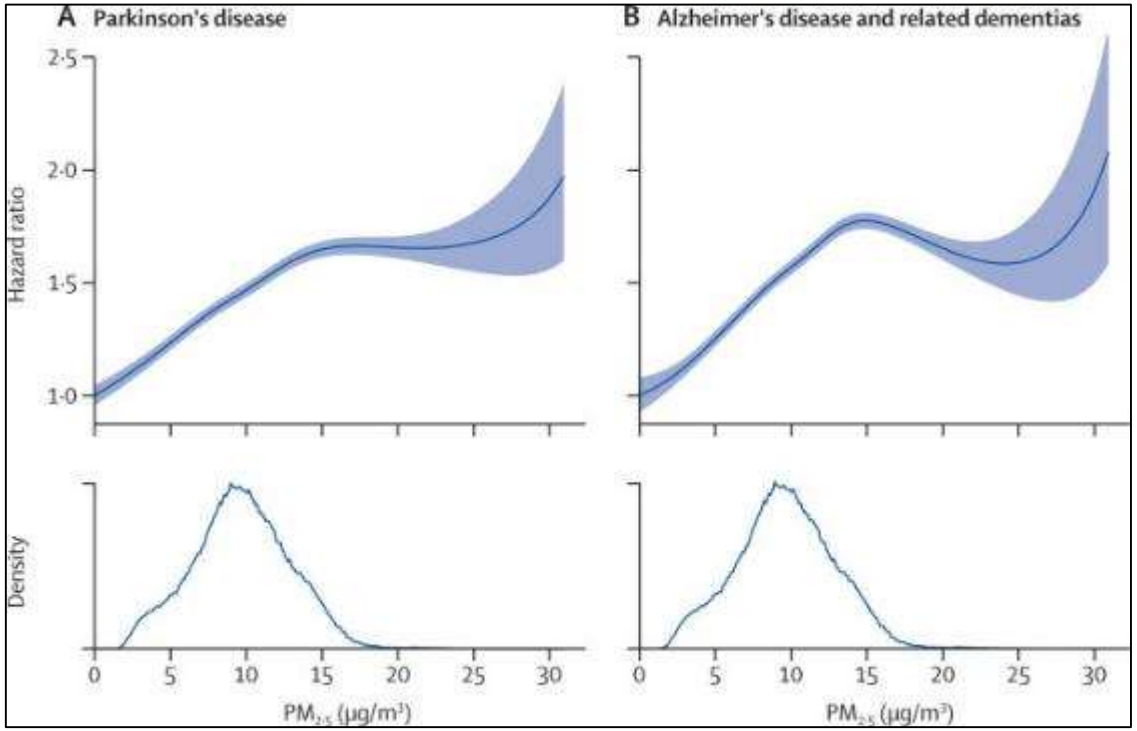
Methods We did a longitudinal cohort study in which we constructed a population-based nationwide open cohort including all fee-for-service Medicare beneficiaries (aged ≥65 years) in the contiguous United States (2000–16) with no exclusions. We assigned $PM_{2·5}$ postal code (ie, ZIP code) concentrations based on mean annual predictions from a high-resolution model. To accommodate our very large dataset, we applied Cox-equivalent Poisson models with parallel computing to estimate hazard ratios (HRs) for first hospital admission for Parkinson's disease or Alzheimer's disease and related dementias, adjusting for potential confounders in the health models.

Findings Between Jan 1, 2000, and Dec 31, 2016, of 63 038 019 individuals who were aged 65 years or older during the study period, we identified 1·0 million cases of Parkinson's disease and 3·4 million cases of Alzheimer's disease and related dementias based on primary and secondary diagnosis billing codes. For each 5 μg/m³ increase in annual $PM_{2·5}$ concentrations, the HR was 1·13 (95% CI 1·12–1·14) for first hospital admission for Parkinson's disease and 1·13 (1·12–1·14) for first hospital admission for Alzheimer's disease and related dementias. For both outcomes, there was strong evidence of linearity at $PM_{2·5}$ concentrations less than 16 μg/m³ (95th percentile of the $PM_{2·5}$ distribution), followed by a plateaued association with increasingly larger confidence bands.

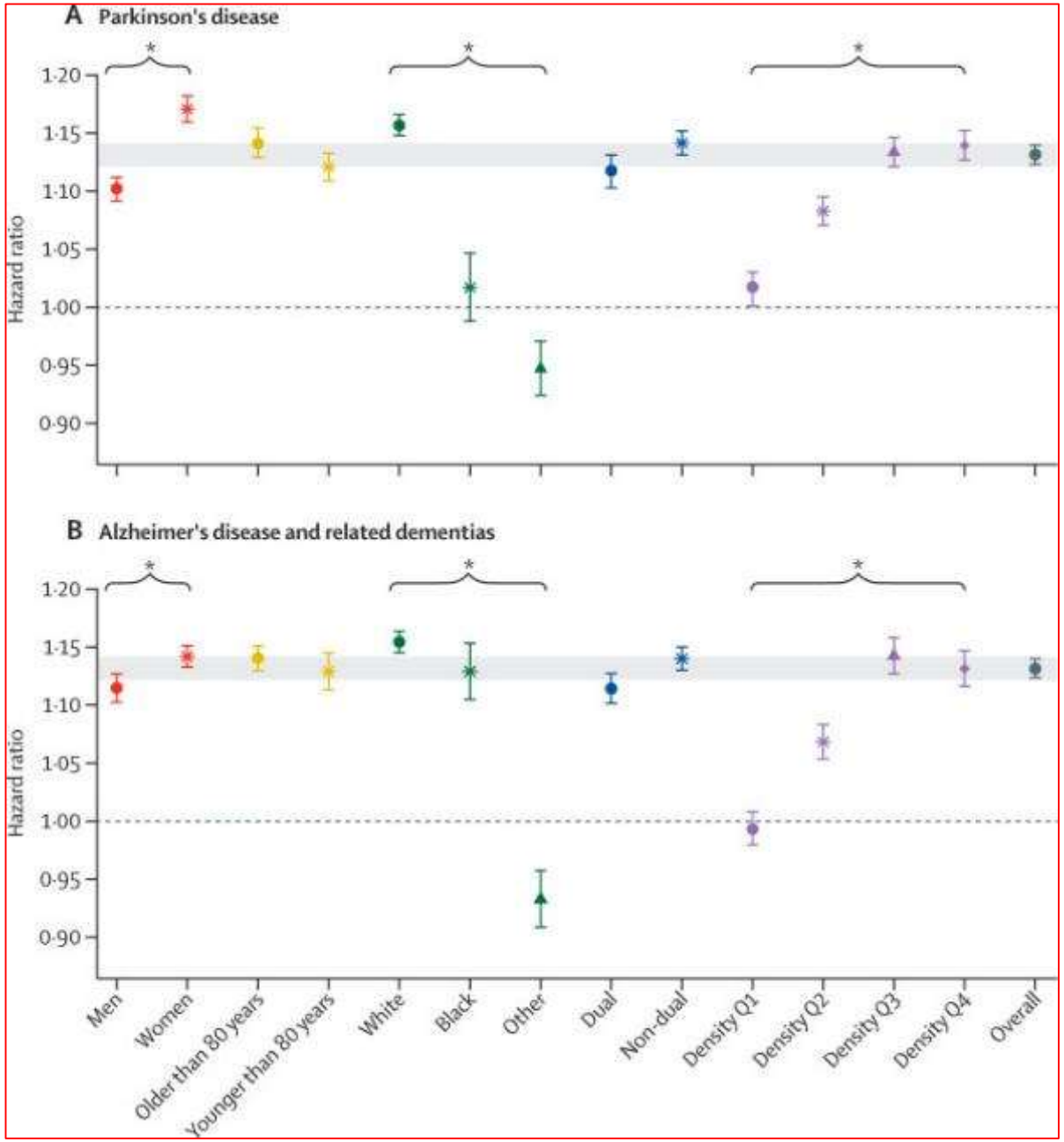
Interpretation We provide evidence that exposure to annual mean $PM_{2·5}$ in the USA is significantly associated with an increased hazard of first hospital admission with Parkinson's disease and Alzheimer's disease and related dementias. For the ageing American population, improving air quality to reduce $PM_{2·5}$ concentrations to less than current national standards could yield substantial health benefits by reducing the burden of neurological disorders.



www.thelancet.com/planetary-health Published online October 19, 2020 https://doi.org/10.1016/S2542-5196(20)30227-8



Hazard ratios for Parkinson's disease (A) and Alzheimer's disease and related dementias (B) associated with a 5 µg/m^3 increase in $PM_{2·5}$ concentrations by study subgroups. The shading represents the estimated main effects for the overall population. Dual or non-dual refers to eligibility for Medicaid. Density Q1–Q4 denote quartiles of population density—ie, low population density, low to medium population density, medium to high population density, and high population density. Other included Asian, Hispanic, American Indian or Alaskan Native, and unknown race. *Significant modification (at α=0·05 level).

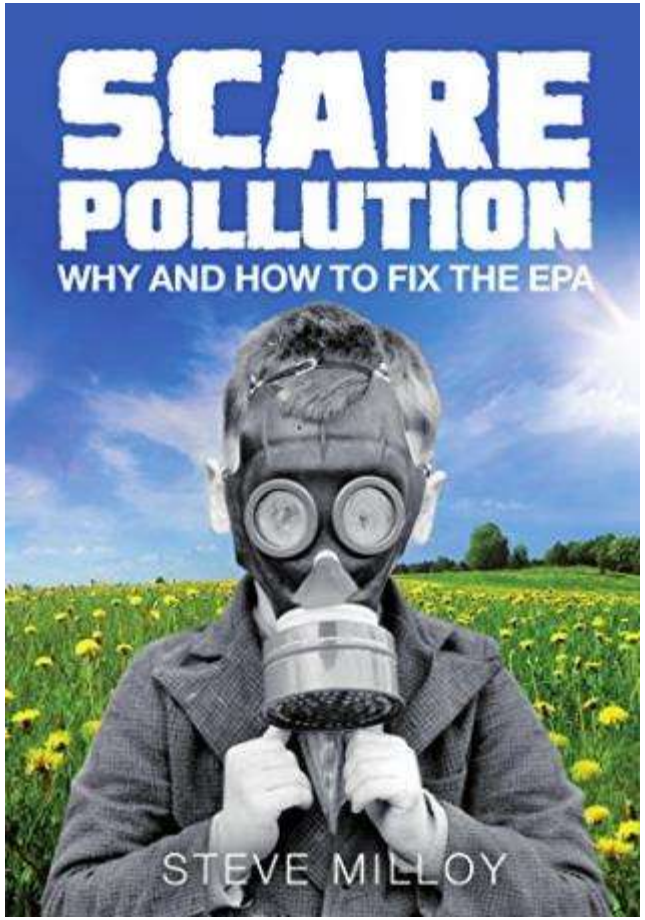


Is this relevant/important?

“air pollution denial”

www.theguardian.com/environment/2017/nov/16/ 'Modern air is too clean': the rise of air pollution denial

US sceptics are questioning the science behind air pollution and mortality, a trend that is starting to appear in countries where the air is much more toxic



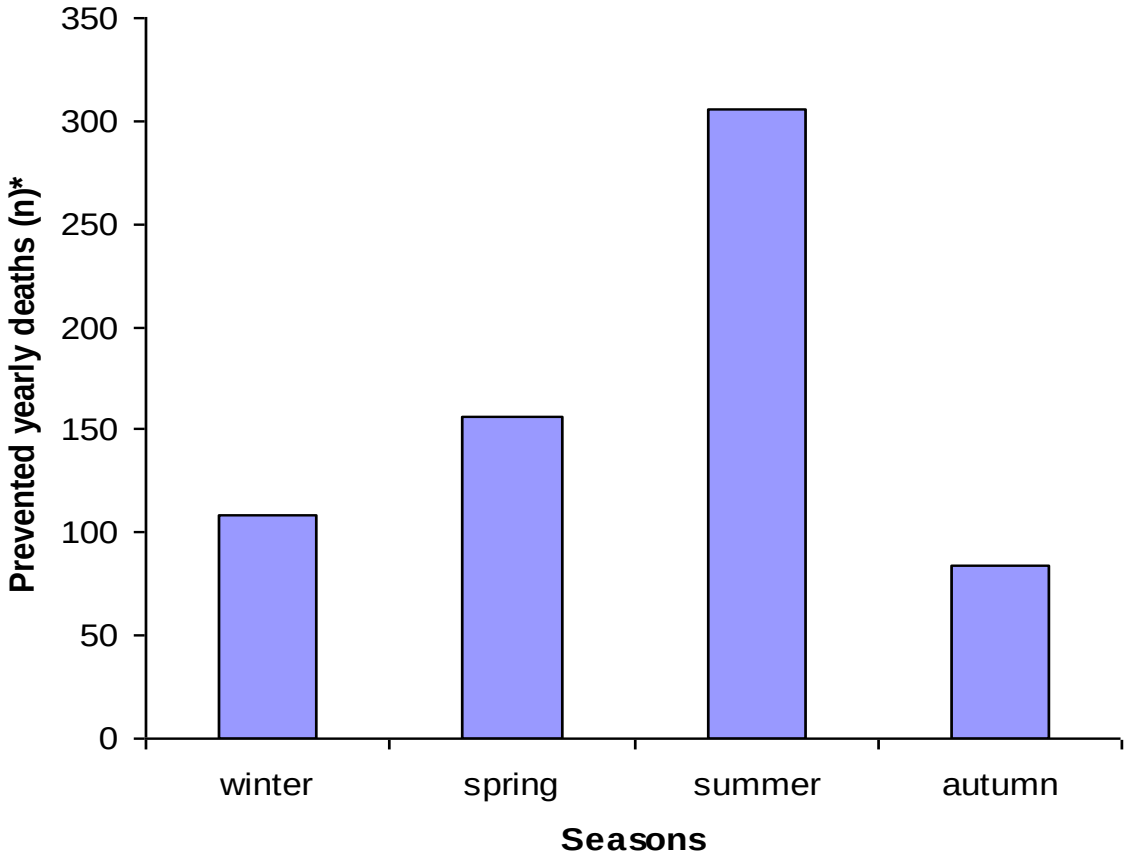
The U.S Environmental Protection Agency (EPA) claims that outdoor air kills hundreds of thousands of Americans every year. EPA has used this claim to: wreck the coal industry; justify expensive and job-killing air quality and climate rules; and to scare Americans about the air they breathe. Milloy not only debunks the outrageous EPA's claims and exposes them as rank scientific fraud in no uncertain terms, but offers a roadmap for fixing the rogue and out-of-control EPA.

Relevance

- A small (“trivial”) average effect in the population does not mean that the effect is trivial
  - for public health
  - for some individuals (vulnerable/susceptible people)

Avoidable deaths per year

If mean daily PM_{10}-levels had not exceeded 20 µg/m³



630 deaths/year
(total deaths: 50,000/year)

Nawrot *et al*. J Epidemiol Comm Health 2007, 61, 146-9

Public health importance of triggers of myocardial infarction: a comparative risk assessment

Tim S Nawrot, Laura Perez, Nino Künzli, Elke Munters, Benoit Nemery

Lancet 2011; 377: 732–40

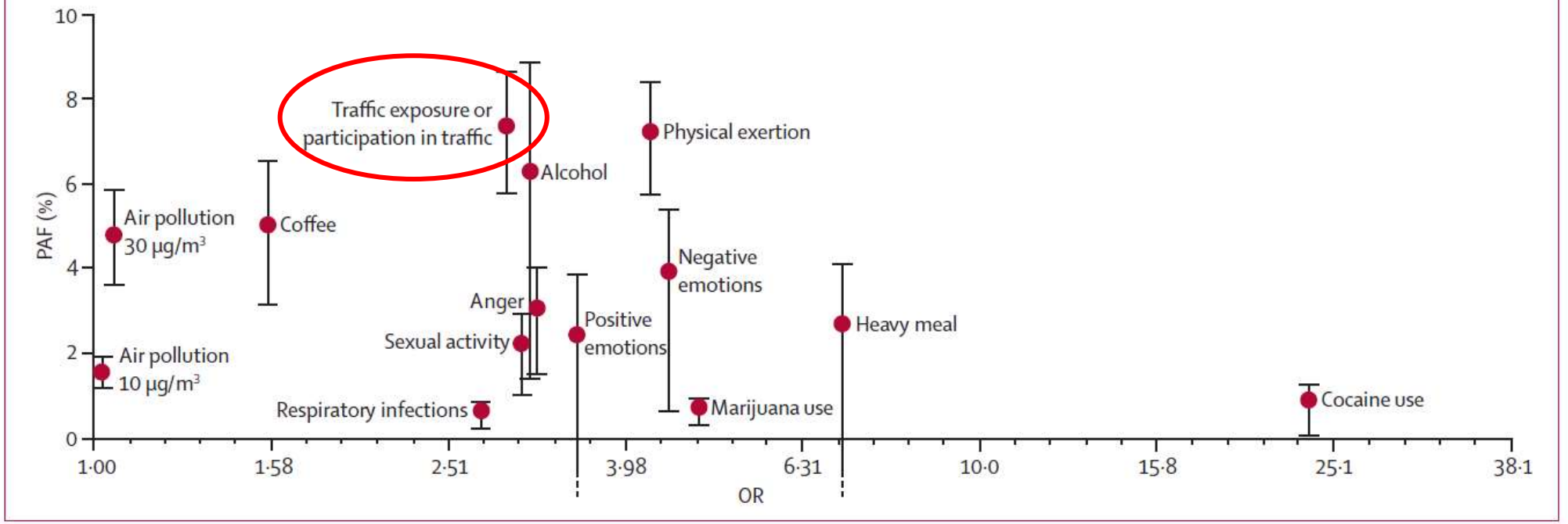


Figure 2: **Relation between OR and the PAF for each studies trigger**

PAFs were calculated and reported with their 95% CI (error bars). Not significant triggers show 95% CIs that are lower than 0%. X-axis is log scale, and ORs are given as anti-logs. OR=odds ratio. PAF=population attributable fraction.

Short term exposure to fine particulate matter and hospital admission risks and costs in the Medicare population: time stratified, case crossover study

BMJ 2019;367:l6258 | doi: 10.1136/bmj.l6258

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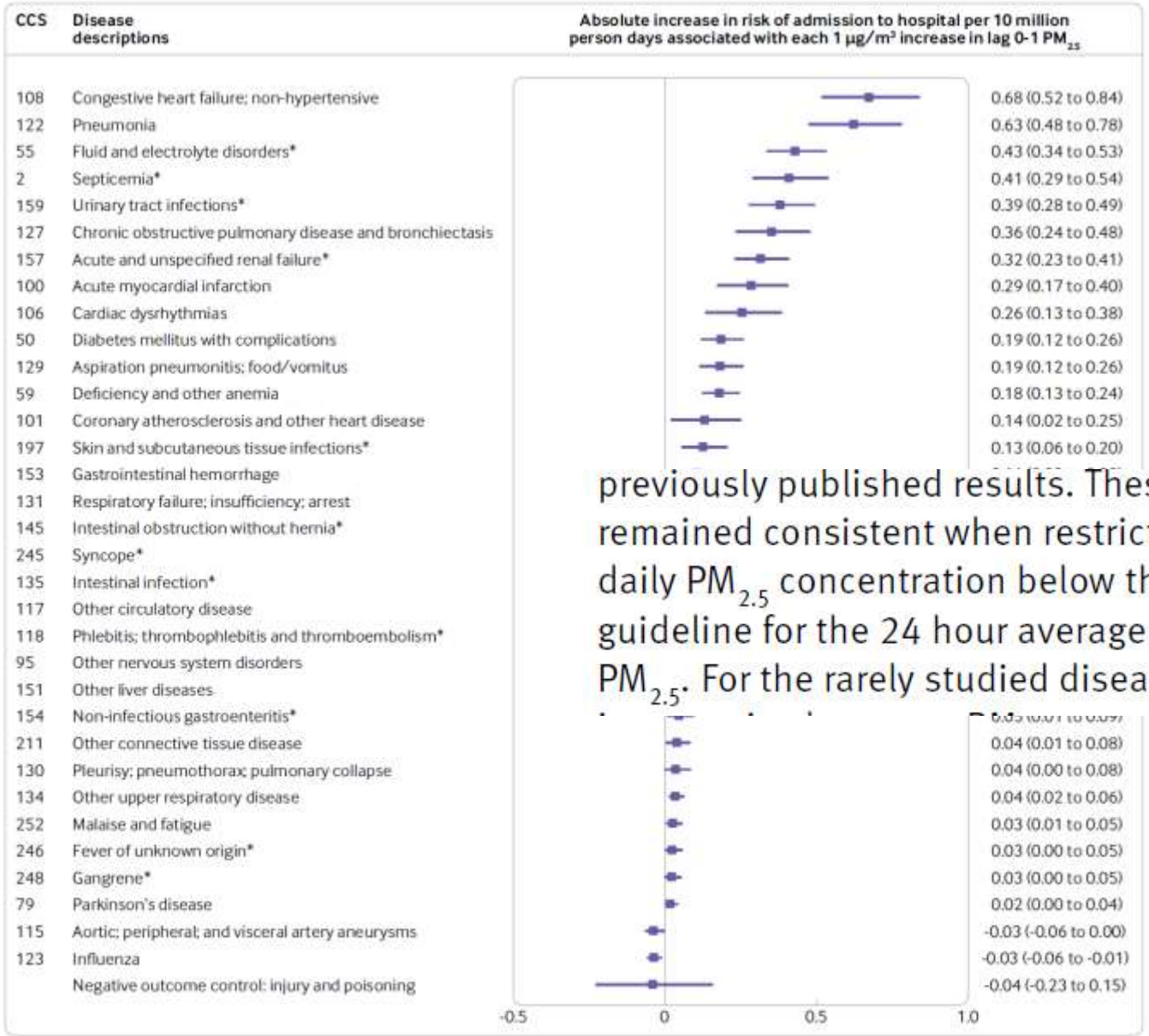
SETTING

Medicare inpatient hospital claims in the United States, 2000-12 (n=95 277 169).

PARTICIPANTS

All Medicare fee-for-service beneficiaries aged 65 or older admitted to hospital.



previously published results. These associations remained consistent when restricted to days with a daily $PM_{2.5}$ concentration below the WHO air quality guideline for the 24 hour average exposure to $PM_{2.5}$. For the rarely studied diseases, each 1 µg/m^3

Fig 2 | Main analysis showing absolute increases in risk of hospital admission, ordered from highest to lowest, associated with each 1 µg/m^3 increase in lag 0-1 $PM_{2.5}$. The main analysis was conducted in the case crossover study setting with lag 0-1 $PM_{2.5}$ as the exposure, adjusted for penalized splines of lag 0-1 air and dew point temperatures for each disease group. The Bonferroni correction was used to adjust 95% confidence intervals for disease groups associated with lag 0-1 $PM_{2.5}$ and negative outcome control (injury and poisoning). CCS=Clinical Classification Software code. *Indicates newly identified disease groups. Figure S2 in the supplementary online contents provides results for each of the 214 disease groups

risk of hospital admission associated with each 1 µg/m^3 increase in lag 0-1 $PM_{2.5}$. rease in risk of hospital admission. The main analysis was conducted in the case usted for penalized splines of lag 0-1 air and dew point temperatures for each disease dence intervals for disease groups associated with lag 0-1 $PM_{2.5}$ and negative outcome ware code. *Indicates newly identified disease groups. Figure S2 in the supplementary oups

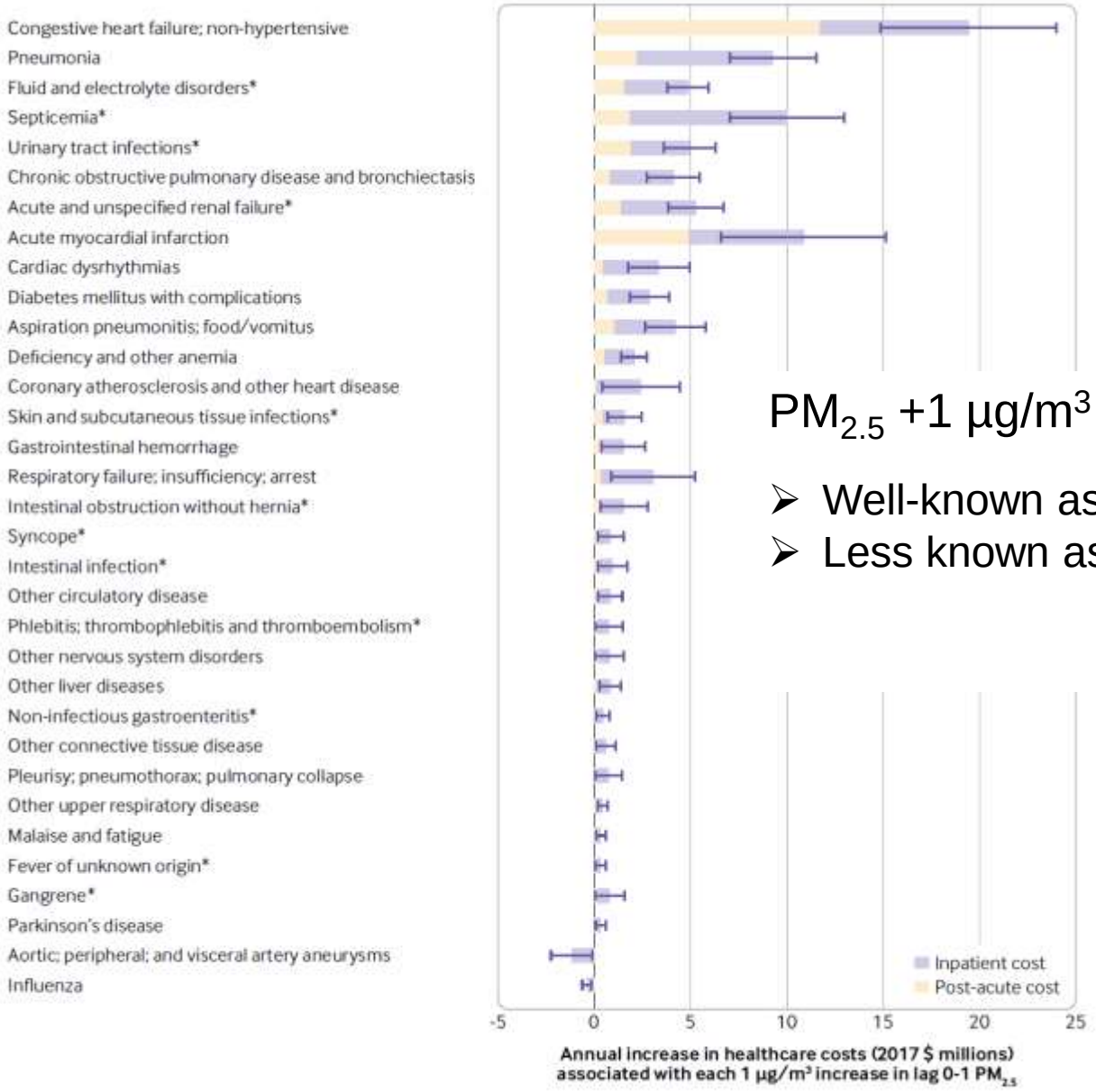


Fig 6 | Annual increase in healthcare costs (inpatient and post-acute care) associated with each 1 µg/m^3 increase in lag 0-1 $PM_{2.5}$. Disease groups are ranked from highest to lowest absolute increase in risk of hospital admission. Error bars show 95% confidence intervals for estimates of annual increase in healthcare costs. *Indicates newly identified disease groups. Results are from the main analysis using the full dataset

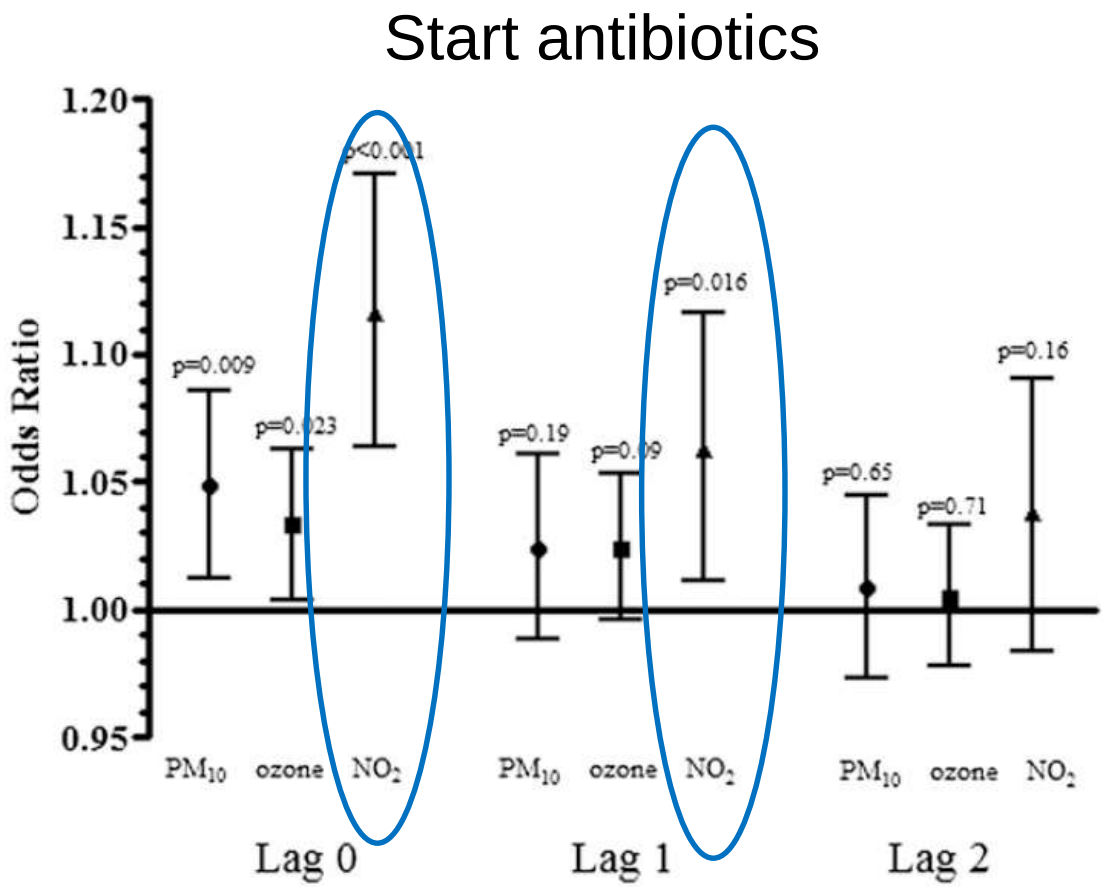
$PM_{2.5}$ +1 µg/m^3

- Well-known associations +3642 hospital admissions = US$ 69M
- Less known associations +2050 hospital admissions = US$ 31M

Relevance

- A small (“trivial”) average effect in the population does not mean that the effect is trivial
  - for public health
  - for some individuals (vulnerable/susceptible people)

Air pollution and exacerbations in patients with cystic fibrosis

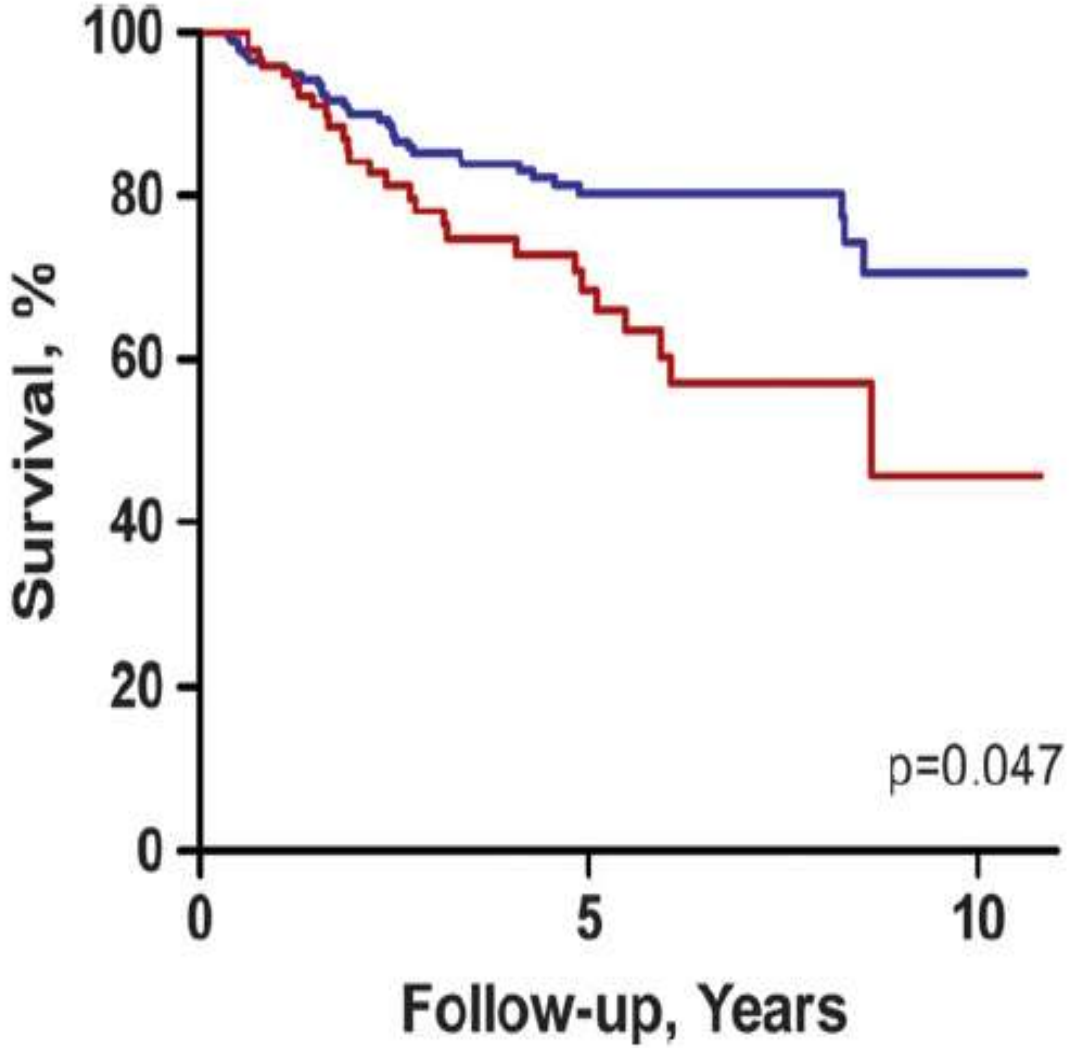


Case-crossover
215 patiënts

(UZ Leuven 1998-2010)

Goeminne *et al. Chest* 2013, 143, 946-54

Life expectancy after lung transplantation and distance between home and heavy traffic



> 171m (192 patiënts)

< 171m (96 patiënts)

(UZ Leuven 1997-2009)

Nawrot *et al. Thorax* 2011, 66, 748-54

Eur Respir J 2012; 39: 525–528
DOI: 10.1183/09031936.00001112

Eur Respir J 2012, 39, 525-528

EDITORIAL

Ten principles for clean air

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1) Citizens are entitled to clean air, just like clean water and safe food.

Thank you for your attention

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