Conferentie Luchtkwaliteit 2014 – Minaraad – Brussel, 05.12.2014

Luchtverontreiniging
Hoe relevant? Voor wie in het bijzonder?

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Impact van luchtverontreiniging op de gezondheid

- Pieken van luchtverontreiniging
- Langdurige (chronische) blootstelling

- ➢ effecten op populatie-niveau
- ➢ effecten op “gevoelige” groepen

Short term effects of pollutant particles (temporal variation)

NEW YORK TIMES

5 Dec 1930

6 Dec 1930

8 Dec 1930

Belgium's Poison Fog Cases Likened to the 'Black Death'

Special Cable to THE NEW YORK TIMES.

LONDON, Dec. 5.—The suggestion that the Belgian fog deaths may be due to some form of plague was advanced tonight by Professor J. B. S. Haldane, prominent Cambridge scientist.

"It seems like something in the nature of the Black Death to me," he told The Daily Mail tonight. "I don't think it can be caused by war gas, because the deaths occurred in different villages. They have been having floods in that district lately and that may be responsible."

The Black Death was the name given in the Middle Ages to the bubonic plague, which was responsible for millions of deaths in the fourteenth century in various parts of Europe.

FOG BROUGHT DEATH ONLY TO OLD AND ILL

Toll of 70 in Belgian Towns Laid to Natural Causes as Menace Passes Away.

PEASANTS STILL IN TERROR

Many Credit Malignant Force —Authorities the World Over Speculate on Phenomenon.

Special Cable to THE NEW YORK TIMES.

BRUSSELS, Dec. 6.—While it is asserted by some medical authorities that the appalling number of deaths attributed to the dense fog in Belgium of the last three days were due in reality only to natural causes.

BELGIAN FOG DEATHS LAID TO POISONOUS GAS

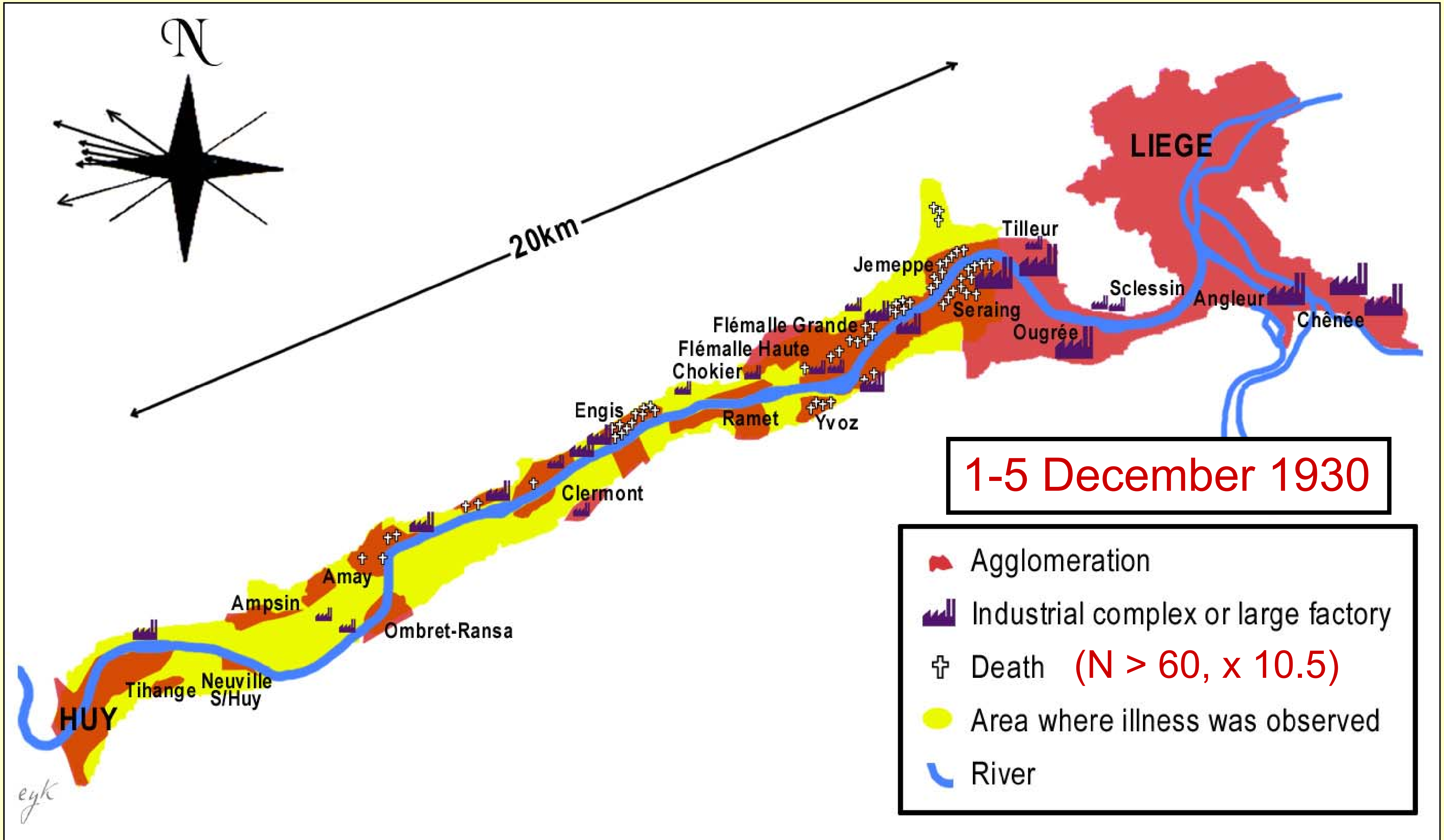
Doctor Who Performs Autopsy Unable to Identify It— Brussels Inquiry Today.

Special Cable to THE NEW YORK TIMES.

BRUSSELS, Dec. 8.—The deaths caused by the fog in the Meuse Valley were ascribed to a poisonous gas by Professor Firket, who performed an autopsy upon several victims today in Liége. He said, however, that he had been unable to determine exactly what gas had wrought the havoc.

"It is neither any known form of war gas, nor a gas such as might be derived from an ammonia explosion," he said. "We rather incline to the theory that it had its origin in some industrial accident, which resulted in the release of noxious gas."

Scientists investigating the incident agree that such a noxious gas could be carried by the fog. At the same time, no progress has been



Firket, *Bull.Acad.R.Méd.Belg.*, 1931, 11, 683-734

Medische waarnemingen (1930)

- Wie was aangetast?
  - Vooral ouderen, astmalijders, hartpatiënten & verzwakten, zelfs indien binnen gebleven
  - toch ook wie voorheen gezond was
  - ook kinderen
  - ➢ "vele duizenden"

  - vee ook aangetast (tenzij uit de vallei naar de heuvels weggebracht)

Conclusies (1930)

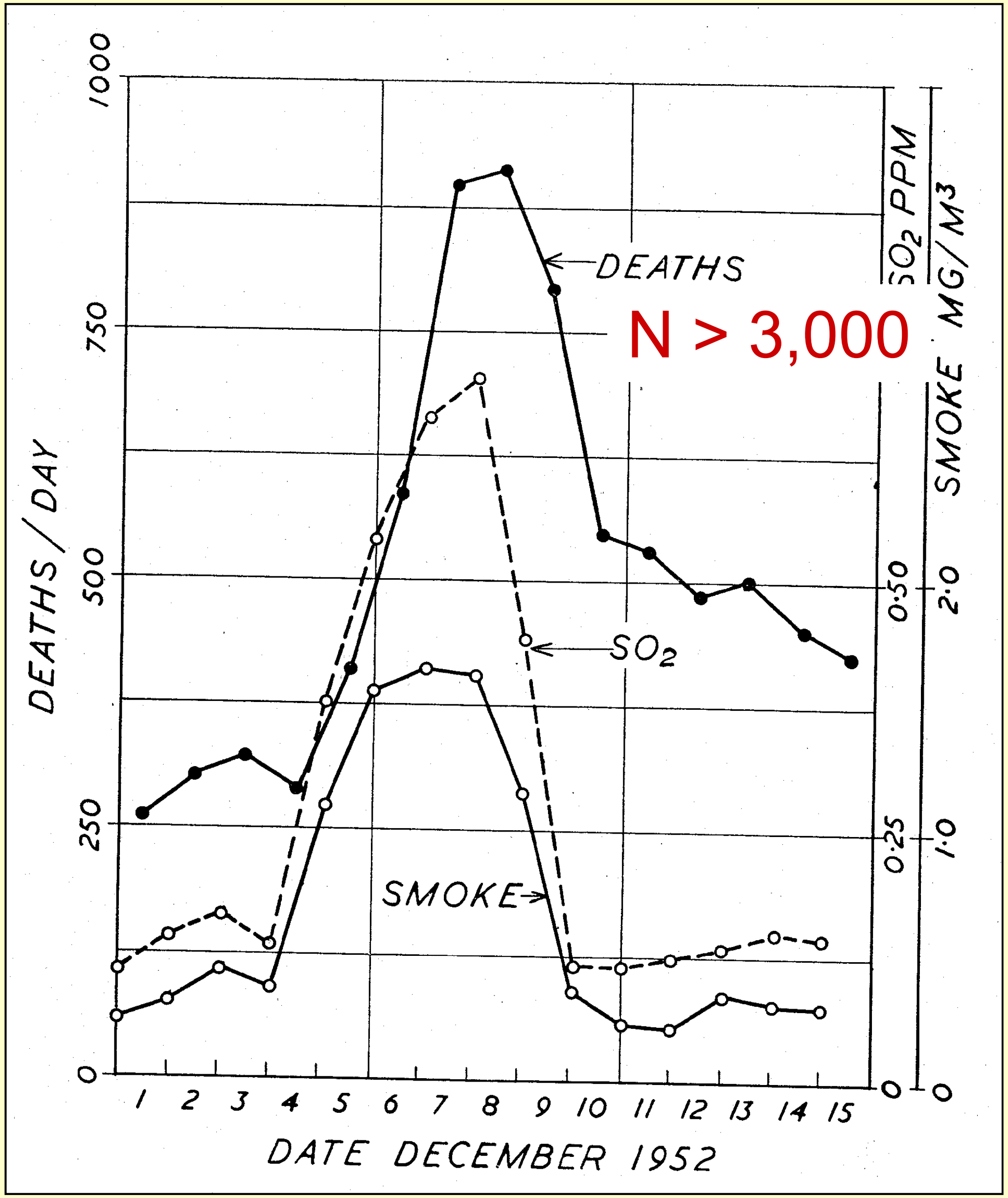
"Si les mêmes conditions se trouvent réunies, les mêmes accidents se reproduiront"

Onder dezelfde voorwaarden zijn dezelfde gevolgen te verwachten

"Si un désastre survenait à Londres dans des conditions analogues on aurait à déplorer 3.179 morts immédiates"

Een soortgelijke catastrofe zou in Londen leiden tot 3.179 onmiddellijke doden

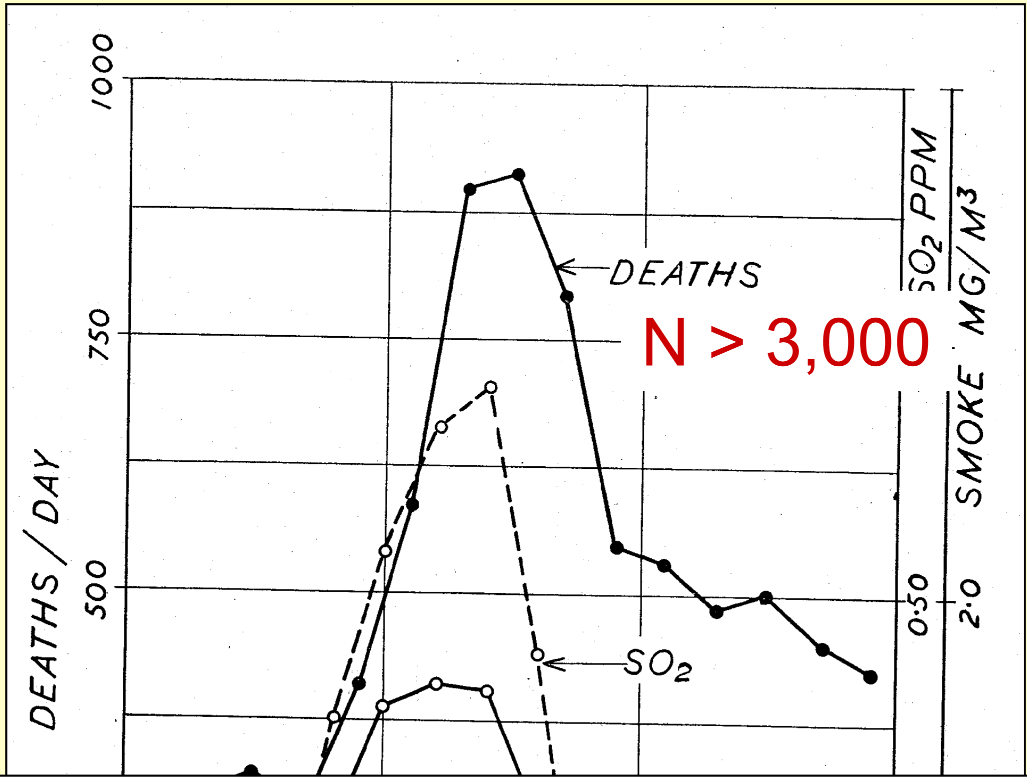
London fog
5-9 December 1952



Wilkins E.T. *Journal of the Royal Sanitary Institute*, 1954, 74, 1-21

London fog

5-9 December 1952



Dec 1952 – Feb 1953: ~12,000 excess deaths

Bell ML, Davis DL. Reassessment of the Lethal London Fog of 1952: Novel Indicators of Acute and Chronic Consequences of Acute Exposure to Air Pollution. *Environ Health Perspect* 2001;109 Suppl 3:389-94.

not due to influenza

Bell ML *et al*. *Environ Health Perspect* 2004;112:6-8

Smog in China treft gebied dat veertig keer zo groot is als België

DE STANDAARD woensdag 30 januari 2013

Short term effects of air pollution

- Time-series studies:

  Statistical relation between

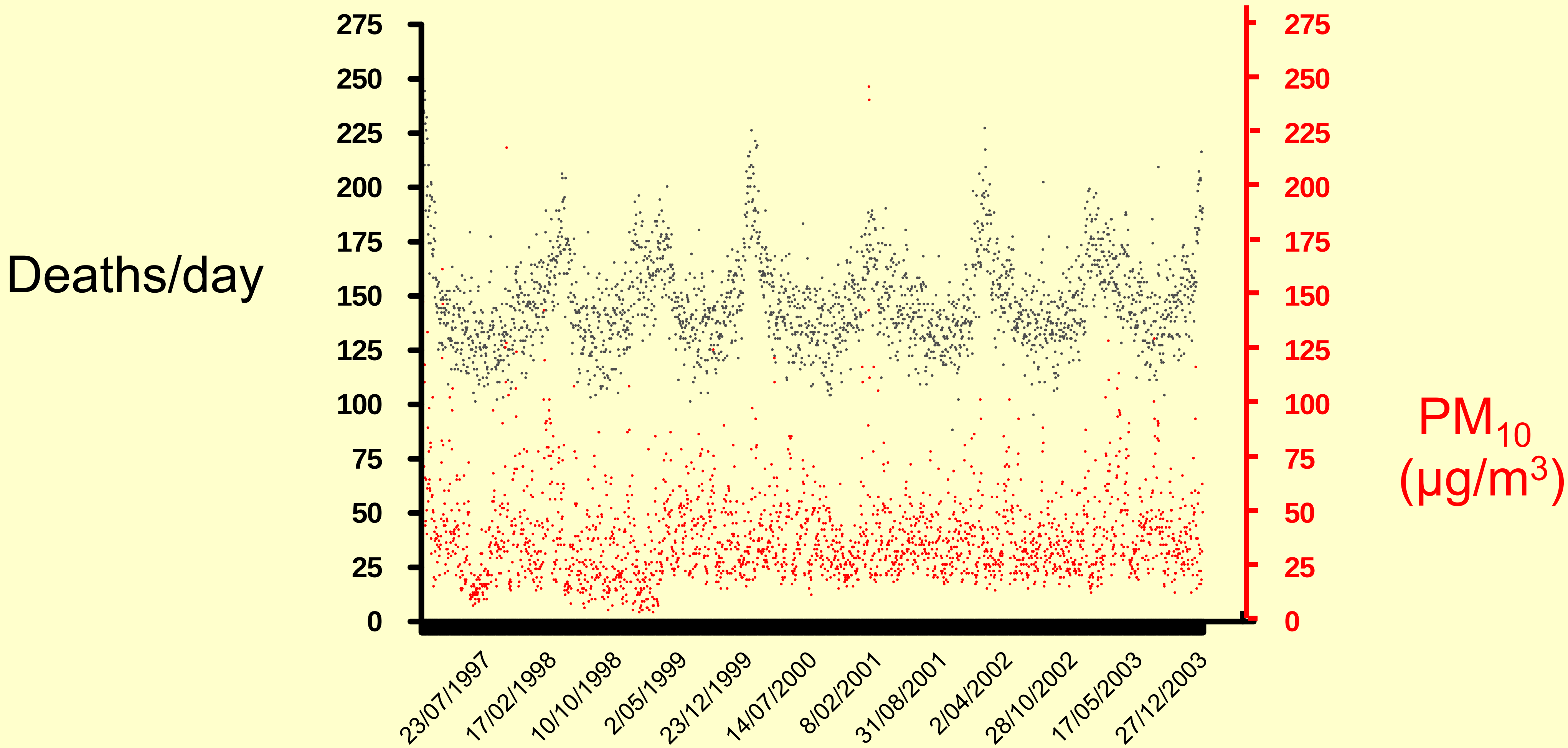
  - daily mortality

    and

  - air pollution (PM_{10})

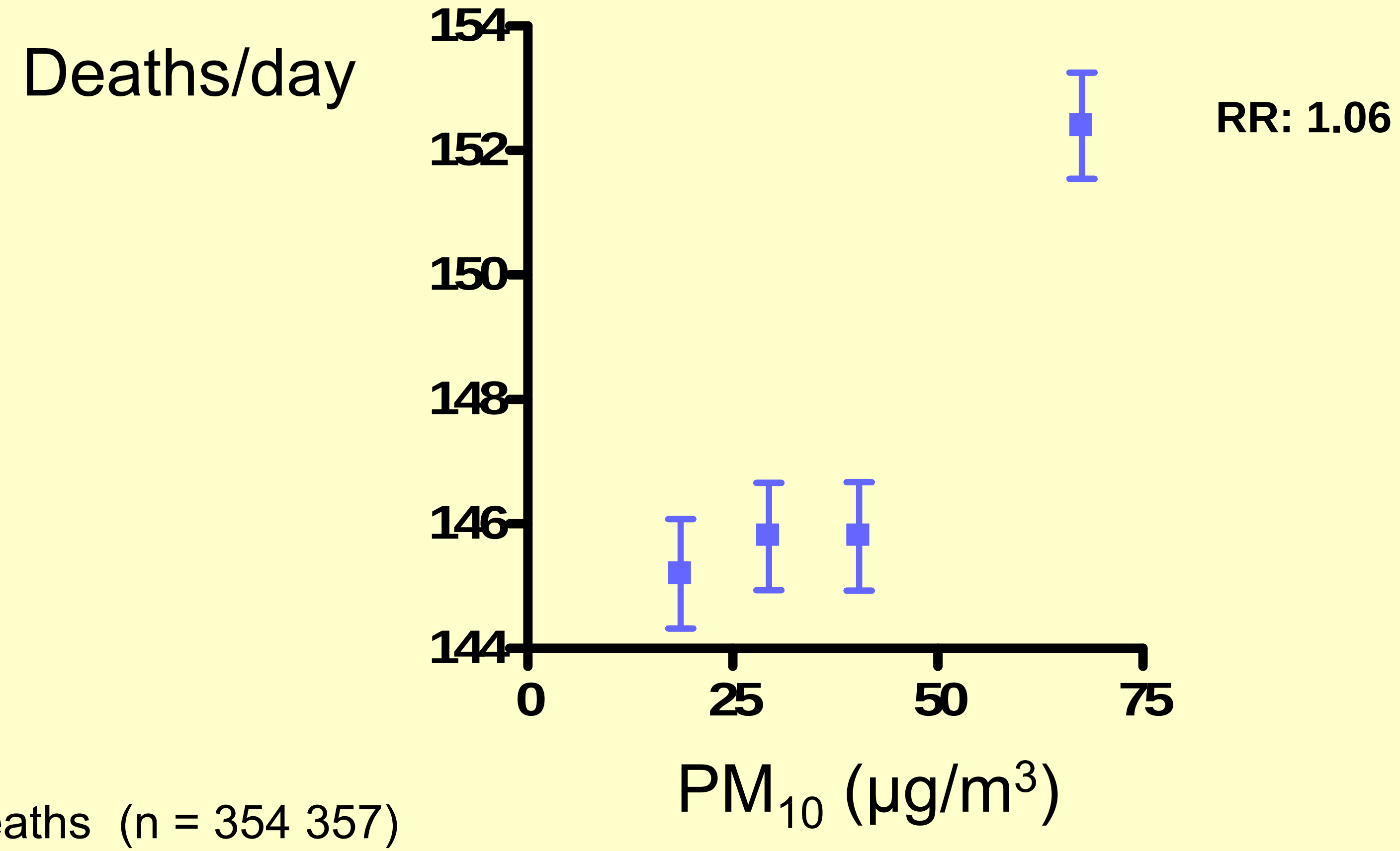
  + taking into account weather variables, etc.

Variation in daily mortality and PM_{10} Flanders, 1997-2003



non-traumatic deaths (n = 354 357)

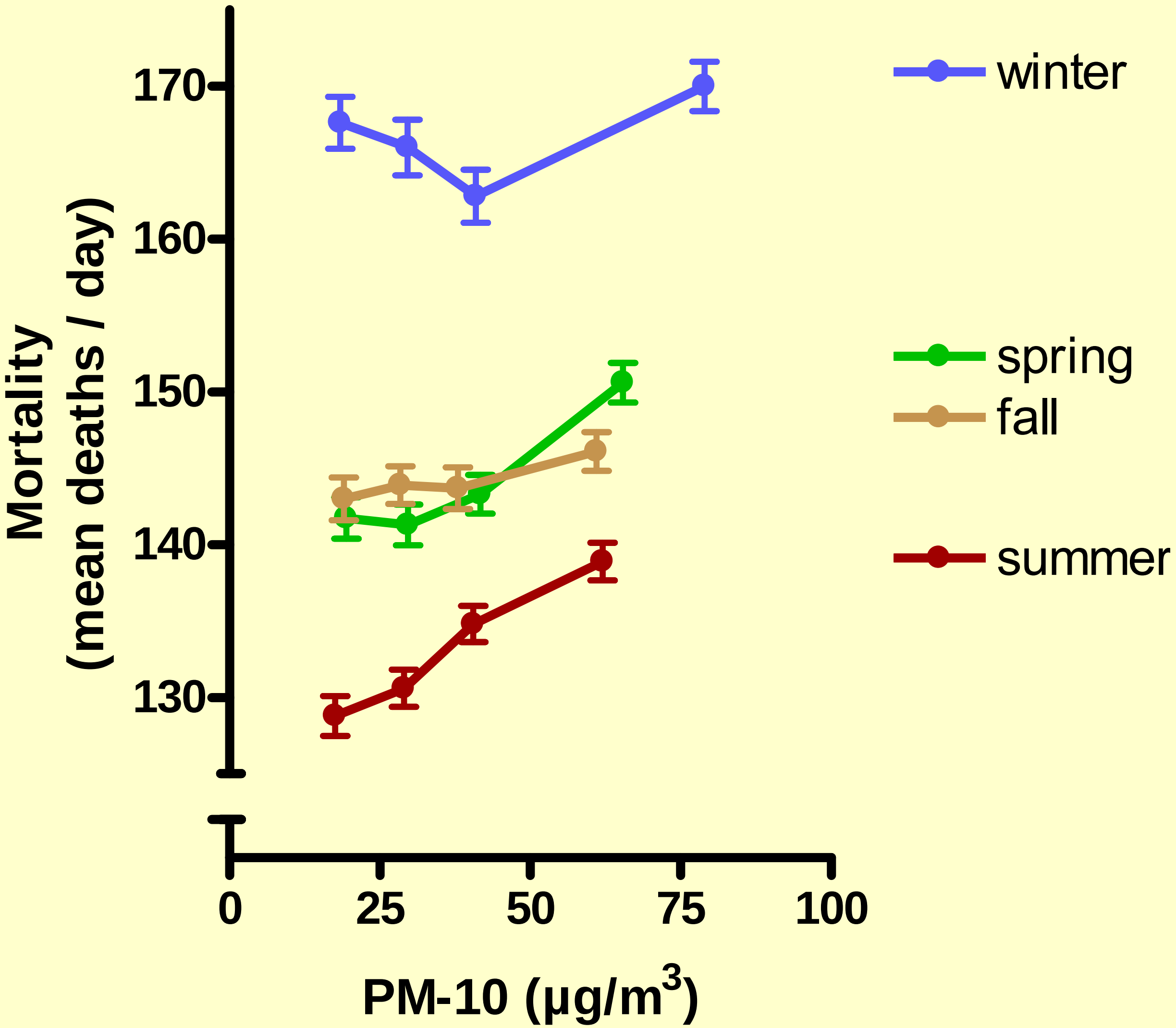
Daily mortality *vs* quartiles of PM_{10}
Flanders, 1997-2003



non-traumatic deaths (n = 354 357)

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

Mean daily mortality by season specific quartiles of PM_{10}

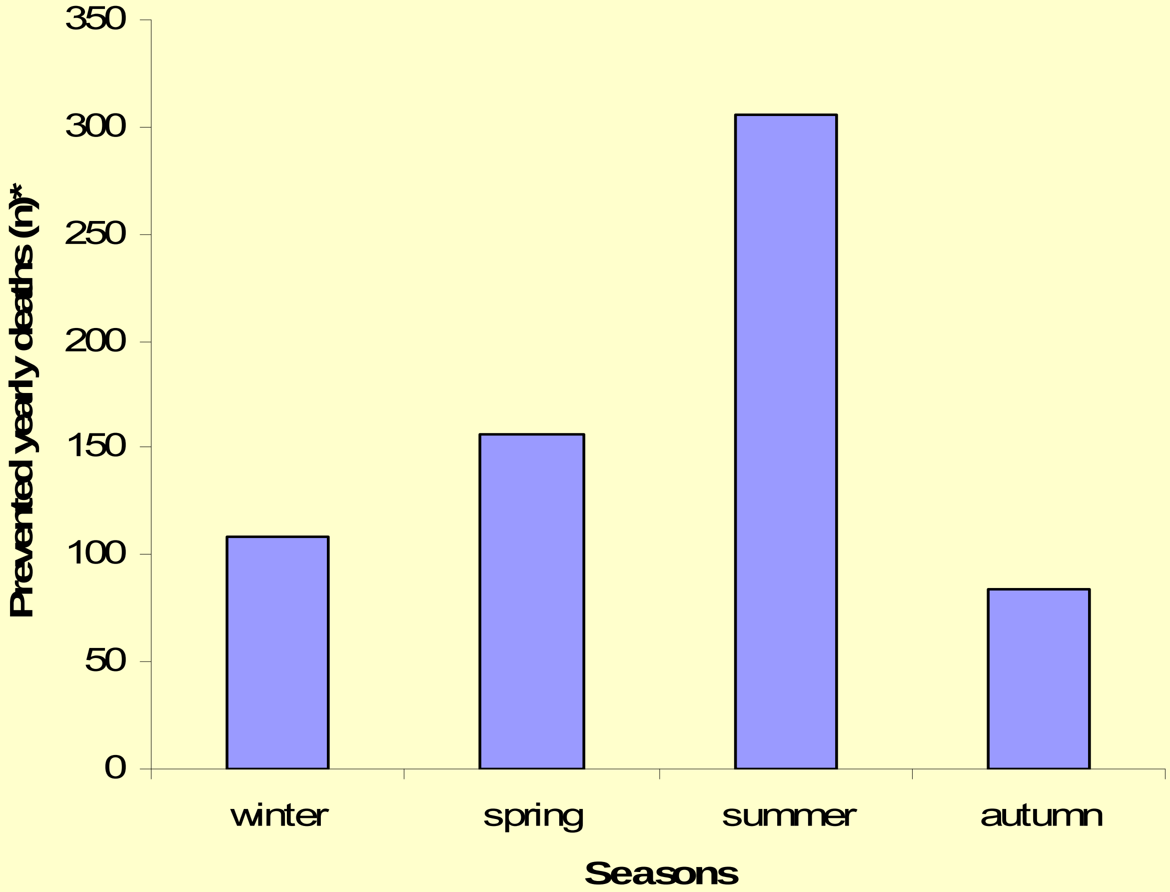


Non-traumatic deaths (n = 354 357)

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

Avoidable deaths per year

If mean daily PM_{10}-levels had not exceeded 20 µg/m^3

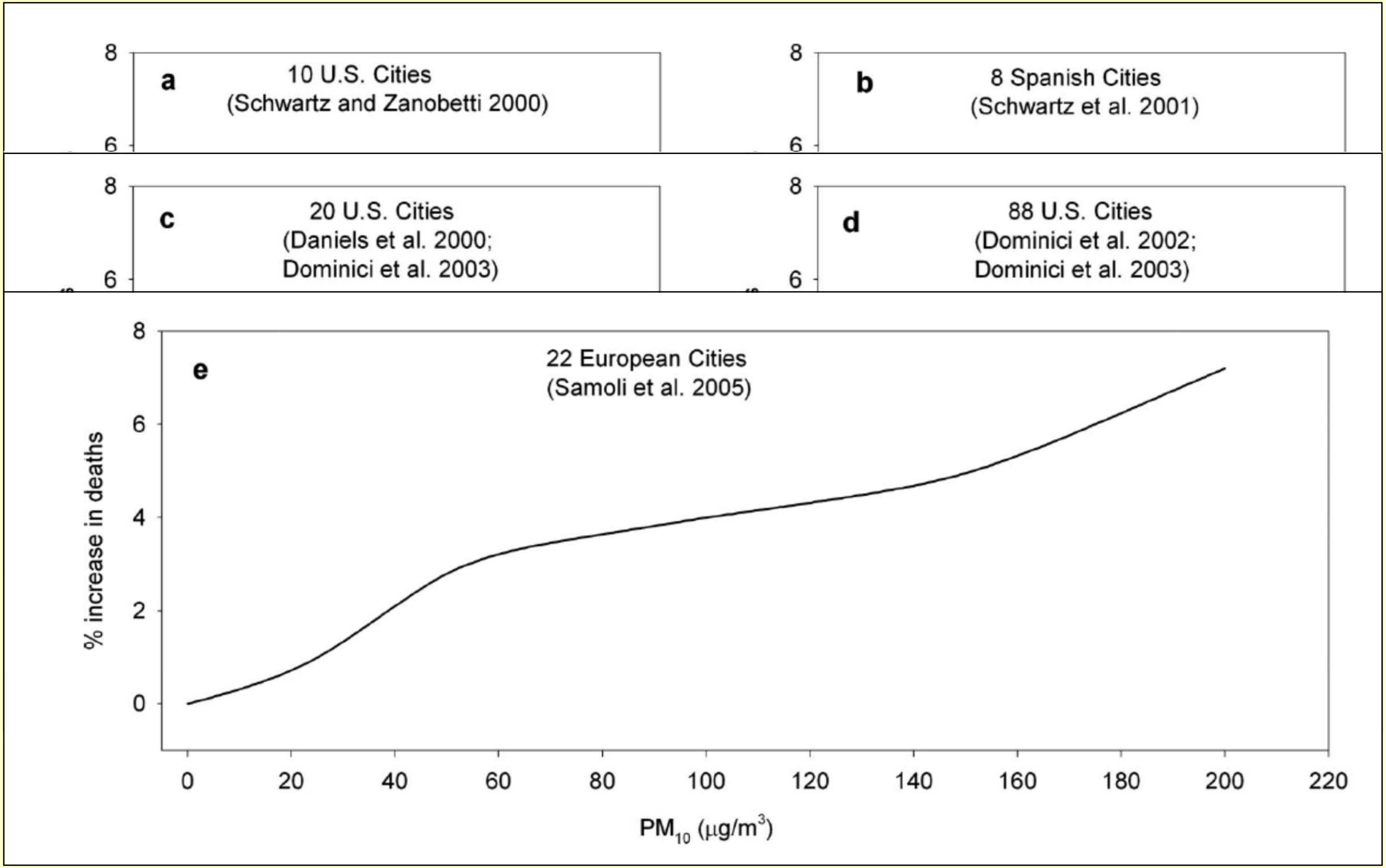


630 deaths/year

(total deaths: 50,000/year)

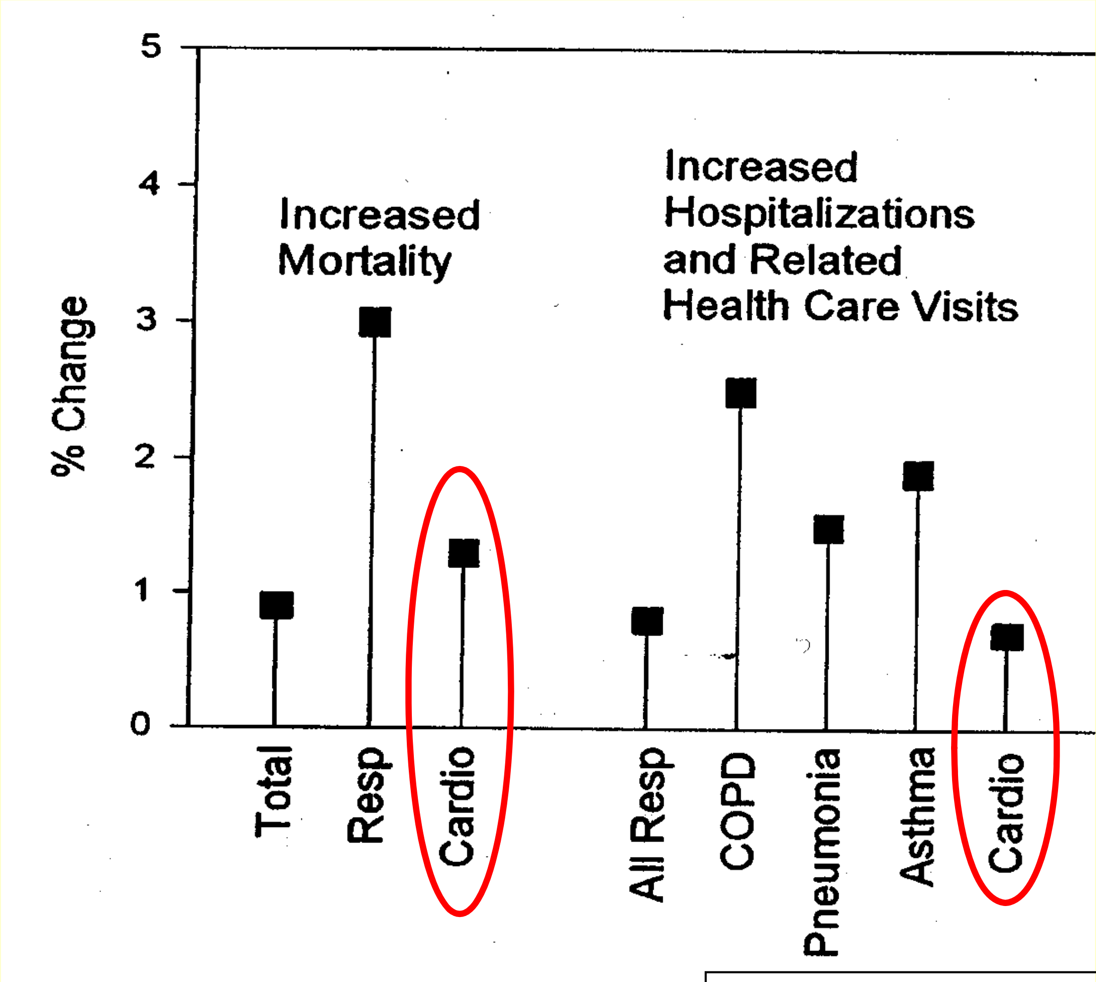
Nawrot *et al*. J Epidemiol Comm Health 2007, 61, 146-9

Pope & Dockery. *J Air Waste Manage Assoc* 2006, 56, 709-742



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

Cardiovascular morbidity

Peters *et al*. "Exposure to traffic and the onset of myocardial infarction" *N Engl J Med*, 2004, 351, 1721-30

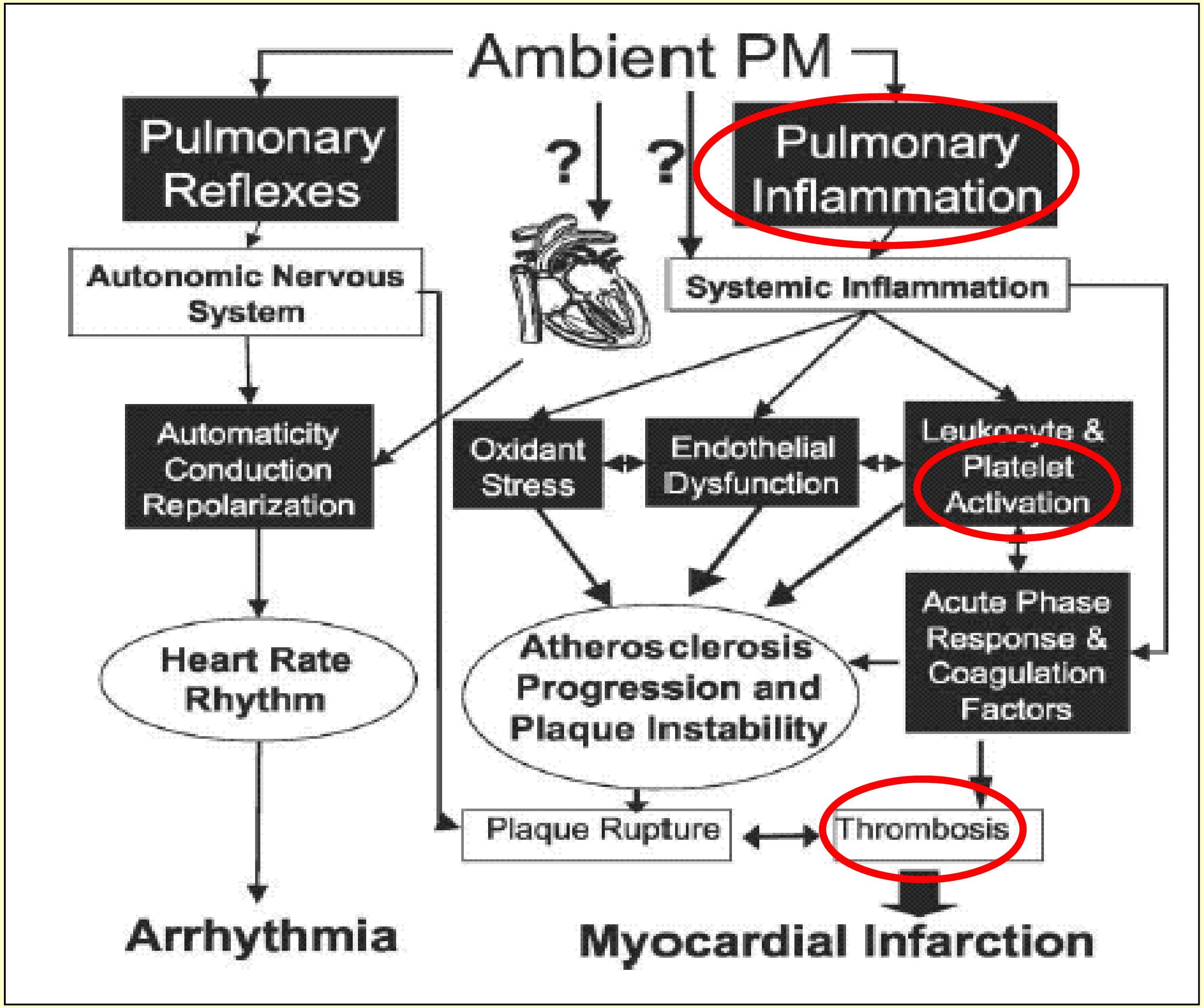
Case-crossover study, 691 nonfatal MI (Augsburg; 1999-2001)

activity before onset of MI (standardized interview-based diary)?

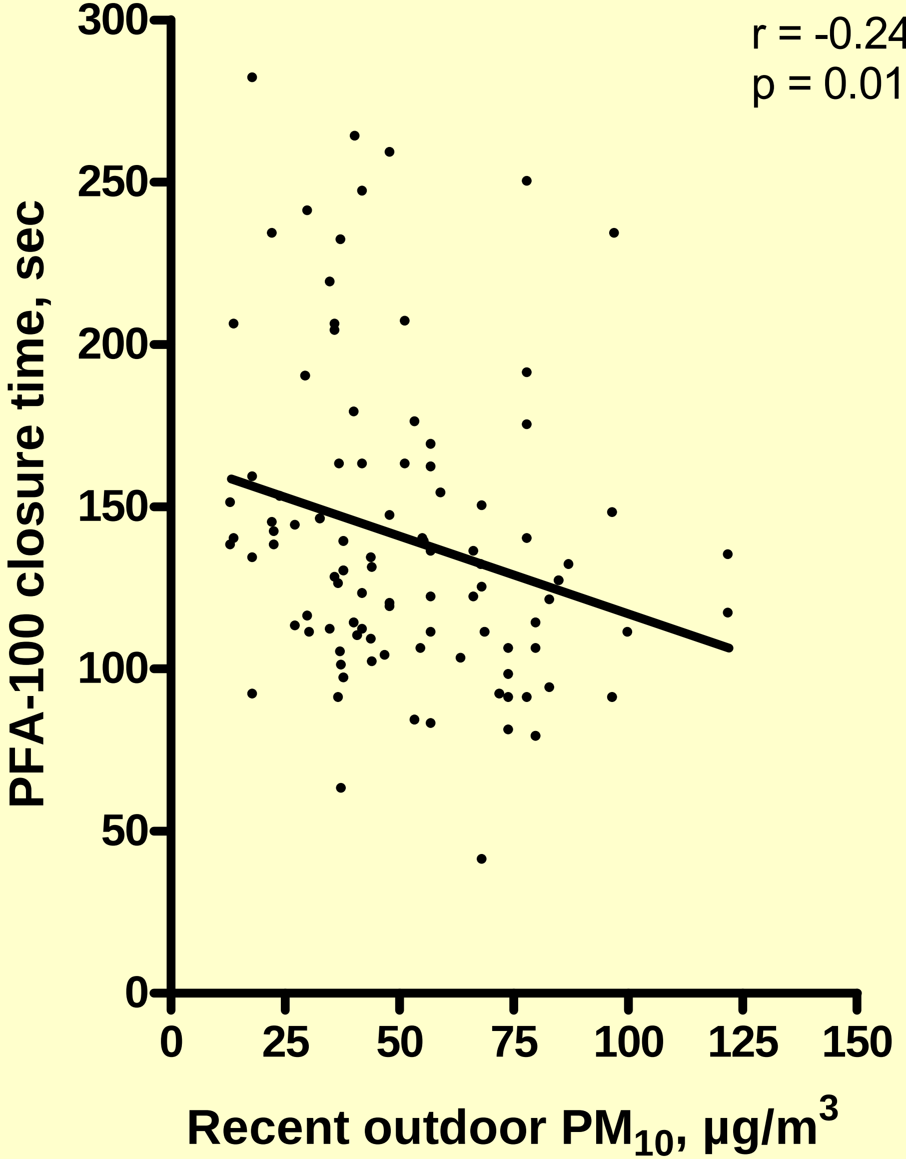
1h before MI *vs* control (24-71 h before MI)

- any means of transportation → O.R.=2.92
  - car → O.R.=2.60
  - bicycle → O.R.=3.94
  - public transport → O.R.=3.04
- severe exertion → O.R.=6.38

Brook RD *et al*. Air pollution and cardiovascular disease. A statement for health-care professionals from the expert panel on population and prevention science of the American Heart Association. *Circulation* 2004 (June 1); 109: 2655-71



Platelet activation



Jacobs *et al.*
EHP 2010,118, 191-6

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

Summary

Background Acute myocardial infarction is triggered by various factors, such as physical exertion, stressful events, heavy meals, or increases in air pollution. However, the importance and relevance of each trigger are uncertain. We compared triggers of myocardial infarction at an individual and population level.

Methods We searched PubMed and the Web of Science citation databases to identify studies of triggers of non-fatal myocardial infarction to calculate population attributable fractions (PAF). When feasible, we did a meta-regression analysis for studies of the same trigger.

Findings Of the epidemiologic studies reviewed, 36 provided sufficient details to be considered. In the studied populations, the exposure prevalence for triggers in the relevant control time window ranged from 0·04% for cocaine use to 100% for air pollution. The reported odds ratios (OR) ranged from 1·05 to 23·7. Ranking triggers from the highest to the lowest OR resulted in the following order: use of cocaine, heavy meal, smoking of marijuana, negative emotions, physical exertion, positive emotions, anger, sexual activity, traffic exposure, respiratory infections, coffee consumption, air pollution (based on a difference of 30 μg/m³ in particulate matter with a diameter <10 μm [PM_{10}]). Taking into account the OR and the prevalences of exposure, the highest PAF was estimated for traffic exposure (7·4%), followed by physical exertion (6·2%), alcohol (5·0%), coffee (5·0%), a difference of 30 μg/m³ in PM_{10} (4·8%), negative emotions (3·9%), anger (3·1%), heavy meal (2·7%), positive emotions (2·4%), sexual activity (2·2%), cocaine use (0·9%), marijuana smoking (0·8%) and respiratory infections (0·6%).

Interpretation In view of both the magnitude of the risk and the prevalence in the population, air pollution is an important trigger of myocardial infarction, it is of similar magnitude (PAF 5–7%) as other well accepted triggers such as physical exertion, alcohol, and coffee. Our work shows that ever-present small risks might have considerable public health relevance.

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

	Prevalence of exposure*	OR† (95% CI)	PAF (95% CI)
Air pollution, 10 μg/m³ reduction (n=11)†	100%	1·02 (1·01–1·02)	1·57% (0·89 to 2·15)
Air pollution, 30 μg/m³ reduction (n=11)†	100%	1·05 (1·03–1·07)	4·76% (2·63 to 6·28)
Alcohol	3·2%	3·1 (1·4–6·9)	5·03% (2·91 to 7·06)
Anger (n=4)†	1·5%	3·11 (1·8–5·4)	3·07% (1·19 to 6·16)
Cocaine use	0·04%	23·7 (8·1–66·3)	0·90% (0·28 to 2·55)
Coffee	10·6%	1·5 (1·2–1·9)	5·03% (2·08 to 8·71)
Emotions positive	1·0%	3·5 (0·7–16·8)	2·44% (–0·30 to 13·64)
Emotions negative (n=3)†	1·2%	4·46 (1·85–10·77)	3·92% (0·99 to 10·34)
Heavy meal	0·5%	7·00 (0·8–66)	2·69% (–0·09 to 23·00)
Marijuana	0·2%	4·8 (2·9–9·5)	0·75% (0·38 to 1·67)
Physical exertion (n=6)†	2·4%	4·25 (3·17–5·68)	6·16% (4·20 to 8·64)
Respiratory infection (n=4)†	0·4%	2·73 (1·51—4 95)	0·57% (0·17 to 1·29)
Sexual activity (n=2)†	1·1%	3·11 (1·79–5·43)	2·21% (0·84 to 4·53)
Traffic exposure	4·1%	2·92 (2·22–3·83)	7·36% (4·81 to 10·49)

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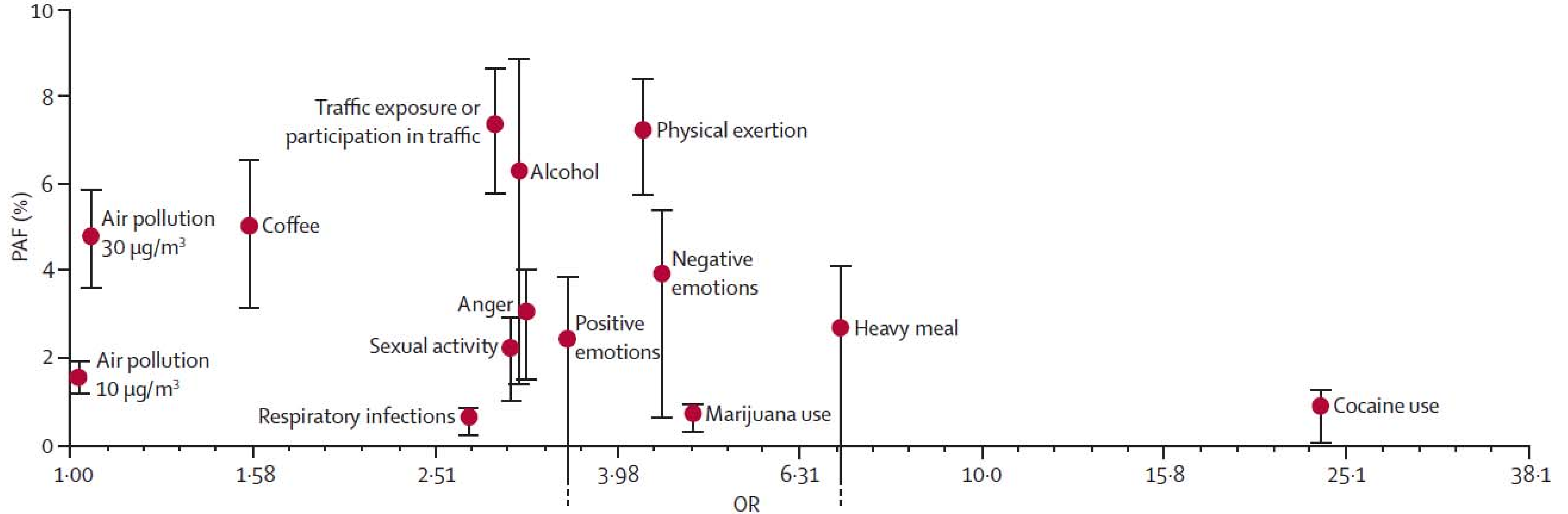
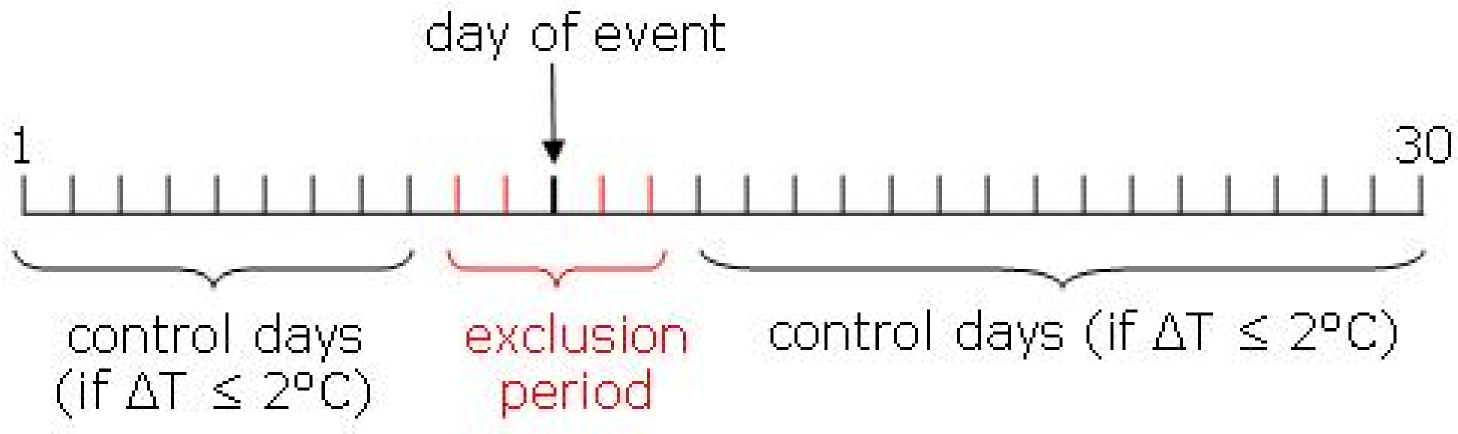


Figure 2: **Relation between OR and the PAF for each studies trigger**
PAFs were calculated and reported with their 95% CI (error bars). Not significant triggers show 95% CIs that are lower than 0%. X-axis is log scale, and ORs are given as anti-logs. OR=odds ratio. PAF=population attributable fraction.

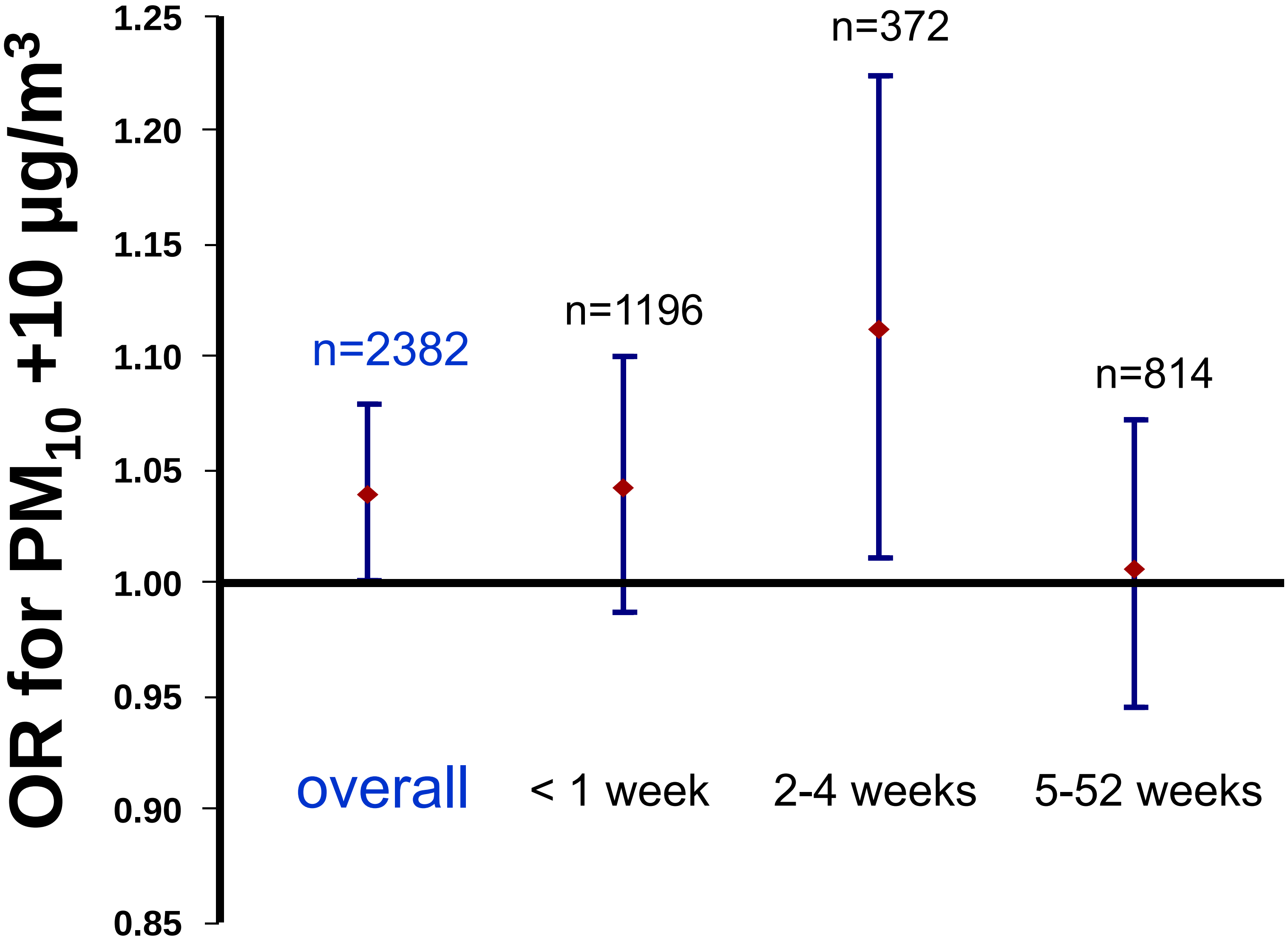
EHP 2011, 119,1017-1022

Does Air Pollution Trigger Infant Mortality in Western Europe? A Case-Crossover Study

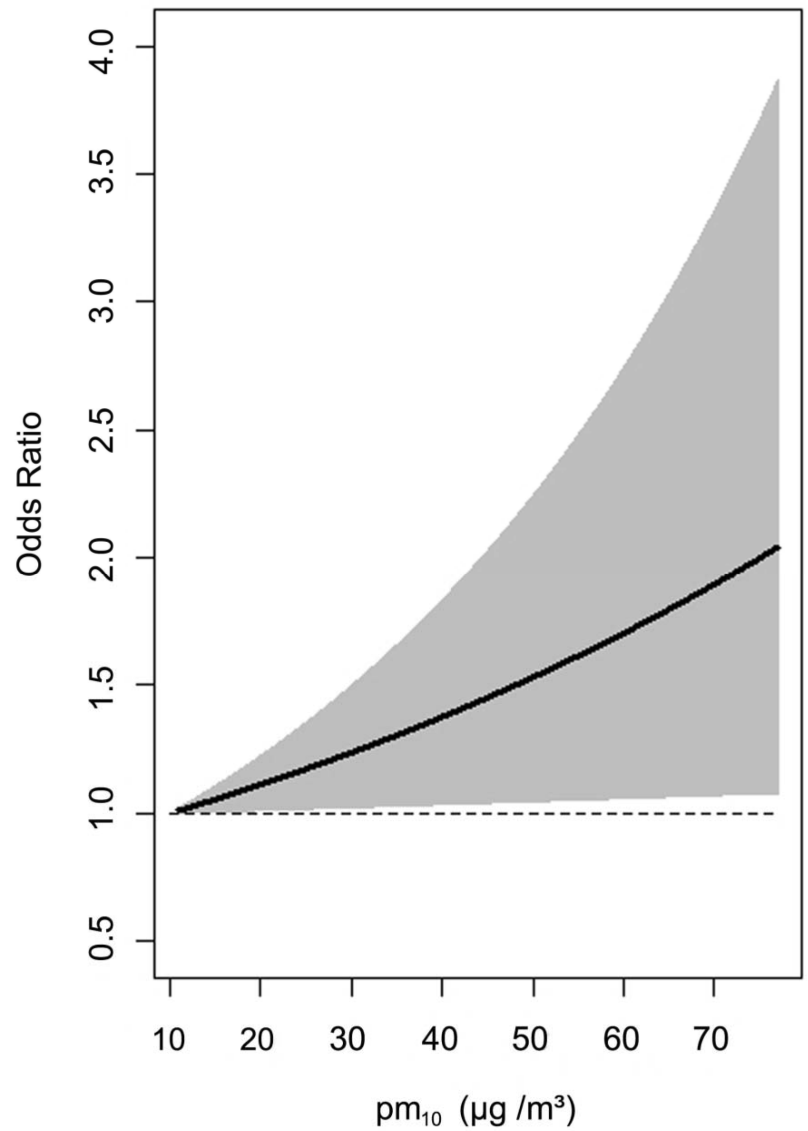
Hans Scheers,[1] Samuel M. Mwalili,[2] Christel Faes,[3] Frans Fierens,[4] Benoit Nemery,[1] and Tim S. Nawrot[1,5]*



PM exposure and infant mortality
(Flanders, 1998-2007) (Scheers *et al.* 2011)



PM exposure and mortality in late neonates (Flanders, 1998-2007) (Scheers *et al.* 2011)



CHEST

Original Research

GENETIC AND DEVELOPMENTAL DISORDERS

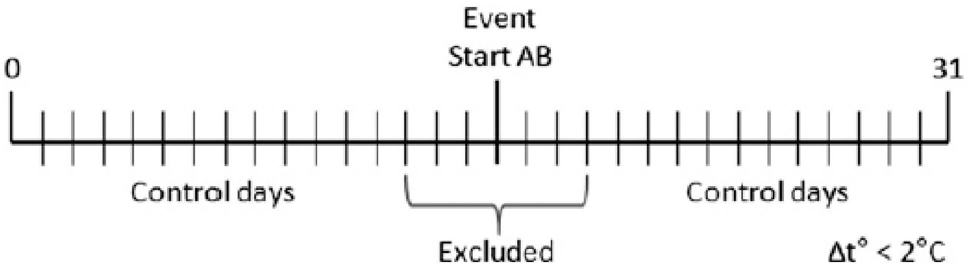
Impact of Air Pollution on Cystic Fibrosis Pulmonary Exacerbations

A Case-Crossover Analysis

CHEST 2013; 143(4):946–954

Pieter C. Goeminne, MD; Michał Kiciński, MSc; François Vermeulen, MD; Frans Fierens, MSc, Kris De Boeck, MD, PhD; Benoit Nemery, MD, PhD; Tim S. Nawrot, PhD; and Lieven J. Dupont, MD, PhD

- 1998-2010, UZ Leuven
- 215 patients with CF
- 2204 AB cures for exacerbations



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

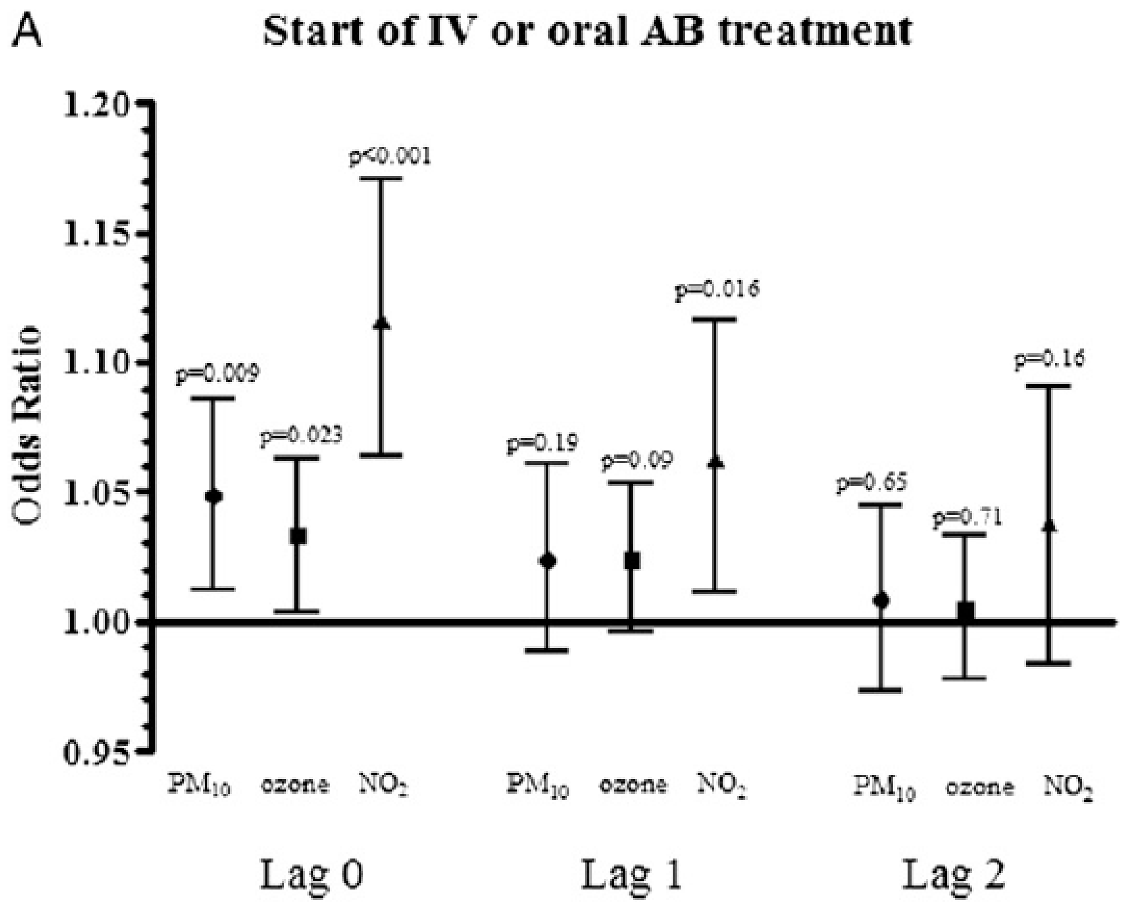


FIGURE 2. Assessment of oral and IV AB treatment per 10-µg/m³ increase of three pollutants.

Long term effects of pollutant particles (spatial variation)

8 MEI 2014

LONDEN EN PARIJS HEBBEN GEZONDERE LUCHT DAN ONZE STEDEN

Welkom in Vlaanderen, de vuilste regio van West-Europa

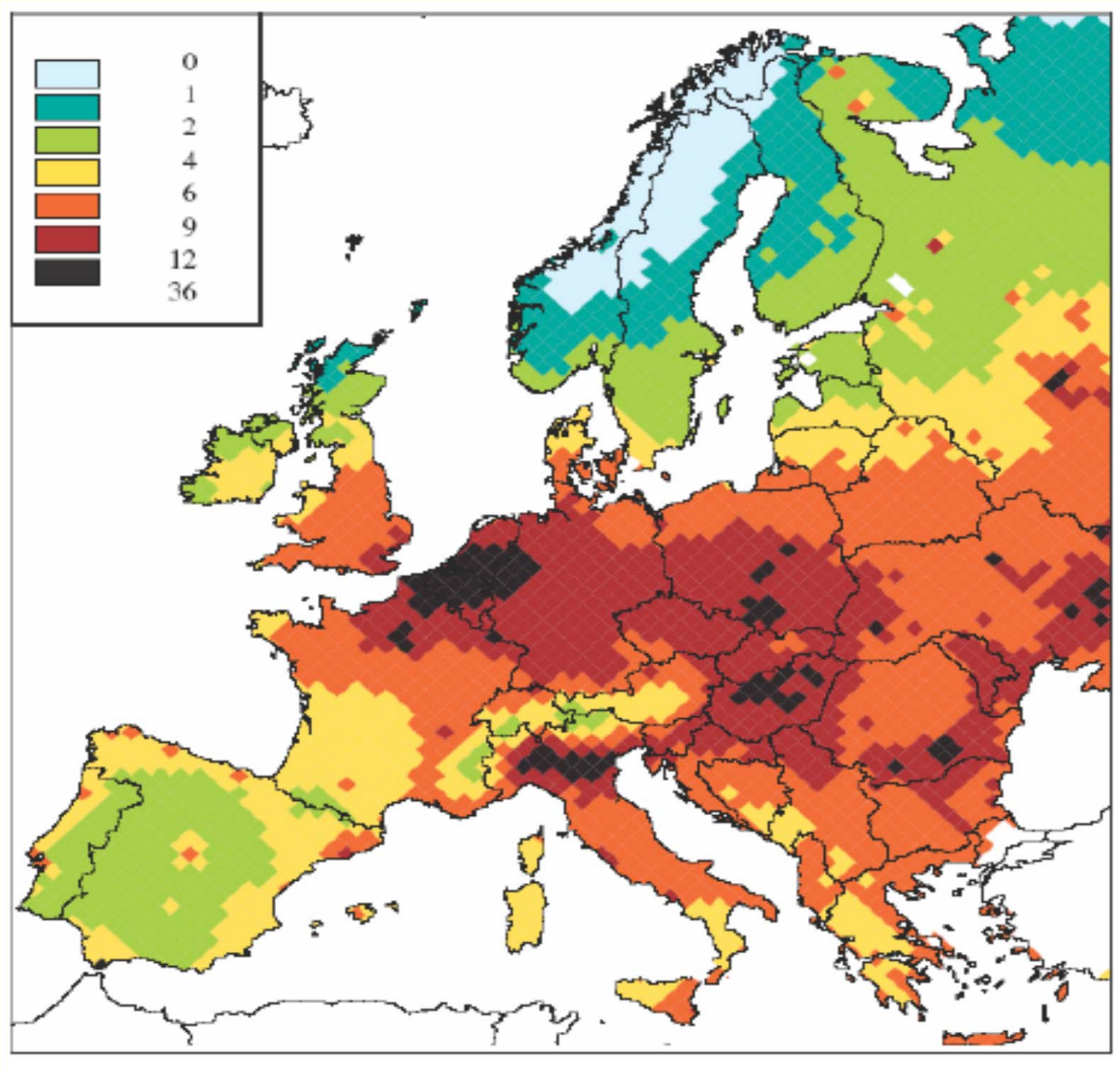
08/05/2014 | Van onze redactrice Maxie Eckert

Geen enkele Belgische stad haalt de doelstelling voor fijn stof die de wereldgezondheidsorganisatie oplegt. De lucht in Gent, Antwerpen en Brussel is zelfs een pak slechter dan de lucht in andere Europese metropolen.

Smog boven Brussel: 'Luchtvervuiling verlaagt de levensverwachting met een jaar.' Bart Dewaele

http://www.standaard.be/cnt/dmf20140507_01096576
http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/#

Estimated loss of life expectancy (months) attributable to $PM_{2.5}$ (2000)



http://europa.eu.int/comm/environment/air/cafe/activities/pdf/cafe_scenario_report_2.pdf

AHA Scientific Statement

Particulate Matter Air Pollution and Cardiovascular Disease

An Update to the Scientific Statement From the American Heart Association

Robert D. Brook, MD, Chair; Sanjay Rajagopalan, MD; C. Arden Pope III, PhD; Jeffrey R. Brook, PhD; Aruni Bhatnagar, PhD, FAHA; Ana V. Diez-Roux, MD, PhD, MPH; Fernando Holguin, MD; Yuling Hong, MD, PhD, FAHA; Russell V. Luepker, MD, MS, FAHA; Murray A. Mittleman, MD, DrPH, FAHA; Annette Peters, PhD; David Siscovick, MD, MPH, FAHA; Sidney C. Smith, Jr, MD, FAHA; Laurie Whitsel, PhD; Joel D. Kaufman, MD, MPH; on behalf of the American Heart Association Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease, and Council on Nutrition, Physical Activity and Metabolism

pathological mechanisms have been elucidated that lend biological plausibility to these findings. It is the opinion of the writing group that the overall evidence is consistent with a causal relationship between $PM_{2.5}$ exposure and cardiovascular morbidity and mortality. This body of evidence has grown and been strengthened substantially since the first American Heart Association scientific statement was published. Finally, $PM_{2.5}$ exposure is deemed a modifiable factor that contributes to cardiovascular morbidity and mortality. (*Circulation*. **2010;121:2331-2378.**)

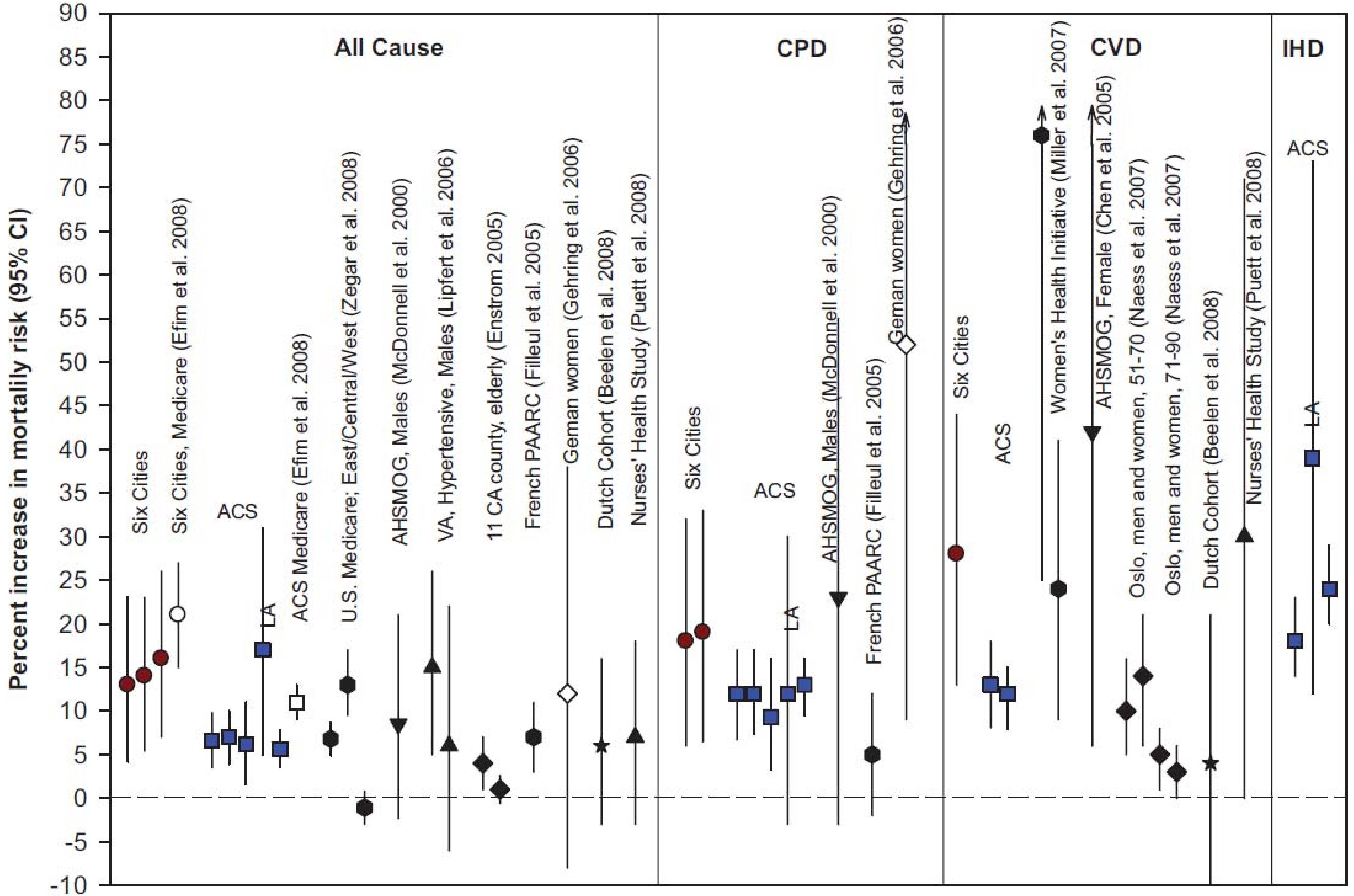


Figure 1. Risk estimates provided by several cohort studies per increment of 10 $\mu g/m^3$ in $PM_{2.5}$ or PM_{10}. CPD indicates cardiopulmonary disease; IHD, ischemic heart disease.

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

PM and mortality (long term)

Rosenbloom *et al.* Residential proximity to major roadway and 10-year all-cause mortality after myocardial infarction. *Circulation* 2012, 125, 2197-2203

- 3,886 subjects hospitalized for MI in 64 US centers, 1989-1996
- 10 year follow-up of 3,547 geocoded subjects: 1,071 deaths

	Distance to Major Roadway				
	≤100 m (n=243)	100–≤200 m (n=230)	200–≤1000 m (n=1311)	>1000 m (n=1763)	P_{trend}
All-cause mortality, n (%)	90 (37)	76 (33)	410 (31)	495 (28)	. . .
Mortality rate per 100 person-years	4.6	4.2	3.8	3.3	. . .
Age-adjusted model HR (95% CI)	1.31 (1.05–1.64)	1.21 (0.95–1.54)	1.16 (1.02–1.32)	1.00	0.0040
Fully adjusted model* HR (95% CI)	1.27 (1.01–1.60)	1.19 (0.93–1.60)	1.13 (0.99–1.30)	1.00	0.016

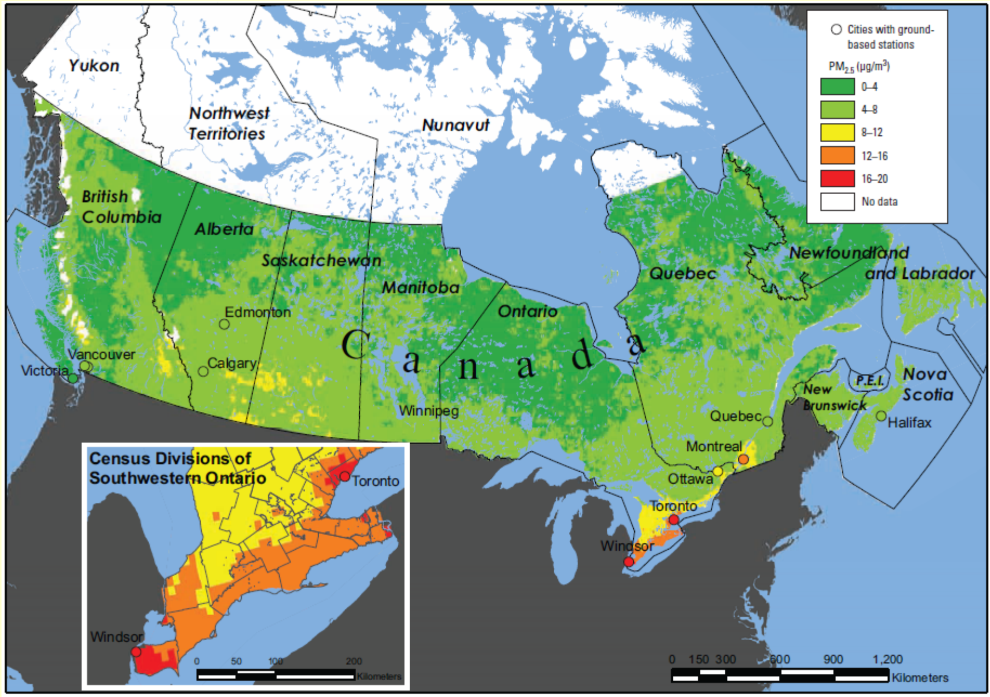
HR indicates hazard ratio; CI, confidence interval.

*Model adjusted for age, sex, marital status, race, individual education, distance to hospital, body mass index, smoking, previous myocardial infarction, previous congestive heart failure, previous angina, diabetes mellitus, hypertension, noncardiac comorbidity, previous cardiac medication use, frequency of physical activity, neighborhood household income, neighborhood education, and urbanicity.

PM and mortality (long term)

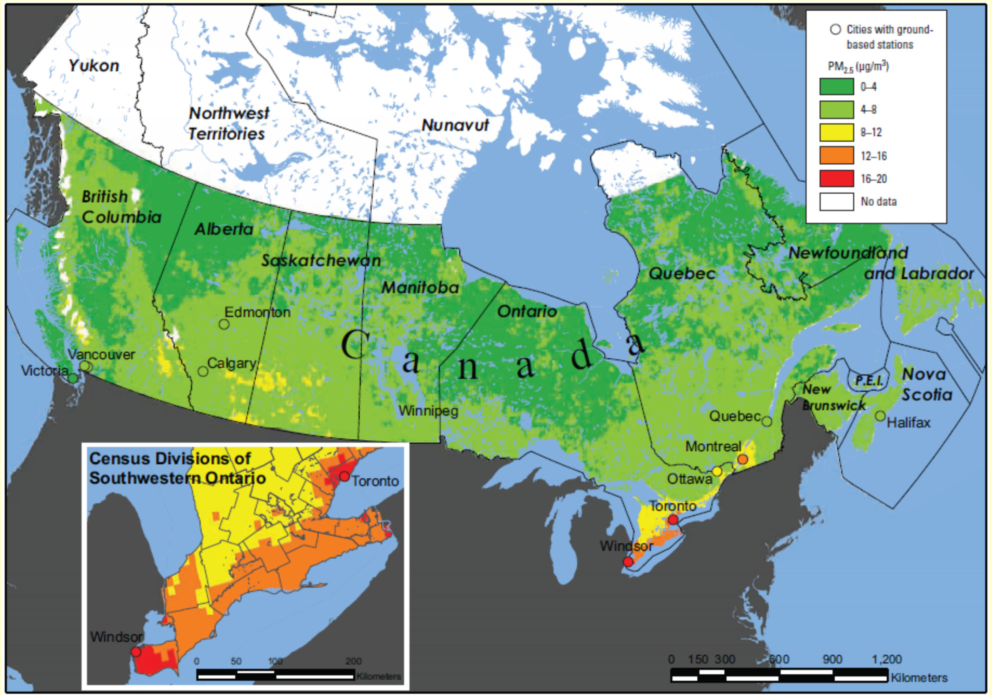
Crouse *et al.* Risk of nonaccidental and cardiovascular mortality in relation to long-term exposure to low concentrations of fine particulate matter: a Canadian national-level cohort study. *Environ Health Persp* 2012, 120, 708-14

- Canada, 2.1×10^6 adults, 1991-2001
- Satellite-derived estimates of $PM_{2.5}$
  mean 8.7 µg/m^3; IQR 6.2 µg/m^3
- HR for 10 µg/m^3 increase in $PM_{2.5}$:
  Cox model with ecological covariates & urban/rural indicator
  - non-accidental mortality: 1.15 [1.13-1.16]
  - ischemic heart disease: 1.31 [1.27-1.35]



PM and mortality (long term)

Crouse *et al.* *EHP* 2012, 120, 708-14



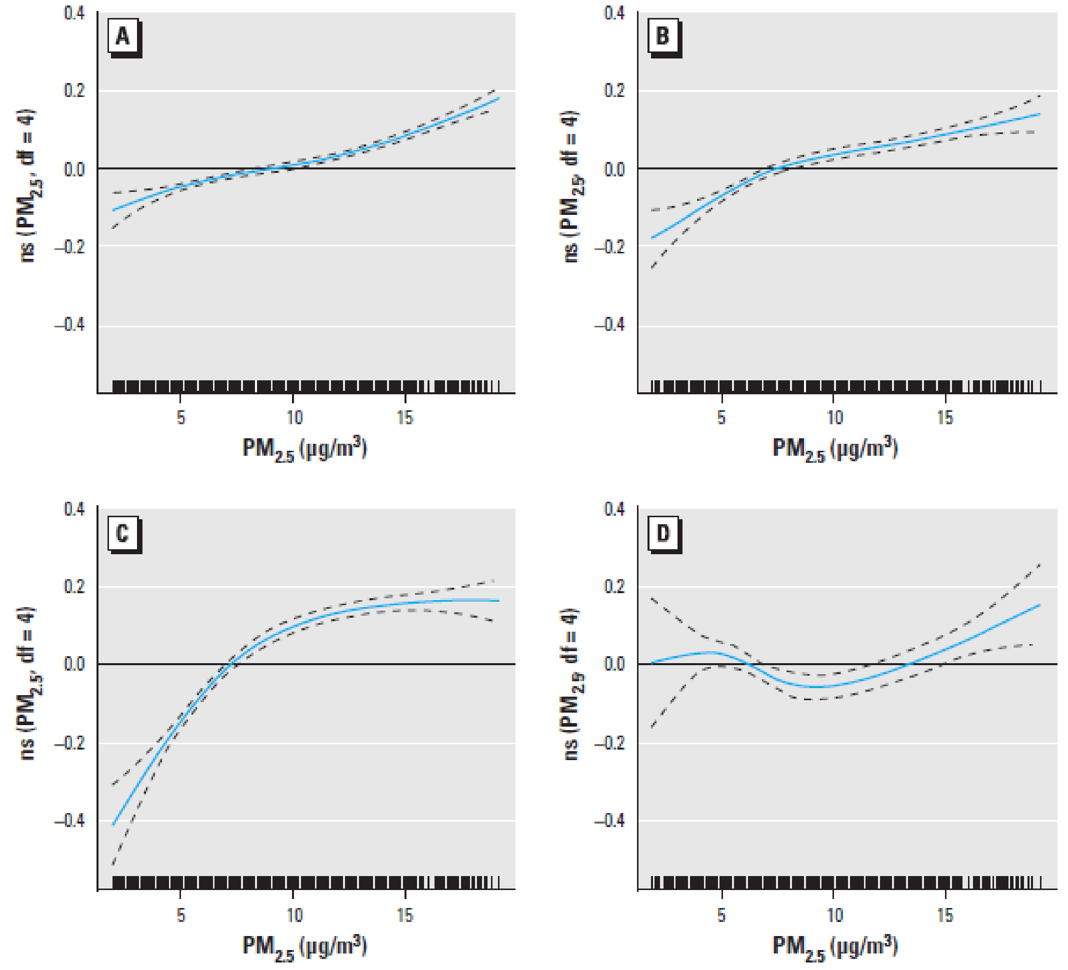
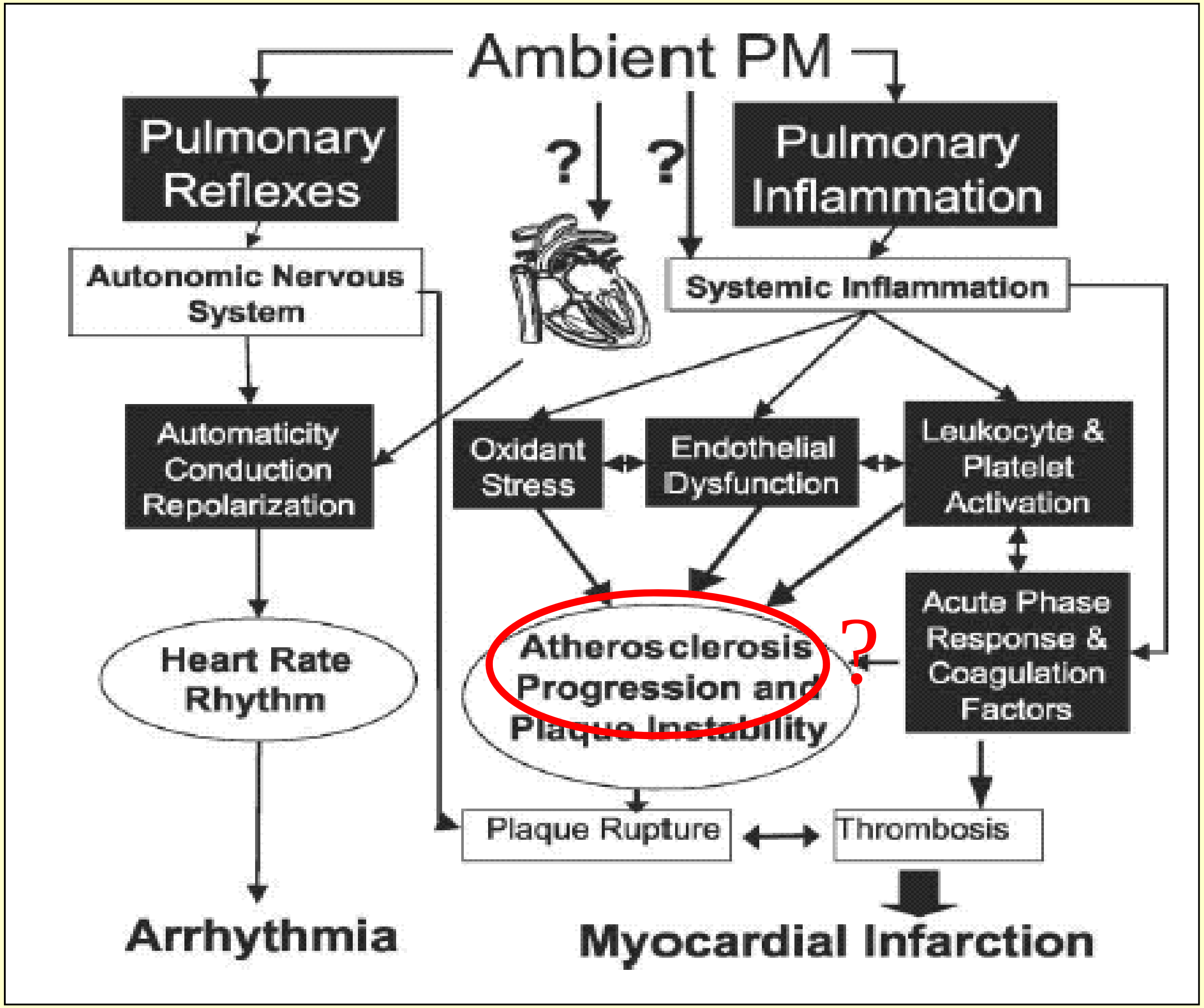


Figure 2. Concentration–response curves (solid lines) and 95% CIs (dashed lines) based on natural spline (ns) models with 4 df, standard Cox models stratified by age and sex, adjusted for all individual-level covariates, urban/rural indicator, and ecological covariates. (*A*) Nonaccidental causes. (*B*) Cardiovascular disease. (*C*) Ischemic heart disease. (*D*) Cerebrovascular disease. The tick marks on the *x*-axis identify the location of the $PM_{2.5}$ concentrations.

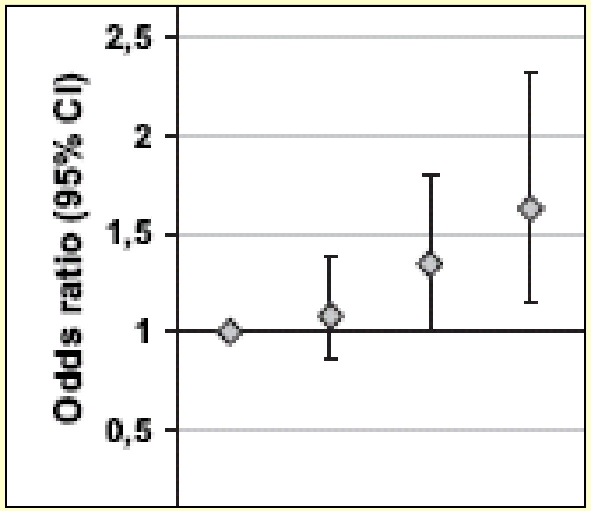
Brook RD *et al*. Air pollution and cardiovascular disease. A statement for health-care professionals from the expert panel on population and prevention science of the American Heart Association. Circulation 2004 (June 1); 109: 2655-71



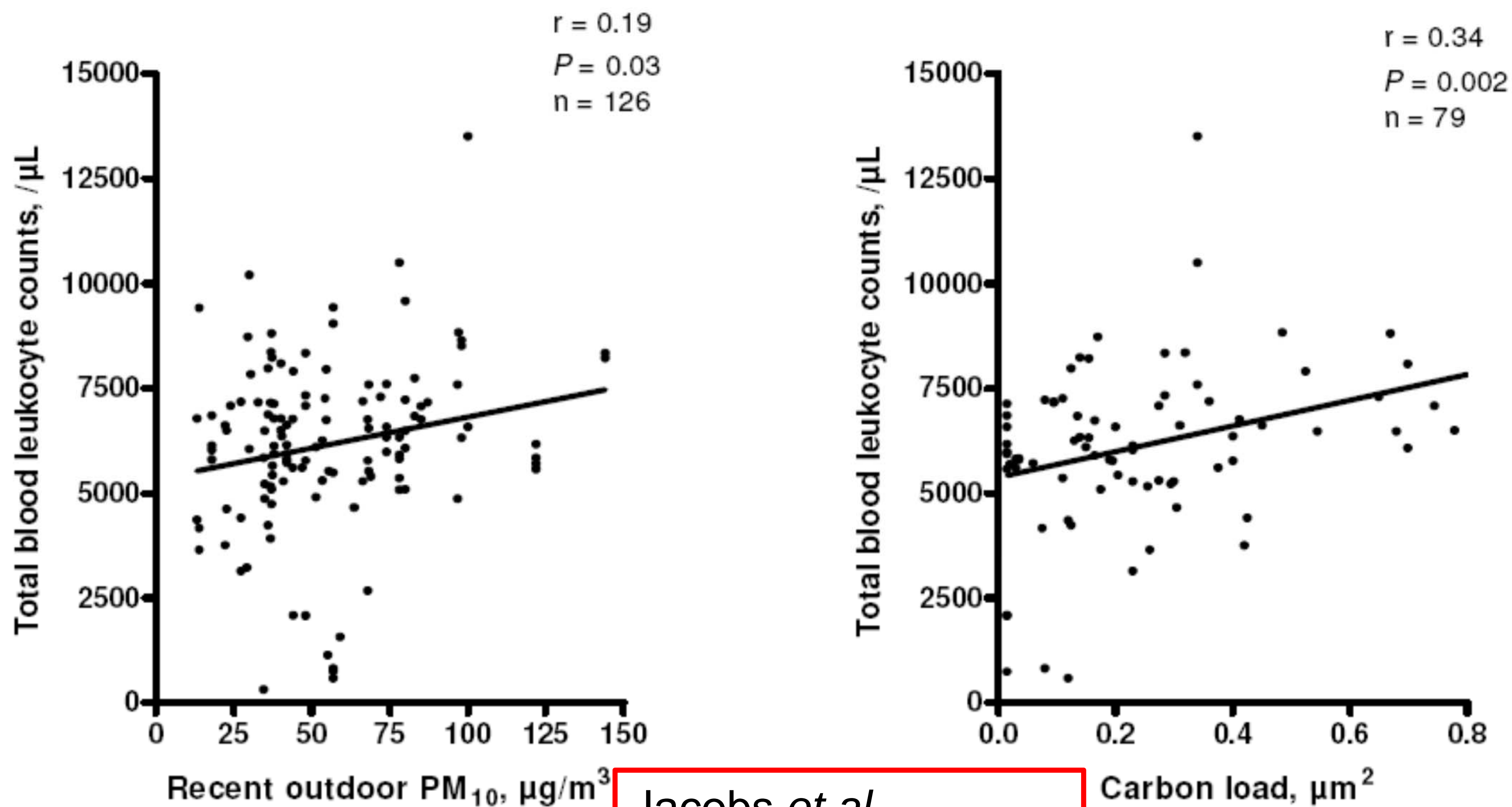
Pollution (long term) and CV morbidity

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

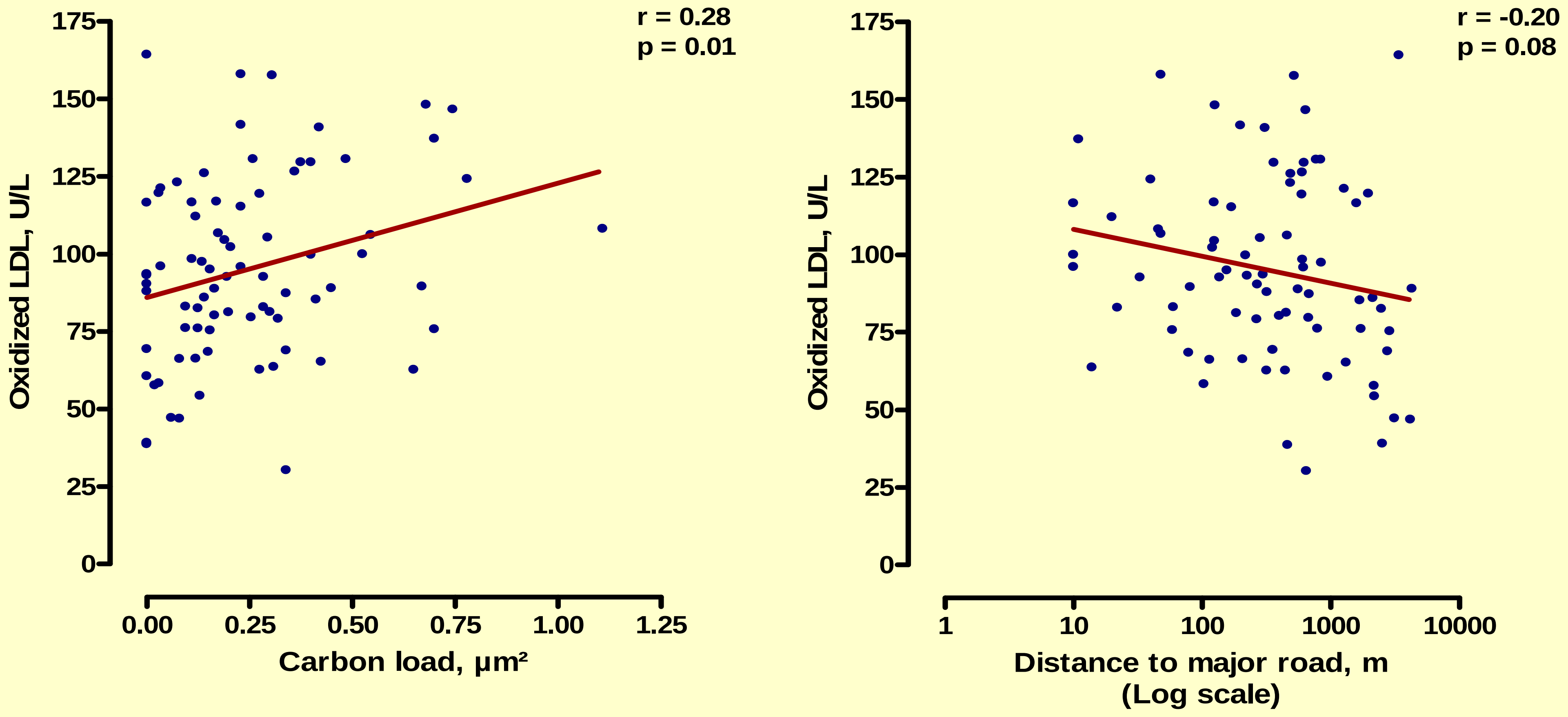


Blood leukocyte count



Jacobs *et al.*
EHP 2010,118, 191-6

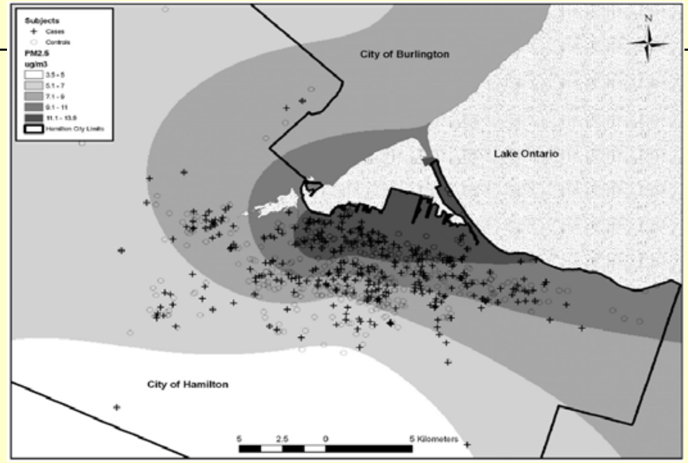
Oxidized LDL



Jacobs L et al, PLoS One 2011, e16200

Air pollution and pneumonia

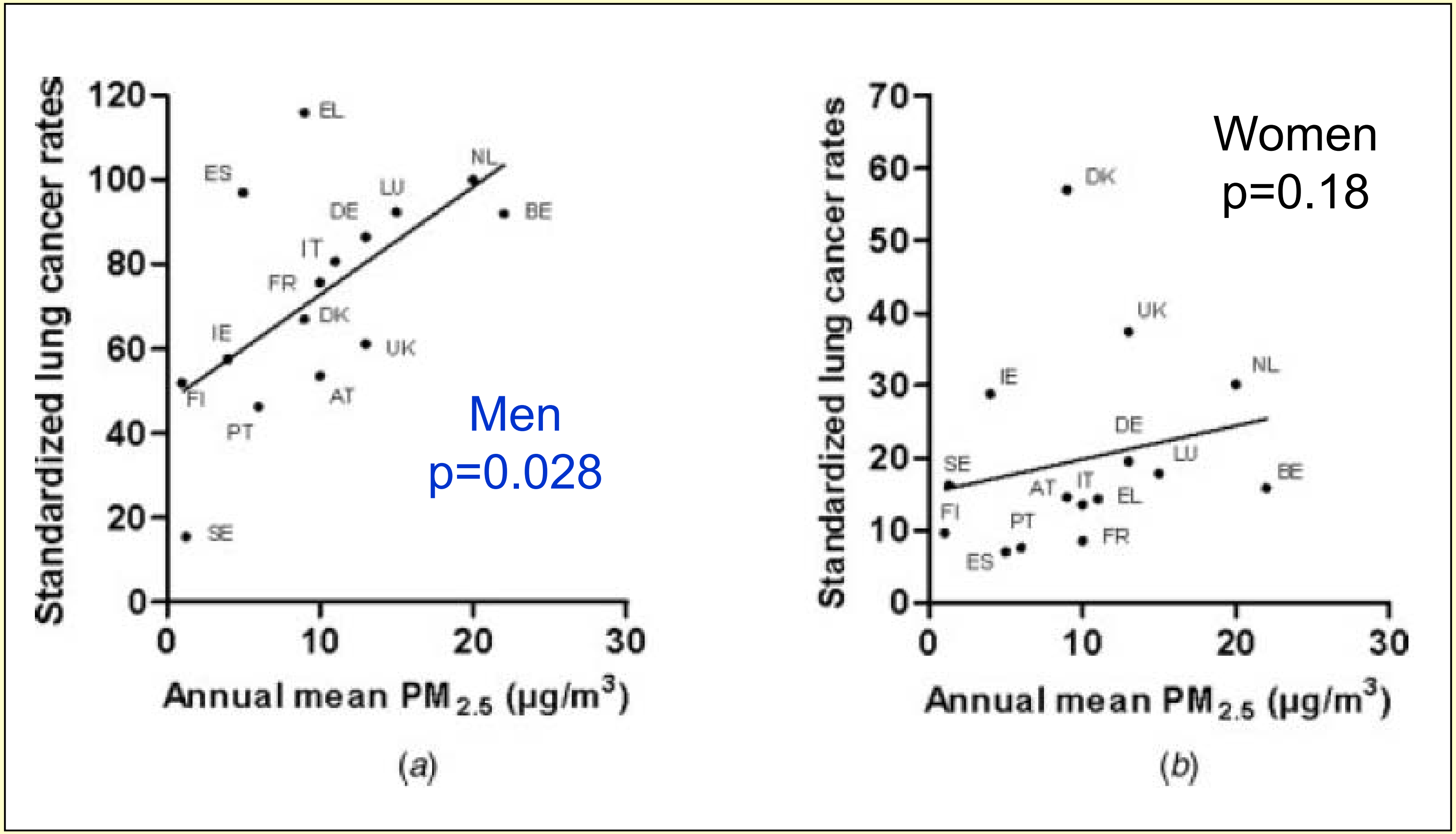
Neupane *et al.* Long-term exposure to ambient air pollution and risk of hospitalization with community-acquired pneumonia in older adults. *AJRCCM* 2010, 181, 47-53



- Hamilton, Ontario
- Case-control study, 2003 – 2005
  345 patients (> 65 y) hospitalized for CAP
  494 controls from community
- Estimated annual exposure to $PM_{2.5}$, NO_2, at residence
- adjusted OR for hospitalization for CAP [↑ from 5th to 95th percentile]:
  - $PM_{2.5}$ [9.3 → 12.4 µg/m^3]   2.26 (1.20-4.24)
  - NO_2 [16.1 → 23.3 µg/m^3]   2.30 (1.25-4.21)
  - SO_2 [4.6 → 7.2 µg/m^3]   0.97 (0.59-1.61)

Air pollution and lung cancer

Nawrot *et al.* Lung cancer mortality and fine particulate air pollution in Europe (Letter). *Int J Cancer* 2007, 120, 1825-6



Air pollution and lung cancer

Turner *et al.* Long-term ambient fine particulate matter air pollution and lung cancer in a large cohort of never-smokers. *AJRCCM* 2011, 184, 1374-81

- ACS, 1982-2008, 188,699 life-long never-smokers
- 1,100 lung cancer deaths
- Estimated exposure to $PM_{2.5}$ at residence (metropolitan stat. area)
- Adjustments for personal variables (incl. passive smoking) + ecologic variables (residential radon, SES)
- For $PM_{2.5}$ + 10 $\mu g/m^3 \rightarrow$ HR +15-27% lung cancer mortality

Air pollution and COPD

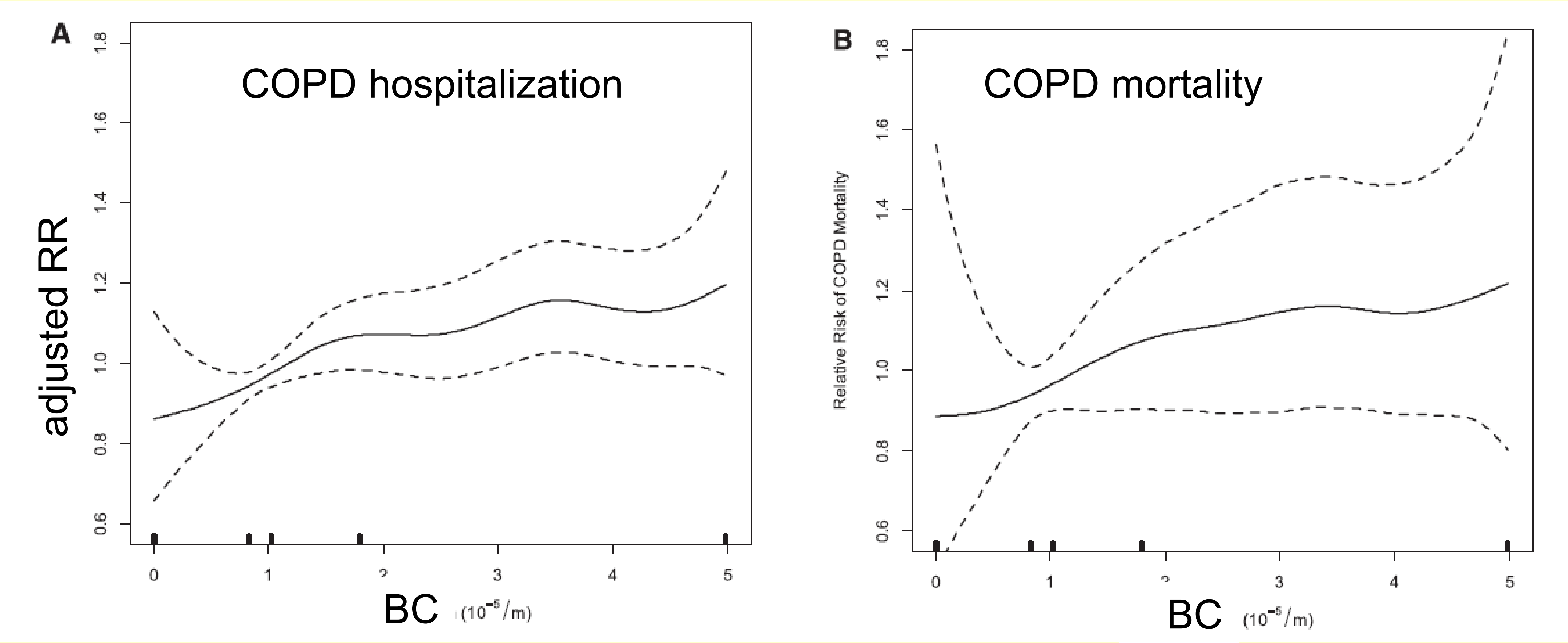
Gan WQ *et al.* Associations of ambient air pollution with chronic obstructive pulmonary disease hospitalization and mortality. *AJRCCM* 2013, 187, 721-7

- Metropolitan Vancouver, 467,994 residents, 45-85 y, without COPD at baseline
  - Estimated 5 y exposure (1994-1998) to traffic-related pollutants [BC, $PM_{2.5}$, NO_2, NO] and woodsmoke
  - 4 y follow-up (1999-2002): COPD hospitalization (n=2,299) or mortality (n=541)

➢ no significant association with $PM_{2.5}$ (0-10.2 µg/m^3) or NO_2, NO, but positive associations with BC (+6% for IQR) and woodsmoke (hospitalizations)

Air pollution and COPD

Gan WQ *et al.* Associations of ambient air pollution with chronic obstructive pulmonary disease hospitalization and mortality. *AJRCCM* 2013, 187, 721-7



Children

Traffic-related pollution and children

McConnell *et al.* Traffic, susceptibility, and childhood asthma. *Env Health Persp* 2006, 114, 766-72

- Cross-sectional study (CHS), southern California:
  - 5,341 children (5-7 y) from 13 communities (2003)
  - Respiratory Questionnaire (ISAAC)
- Exposure:
  - Residence proximity to nearest major road (geocoding)
  - Estimate of exposure to fresh traffic-modeled pollutants
- Adjustments: maternal smoking, ETS, SES, housing characteristics
- ➢ O.R. for lifetime asthma, prevalent asthma or wheeze
  - Residence < 75 m of major road: 1.29, 1.50, 1.40 (*vs* > 300 m)

Traffic-related pollution and children

Gauderman *et al.* Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. *Lancet* 2007, 369, 571-7

- Prospective cohort study (CHS), southern California:
  - 3677 children (10 y) from 12 communities (start 1993 or 1996)
  - 8 y follow-up: yearly questionnaire & spirometry
- Exposure:
  - model-based estimates of traffic-related pollution
  - + proximity to nearest freeway (motorway) or major road
- Adjustments for socioeconomic status (low, middle, high), gas stoves, pets, ETS

➢ Residence within 500 m of motorway (*vs* > 1,500 m) :

FEV_1 -81 mL [-143 – -18] = 97% [94.6-99.4]

Gauderman *et al.* Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. *Lancet* 2007, 369, 571-7

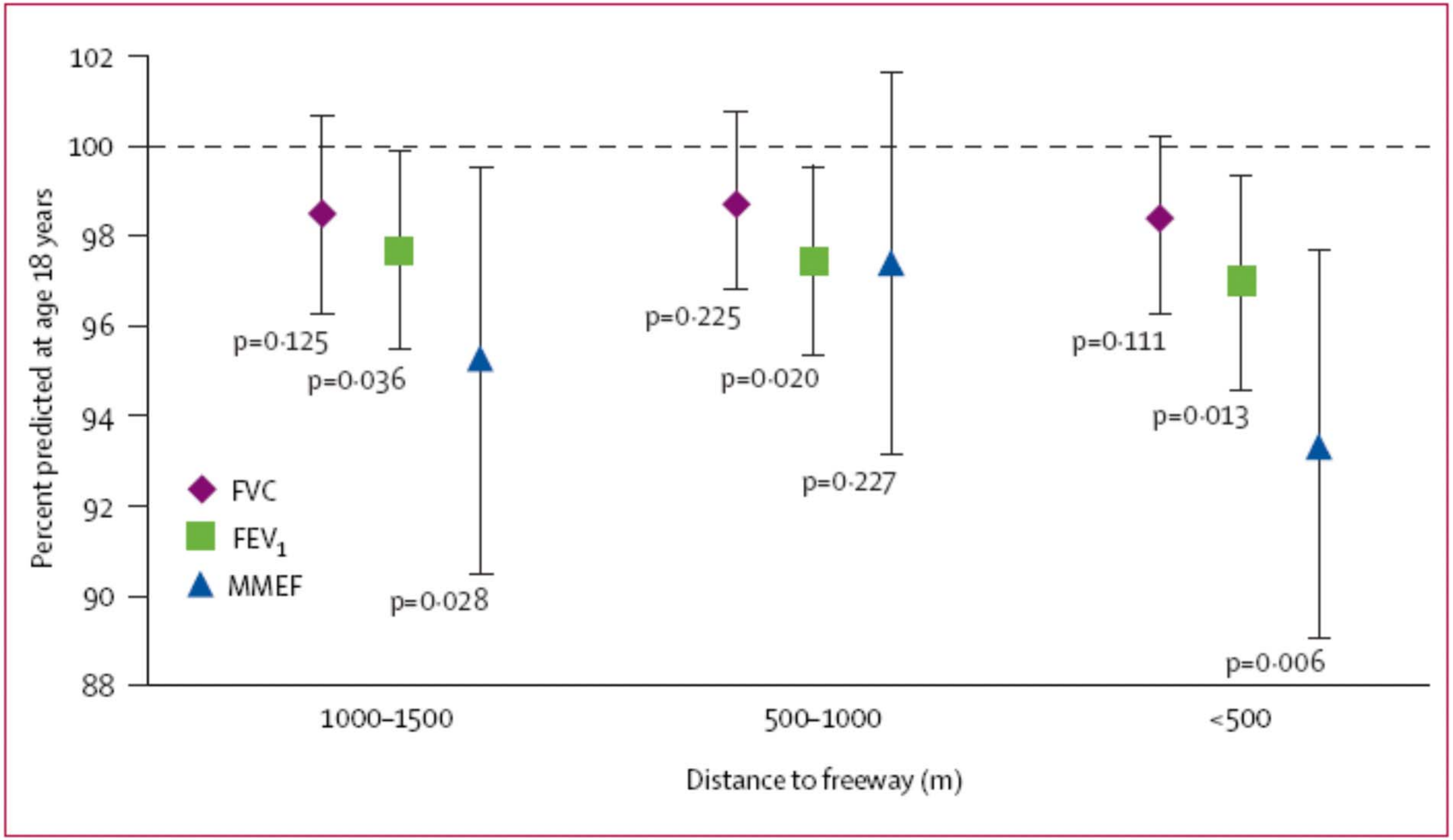


Figure: **Percent-predicted lung function at age 18 years versus residential distance from a freeway**
The horizontal line at 100% corresponds to the referent group, children living >1500 m from a freeway.

Traffic-related pollution and children

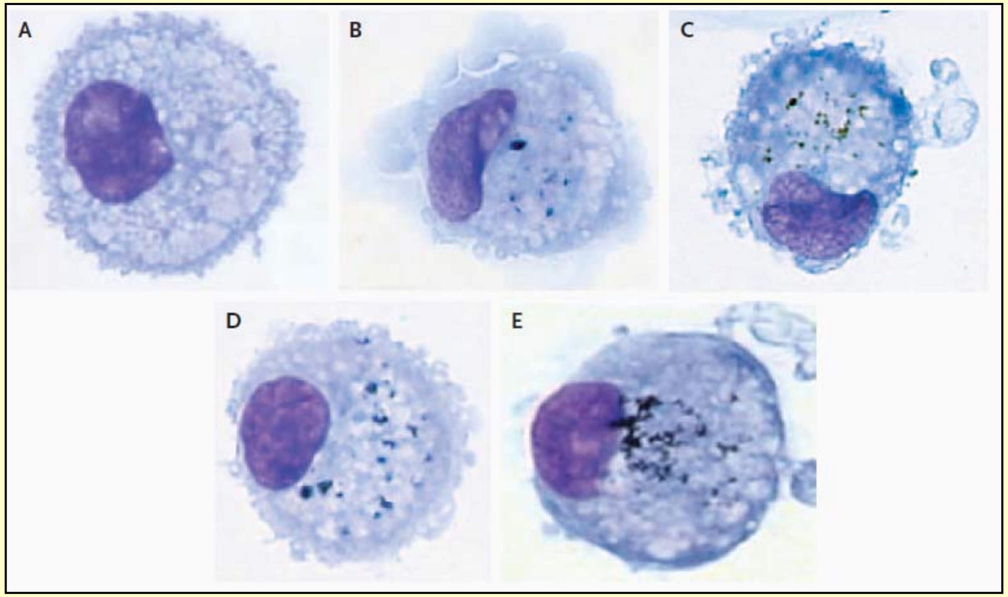
Kulkarni *et al.* Carbon in airway macrophages and lung function in children. *NEJM* 2006, 355, 21-30

- Leicester, UK, 64 healthy children, 8-15 y
- Carbon content of airway macrophages (> induced sputum):

median C surface (μm^2)

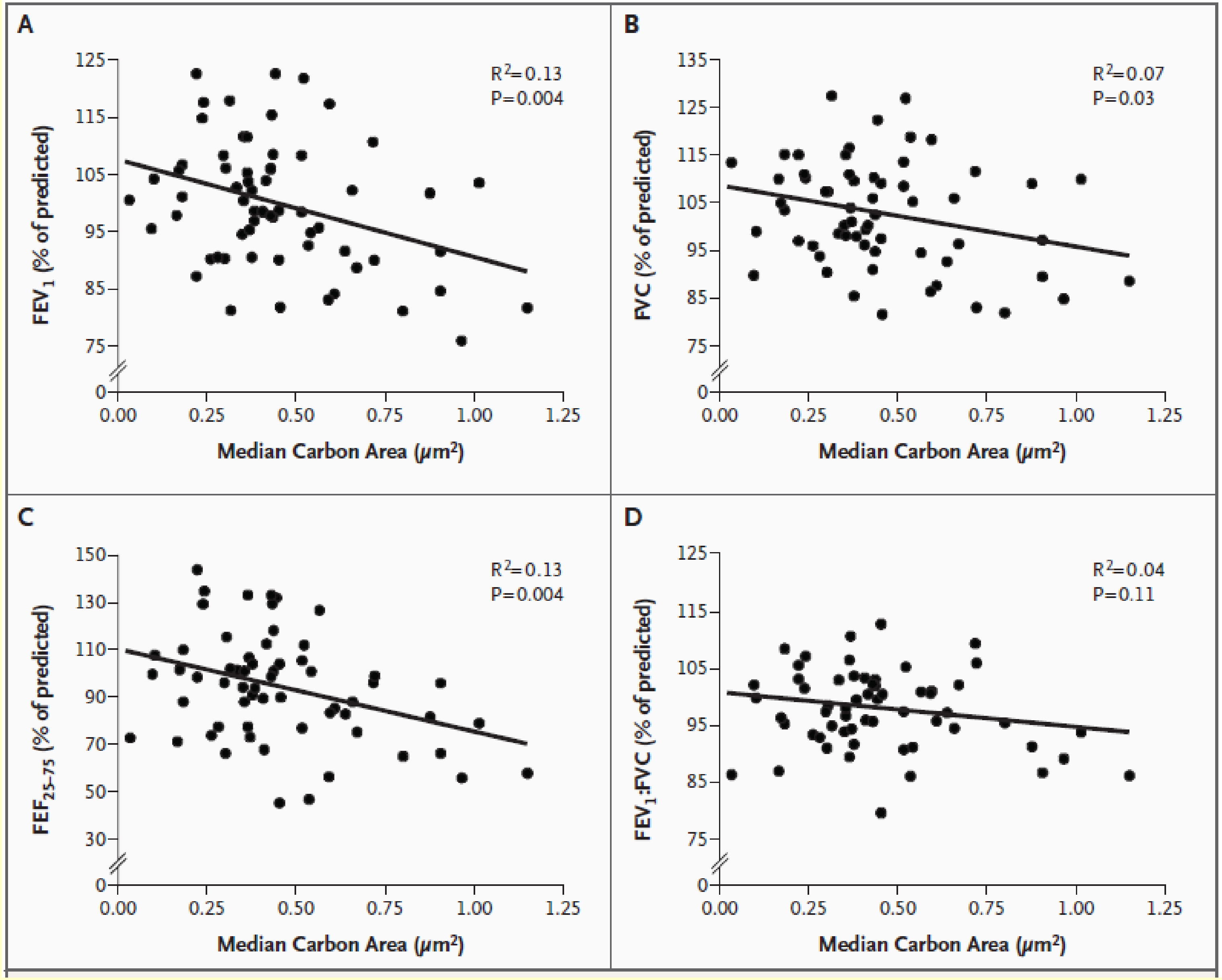
// modeled annual PM_{10} at home:

+ 1.0 µg PM_{10} → + 0.10 μm^2 C



Kulkarni *et al.* Carbon in airway macrophages and lung function in children. *NEJM* 2006, 355, 21-30

+ 1.0 µm² C
→ -17% FEV_1
→ -13% FVC
→ -35% FEF_{25-75}



Traffic-related pollution and children

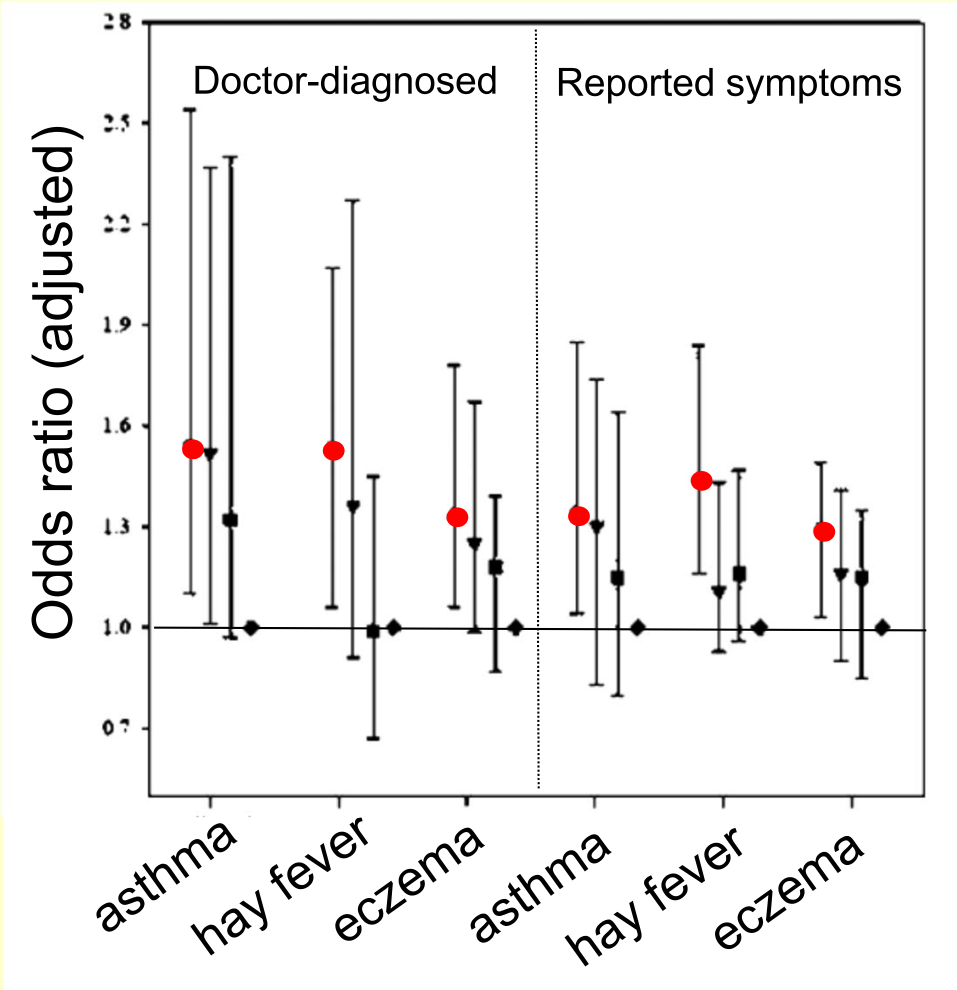
Morgenstern *et al.* Atopic diseases, allergic sensitization, and exposure to traffic-related air pollution in children. *AJRCCM* 2008, 177, 1331-7

- Prospective birth cohort studies, Munich, Germany:
  - 2,860 children (4y) + 3,061 children (6y)
- Exposure assessment:
  - $PM_{2.5}$ & NO_2 at 40 measurements sites (4 x 2 weeks 3/1999 to 7/2000)
  - + GIS-based modeling of pollution at residence (birth, 2 or 3 y, 6y)
  - + distance of residence to major roads
- Adjustments for sex, age, parental atopy, maternal education, siblings, ETS, gas cooking, home dampness, molds, dogs & cats

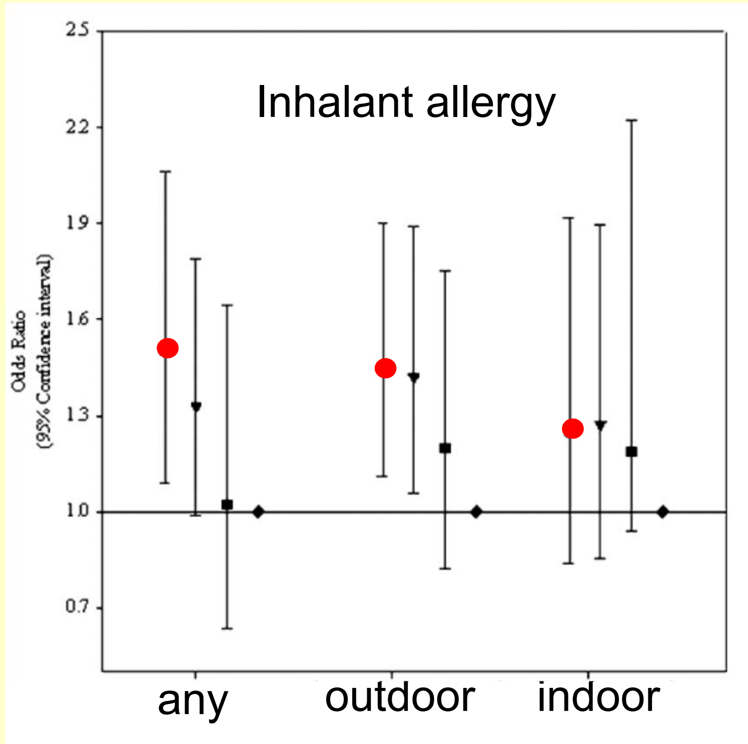
➢ Adjusted OR for "doctor-diagnosed asthmatic bronchitis":

- < 50 m to nearest main road: 1.66 [1.01-2.59] (*vs* > 50 m)

Morgenstern *et al.* Atopic diseases, allergic sensitization, and exposure to traffic-related air pollution in children. *AJRCCM* 2008, 177, 1331-7



● < 50 m from nearest main road
▲ 50-250 m
■ 250-1000 m
♦ > 1000 m



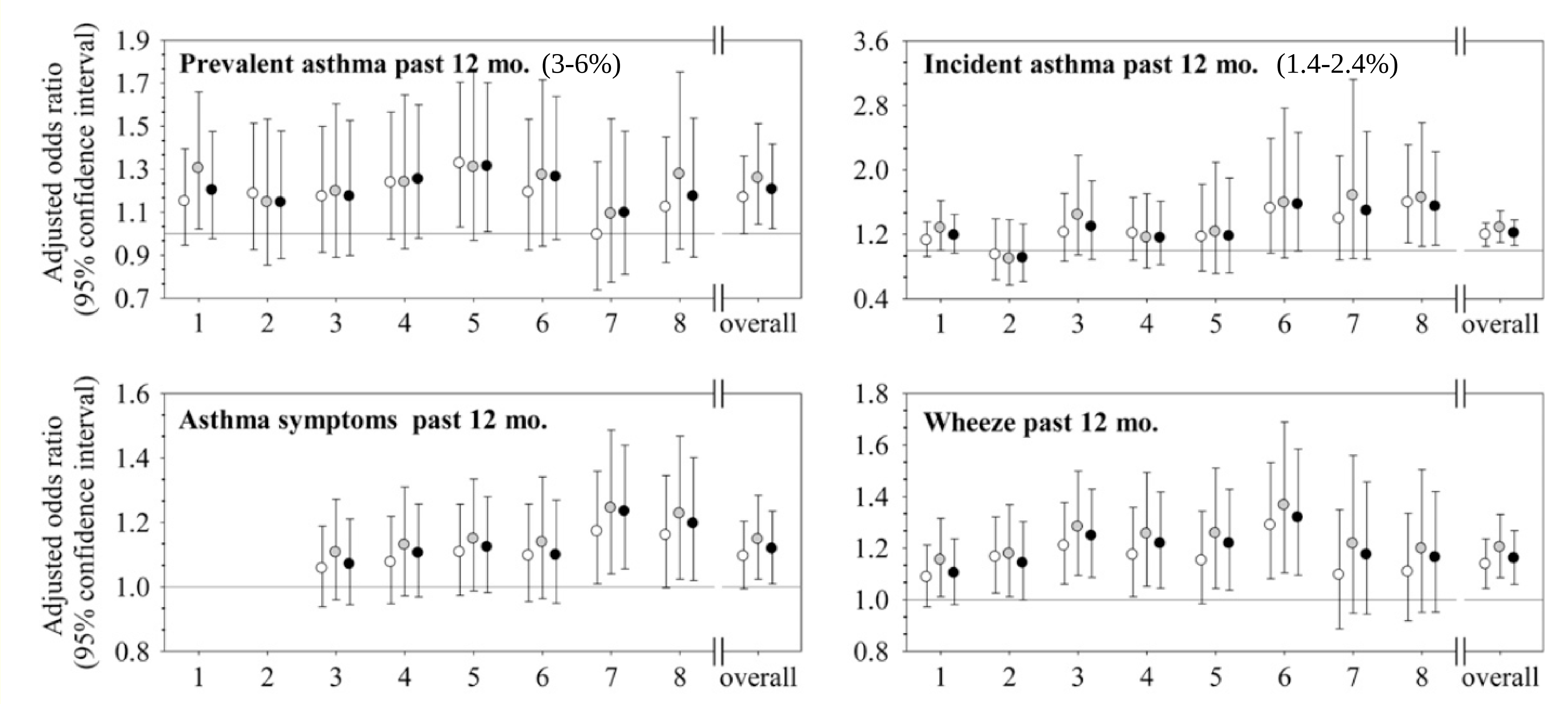
Traffic-related pollution and children

Gehring *et al.* Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. *Am J Respir Crit Care Med* 2010, 181, 596-603

- Prospective birth cohort study (PIAMA), Nl:
  - 3,963 newborns (1996-7) + follow-up up to 8 y (n=3,863)
  - Questionnaires + specific IgE (n=1,700) + BHR (n=936)
- Exposure (birthplace home address):
  - $PM_{2.5}$, soot and NO_2 at 40 sites (4x2weeks, 3/1999 – 4/2000)
  - Traffic intensity (GIS)
- Adjustments: maternal smoking, education, breastfeeding, gas cooking, moving house, …

➢ asthma incidence & prevalence related to air pollution

Gehring *et al.* Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. *Am J Respir Crit Care Med* 2010, 181, 596-603



○	NO_2	IQR 10.4 µg/m^3	[18.5-28.9]
◍	$PM_{2.5}$	IQR 3.2 µg/m^3	[14.9-18.1]
●	soot	IQR 0.57.10^{-5} m^{-1}	[1.35-1.92]

Is dit zo belangrijk?

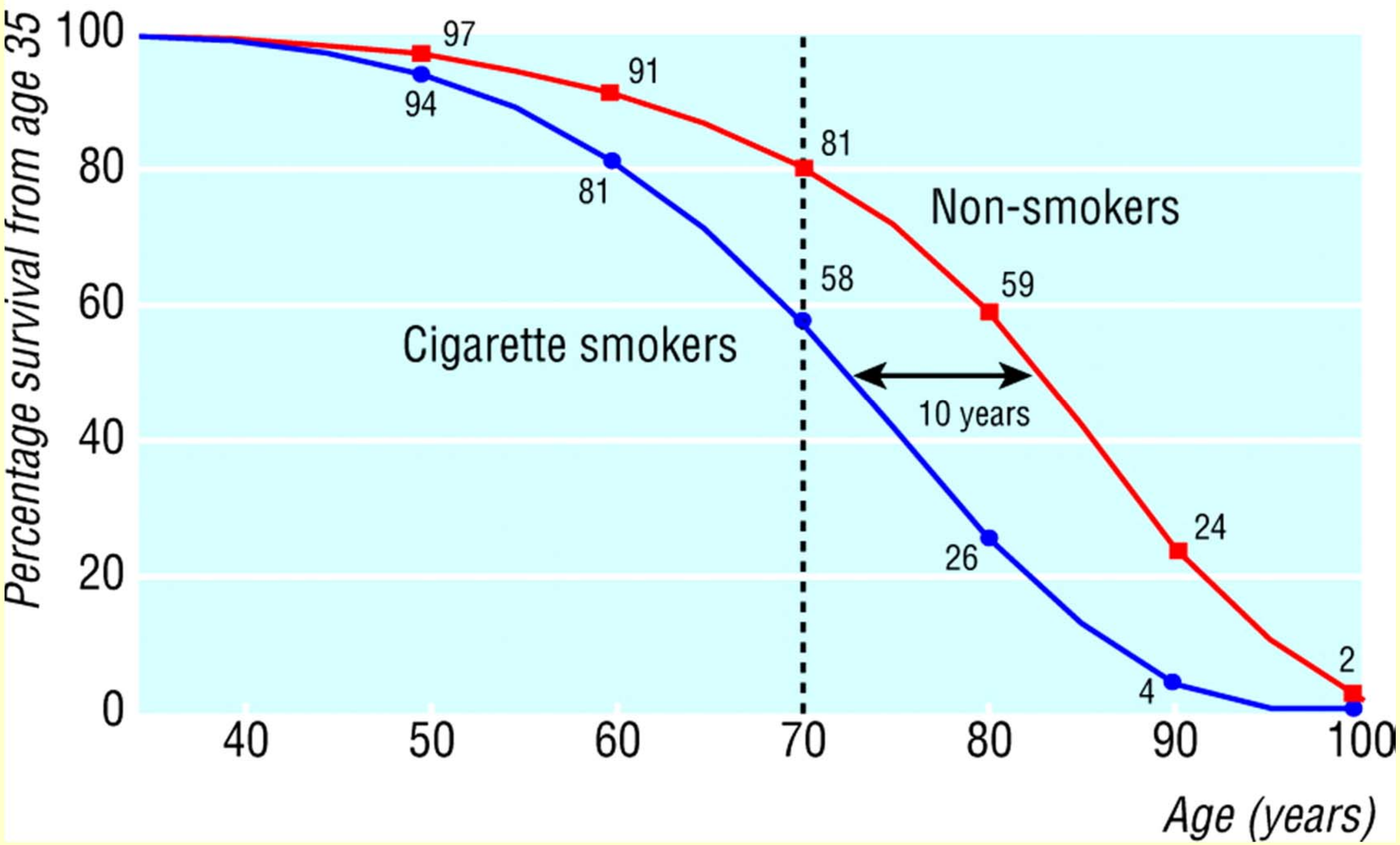
Table 3.17: Losses in statistical life expectancy attributable to the exposure to anthropogenic PM2.5 for the year 2000, the emission ceilings for 2010, the current legislation baseline in 2020 and the optimized scenarios for the three environmental ambition levels (in months)

	2000	*2010* National emission ceilings	*2020* Baseline, Current legislation	*Optimized scenarios for 2020* Case "A"	Case "B"	Case "C"	*2020* Maximum technically feasible reductions
Austria	7.2	5.7	5.4	4.4	4.2	4.0	3.8
Belgium	13.2	9.5	8.9	7.3	7.0	6.7	6.5
Cyprus	4.8	4.3	4.2	4.1	4.1	4.1	4.0
Czech Rep.	8.8	6.5	5.8	4.4	4.1	4.0	3.8
Denmark	5.9	4.7	4.5	3.8	3.6	3.4	3.2
Estonia	3.8	3.2	3.0	2.7	2.6	2.6	2.4
Finland	2.6	2.3	2.2	2.1	2.1	2.1	1.9
France	8.0	6.0	5.5	4.5	4.2	4.1	3.8
Germany	9.2	6.8	6.5	5.1	4.7	4.6	4.4
Greece	6.7	5.5	5.2	4.9	4.8	4.7	4.6
Hungary	10.6	8.3	7.6	5.6	5.3	5.2	4.9
Ireland	4.0	2.9	2.6	2.1	2.0	1.9	1.8
Italy	9.0	6.1	5.3	4.3	4.1	4.0	3.9
Latvia	4.5	4.0	3.8	3.4	3.3	3.2	3.0
Lithuania	6.1	5.4	5.0	4.4	4.3	4.1	3.9
Luxembourg	9.6	7.0	6.8	5.1	4.7	4.4	4.2
Malta	5.6	4.3	4.1	3.8	3.8	3.7	3.6
Netherlands	11.8	8.6	8.3	6.6	6.1	5.9	5.7
Poland	9.6	7.5	6.5	5.2	5.0	4.9	4.7
Portugal	5.1	3.2	3.2	2.8	2.5	2.4	2.2
Slovakia	9.1	7.2	6.4	4.8	4.6	4.4	4.2
Slovenia	8.2	6.5	6.0	4.8	4.6	4.4	4.1
Spain	5.2	3.5	3.2	2.8	2.7	2.6	2.5
Sweden	3.5	2.9	2.7	2.4	2.4	2.2	2.0
UK	6.9	5.0	4.6	3.5	3.2	3.1	3.0
EU-25	8.1	5.9	5.5	4.4	4.1	4.0	3.8

http://europa.eu.int/comm/environment/air/cafe/activities/pdf/cafe_scenario_report_6.pdf

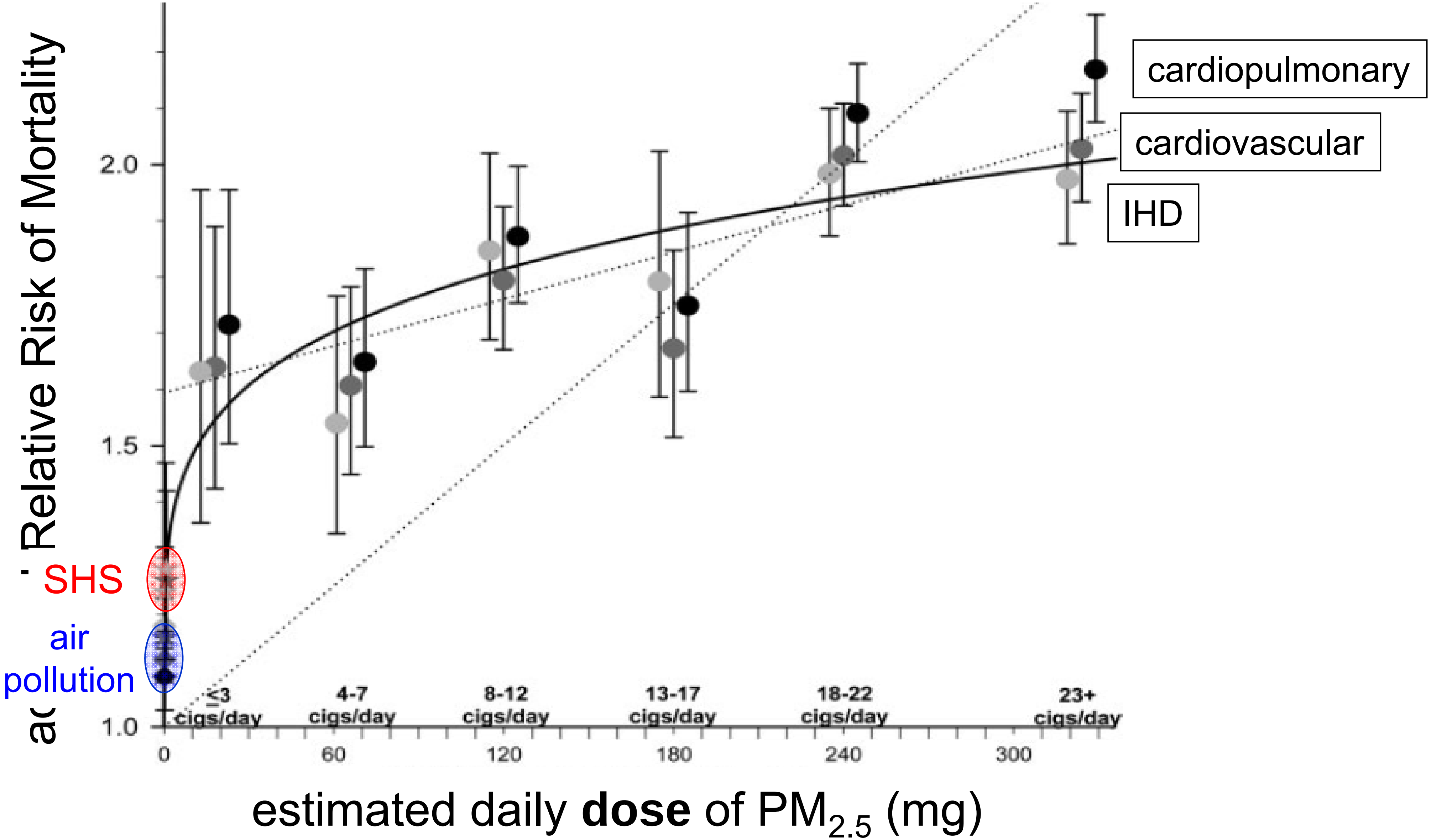
Effects of smoking

34469 British doctors born 1900-1930

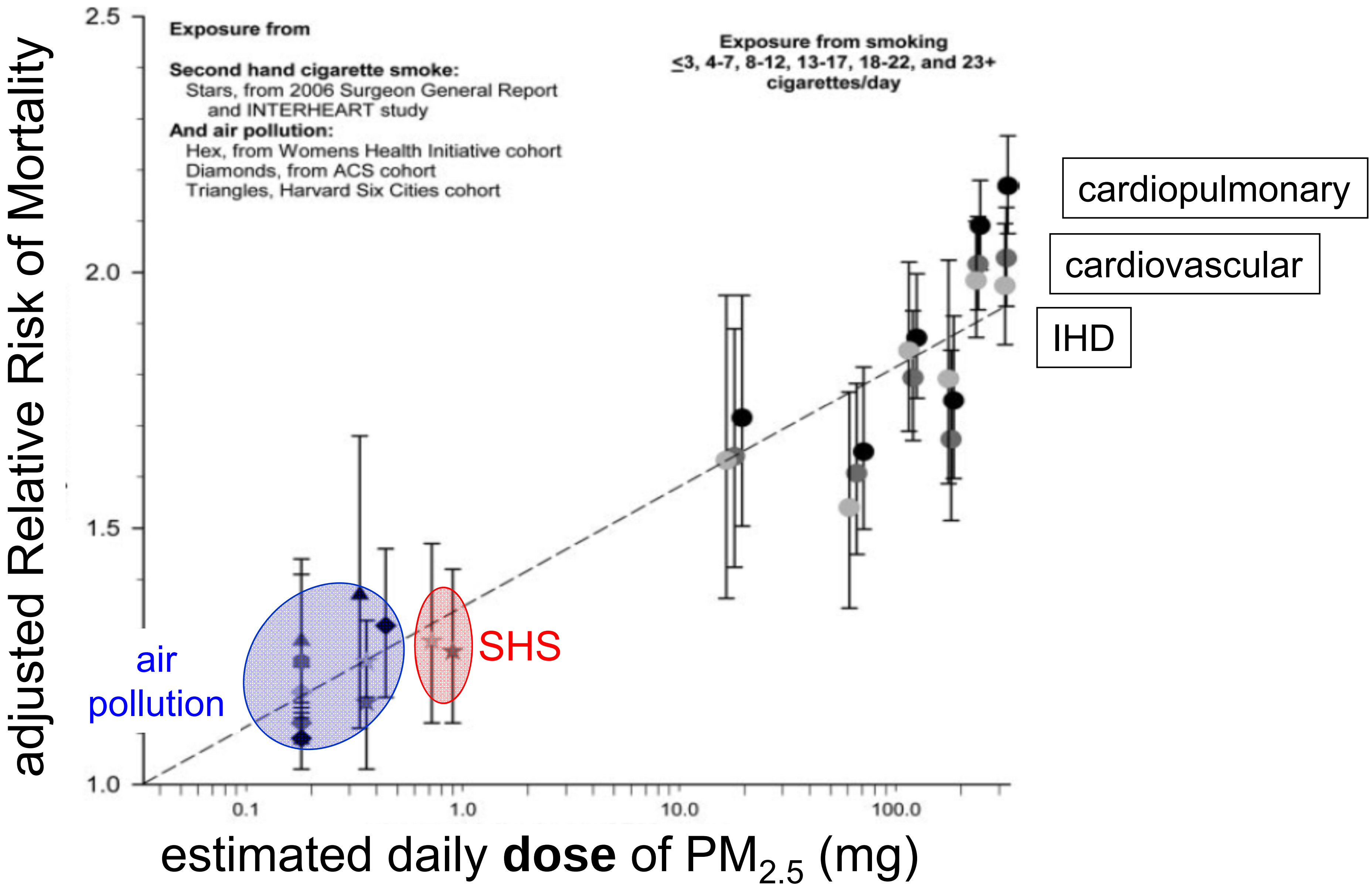


Doll R *et al*. *BMJ* 2004; 328:1519

Pope *et al.* Circulation 2009, 120, 941-8



Pope *et al.* Circulation 2009, 120, 941-8



Pope *et al.* EHP 2011, 119, 1616-21

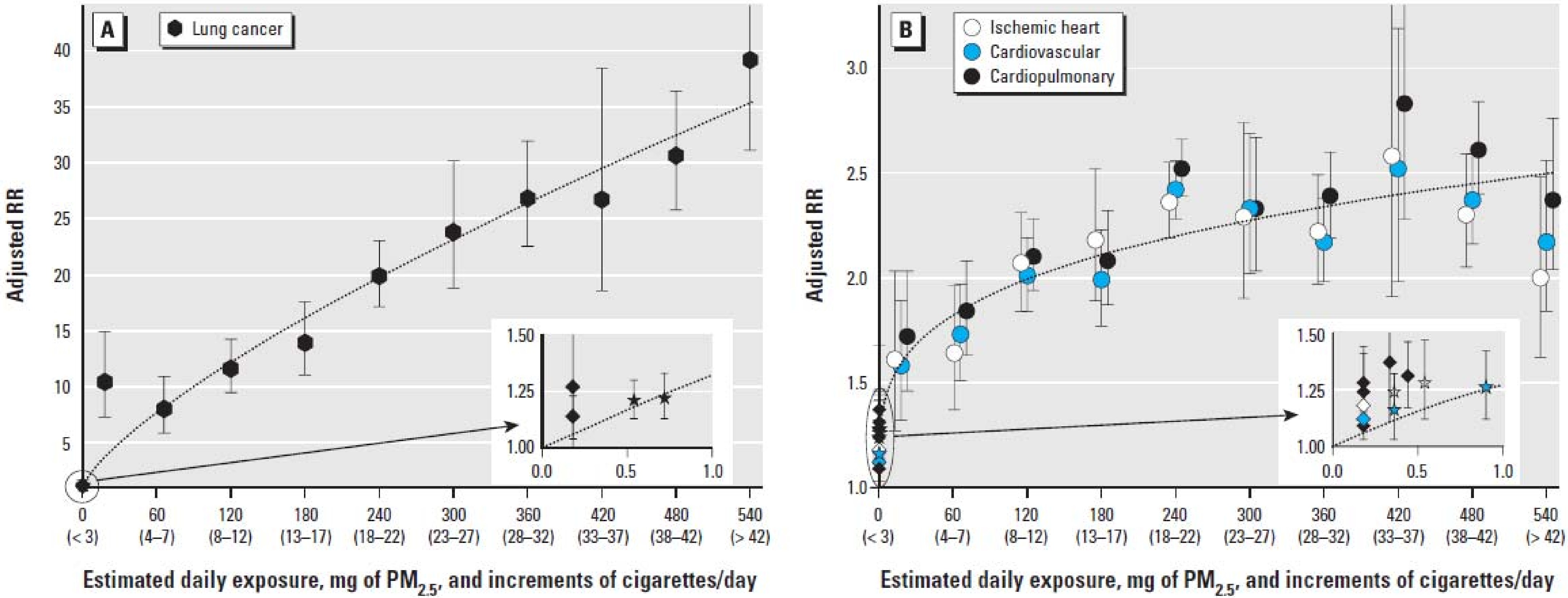


Figure 1. Adjusted RRs [with 95% confidence intervals (CIs)] of lung cancer mortality (*A*) and IHD, cardiovascular, and cardiopulmonary mortality (*B*) plotted over estimated daily exposure of $PM_{2.5}$ (milligrams) and increments of cigarette smoking relative to never smokers (cigarettes/day). Diamonds represent comparative mortality risk estimates (with 95% CIs) for $PM_{2.5}$ from air pollution from the comparative studies (Dockery et al. 1993; Laden et al. 2006; Miller et al. 2007; Pope et al 1995, 2002, 2004). Stars represent comparable pooled RR estimates (with 95% CIs) associated with SHS exposure from comparative studies (Teo et al. 2006; U.S. Department of Health and Human Services 2006). The dotted lines represent the nonlinear power function fit through the origin and the estimates (including active smoking, SHS, ambient $PM_{2.5}$). Estimated doses from different increments of active smoking are dramatically larger than estimated doses from ambient air pollution or SHS; therefore, associations at lower exposure levels (due to ambient air pollution and SHS) are shown as insets with a magnified scale.

Relevantie

- Een klein (“triviaal”) gemiddeld effect op groepsniveau betekent niet dat het effect triviaal is
  - voor bepaalde individuen
  - voor de volksgezondheid

Effects of residential proximity to traffic in lung transplant patients

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

Thorax Online First, published on March 23, 2011 as 10.1136/thx.2010.155192

Lung transplantation

PRESS RELEASE

The impact of traffic air pollution on bronchiolitis obliterans syndrome and mortality after lung transplantation

Tim S Nawrot,[1,2] Robin Vos,[3,4] Lotte Jacobs,[2] Stijn E Verleden,[3,4] Shana Wauters,[4] Veerle Mertens,[4] Christophe Dooms,[3] Peter H Hoet,[2] Dirk E Van Raemdonck,[4,5] Christel Faes,[6] Lieven J Dupont,[3,4] Benoit Nemery,[2] Geert M Verleden,[3,4] Bart M Vanaudenaerde[3,4]

BOS and mortality after lung transplantation and residential proximity to traffic

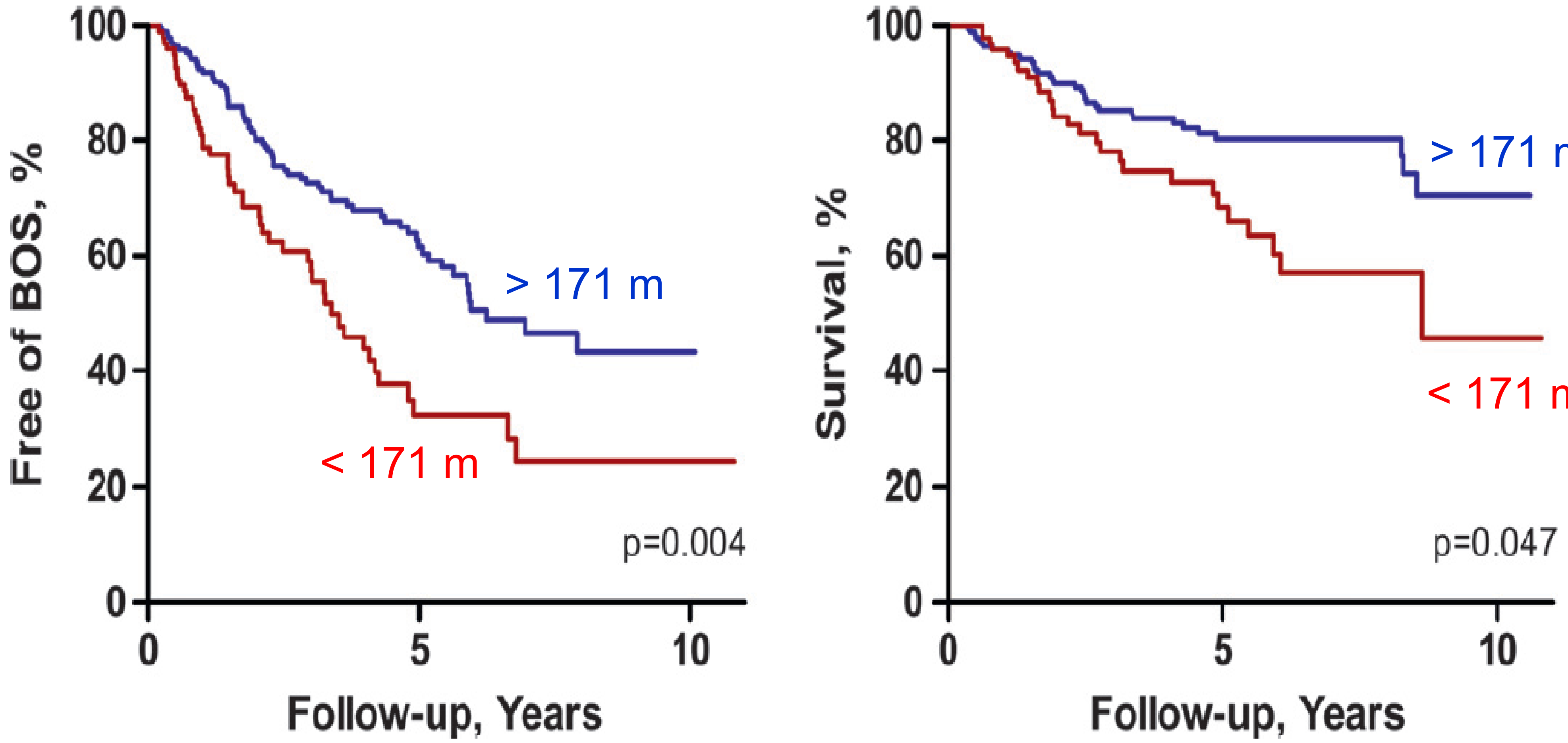
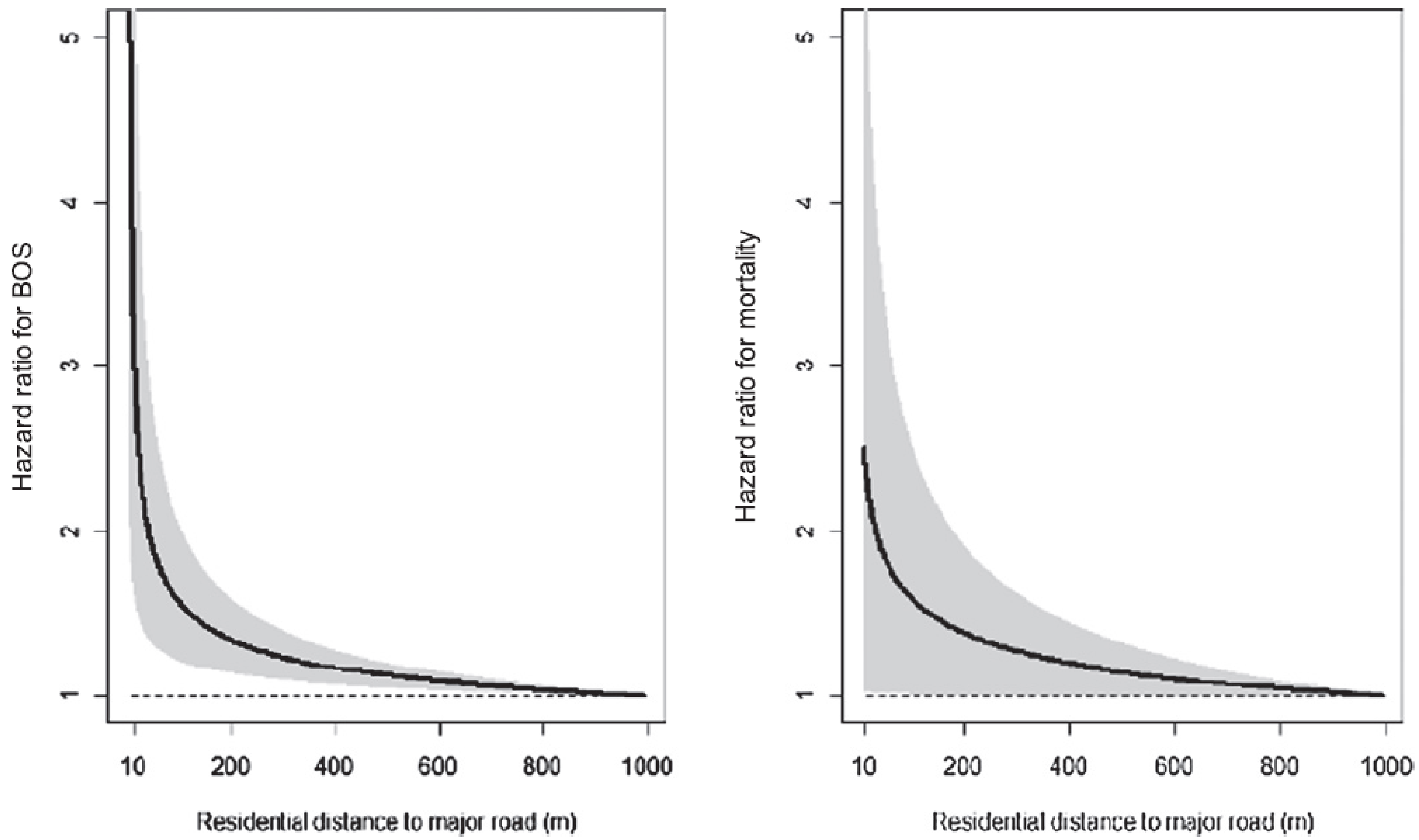


Figure 1 Unadjusted Cox regression in patients after lung transplantation classified according to whether they lived within 171 m of a major road (n=96, lowest tertile, red line) or more than 171 m from a major road (n=192, blue line). BOS, bronchiolitis obliterans syndrome.

Nawrot TS, Vos R, Jacobs L, *et al*. *Thorax* (2011). doi:10.1136/thx.2010.155192



Distance to major road, m	Hazard ratio (95% CI) for BOS	Attributable fraction
1000	1.00	-
800	1.04 (1.02-1.06)	3.8%
600	1.09 (1.04-1.14)	8.2%
400	1.17 (1.04-1.28)	14.7%
200	1.34 (1.14-1.58)	25.4%
150	1.43 (1.17-1.74)	30.0%
100	1.57 (1.22-2.02)	36.3%
50	1.88 (1.32-2.66)	46.7%

Distance to major road, m	Hazard ratio (95% CI) for mortality	Attributable fraction
1000	1.00	-
800	1.05 (1.00-1.09)	4.8%
600	1.11 (1.00-1.23)	9.8%
400	1.20 (1.00-1.45)	16.9%
200	1.39 (1.01-1.90)	27.8%
150	1.47 (1.01-2.14)	31.9%
100	1.60 (1.02-2.52)	37.2%
50	1.83 (1.02-3.30)	45.4%

Figure 2 Adjusted hazard ratio (with 95% CI, the grey area) for the incidence of bronchiolitis obliterans syndrome (BOS) and mortality in patients after lung transplantation, with 1000 m as reference. Hazard ratios were adjusted for sex, age, type of transplantation (single or double lung transplantation), infection with cytomegalovirus (CMV) and non-CMV infections, acute rejections, a factor reflecting time trend and social economic status. A corresponding table is given with HRs (95% CI) and the attributable

Nawrot TS, Vos R, Jacobs L, *et al*. *Thorax* (2011). doi:10.1136/thx.2010.155192

Public health relevance

- Künzli N. The public health relevance of air pollution abatement. *Eur. Respir. J*. 2002, 20, 198-209

France+Austria+Switzerland (73.4 million)

outcome	risk function (+%) per annual mean 10 μg/m^3 PM_{10}	attributable cases	attributable proportion
adult mortality	4.3	40,600	6%
hospital admissions	resp. : 1.31; CV: 1.25	48,000	2%
chronic bronchitis adults	9.8	47,100	12%
chronic bronchitis child	30.6	543,000	30%
restricted activity days	9.4	30.5 million	12%
asthma attacks	child: 4.4; adult: 3.9	1.04 million	6%

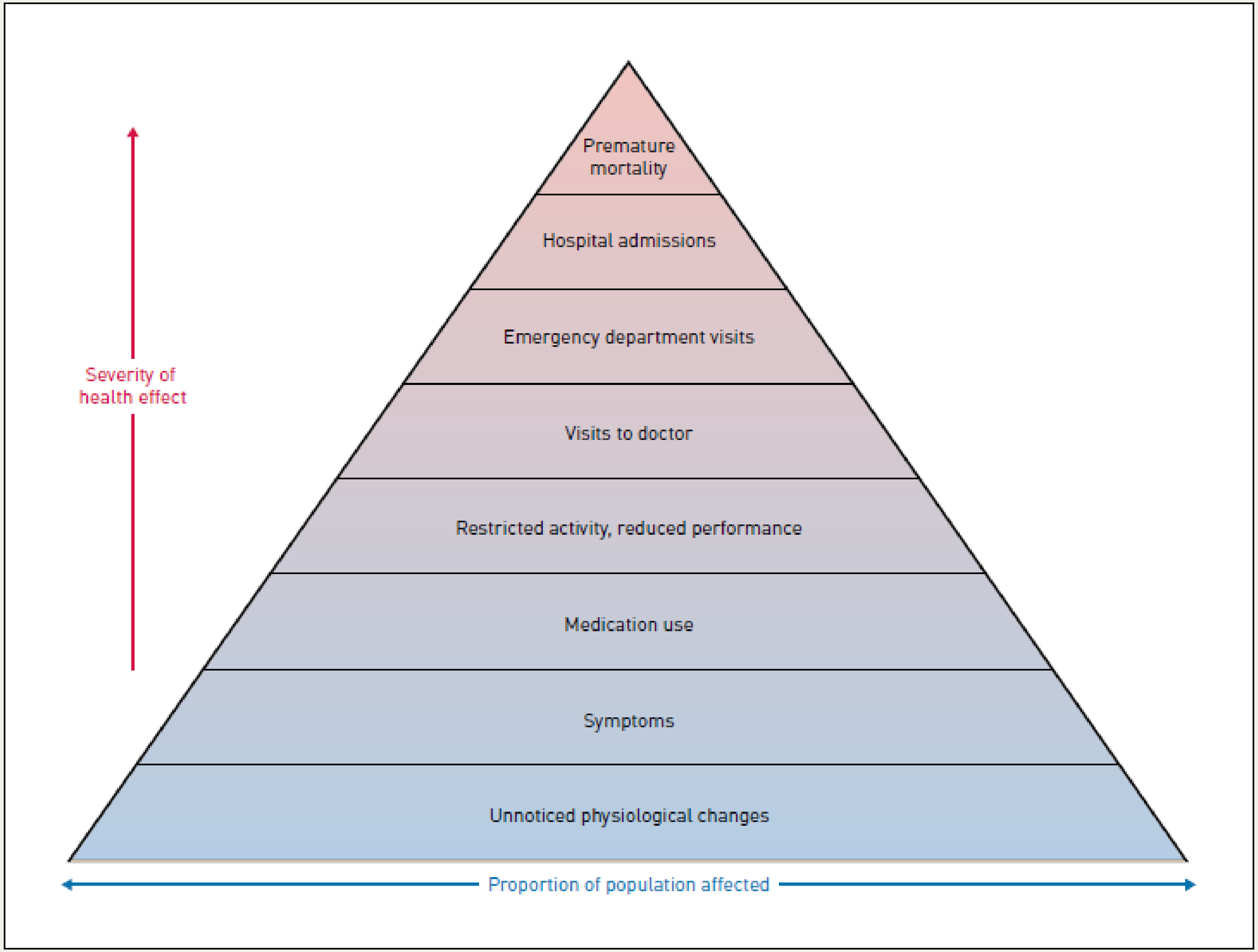


Figure 6a.1. Pyramid of health effects associated with air pollution [21].

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

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

B. Brunekreef*,#, I. Annesi-Maesano¶,+, J.G. Ayres§, F. Forastiere*f*, B. Forsberg**, N. Künzli##,¶¶, J. Pekkanen++,§§ and T. Sigsgaard*ff*

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

2) Outdoor air pollution is one of the biggest environmental health threats in Europe today, leading to significant reductions of life expectancy and productivity.

3) Fine particles and ozone are the most serious pollutants. There is an urgent need to reduce their concentrations significantly.

Dank voor uw aandacht

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Is bestrijding van luchtverontreiniging zinvol?

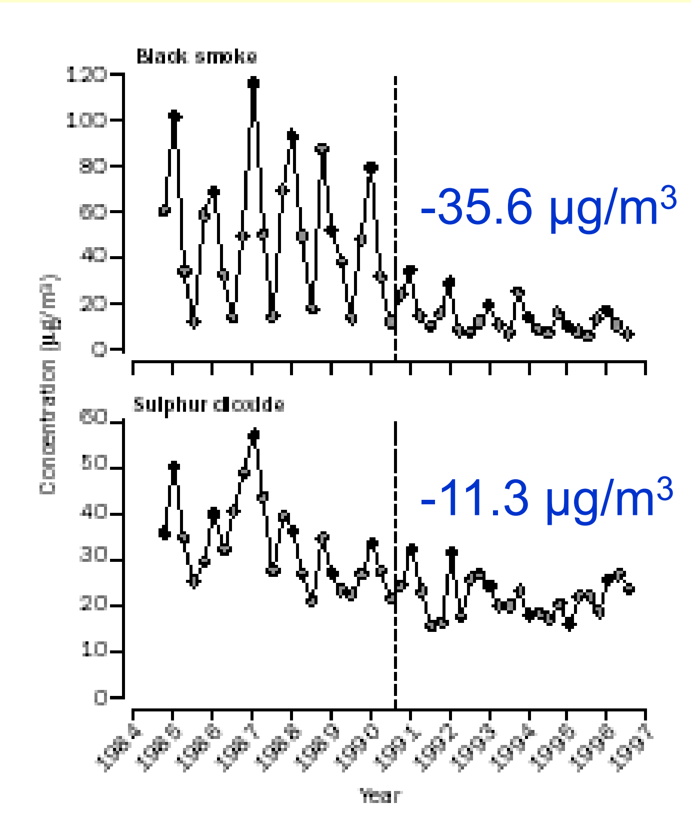
"Interventies"

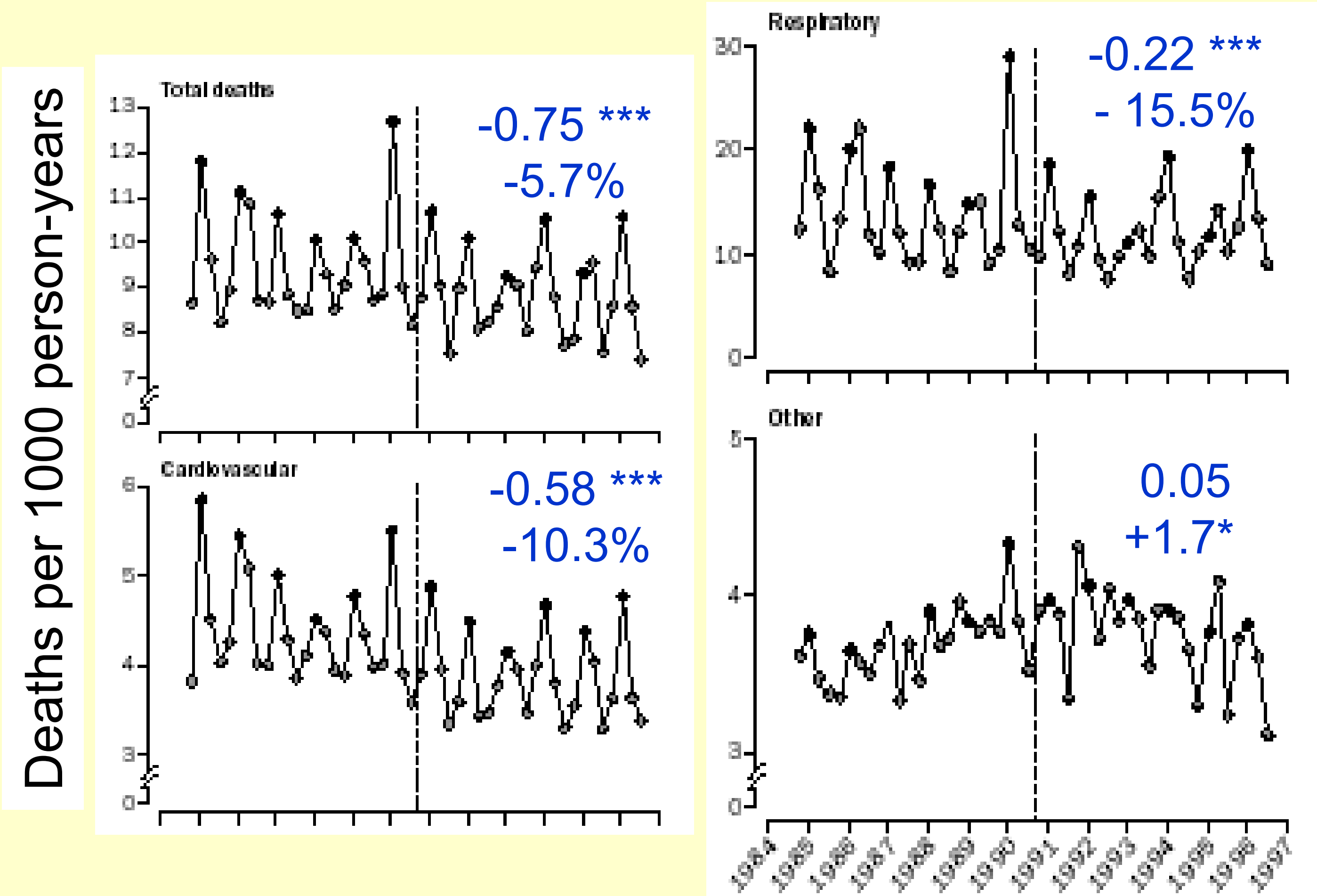
- Pope C.A. Respiratory disease associated with community air pollution and a steel mill, Utah Valley. *Am.J. Publ.Health* 1989, 79, 623-8
  - strike in 1986-87
  - PM_{10} ($\mu g/m^3$): 90 $\rightarrow$ 51 (mean)

    365 $\rightarrow$ 113 (high)
  - 50% fewer hospital respiratory admissions in children

“Interventions”

Clancy *et al*. Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. *Lancet* 2002; 360:1210-44





“Interventies”

- Friedman *et al*. Impact of changes in transportation and community behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma. *JAMA*, 2001, 285, 897-905
  - peak morning traffic counts: -22.5%
  - peak daily O_3 : 81.3 ppb $\rightarrow$ 58.6 ppb
  - mean daily PM_{10} : 36.7 $\rightarrow$ 30.8 μg/m^3
  - asthma acute care events: -41.6%

Beijing Olympics 2008

- Wu *et al*. Association of heart rate variability in taxi drivers with marked changes in particulate air pollution in Beijing in 2008. *EHP*, 2010, 118, 87-91
  - Panel study, 11 taxi drivers, 36 y
  - Before, during, after olympic games
  - ECG HRV: “marked changes”

Table 2. Daily averages of exposure variables inside the taxicab.

Variable	Period[a] Before	During	After
$PM_{2.5}$, real time (μg/m^3)	95.4 ± 58.6	39.5 ± 25.2	64.0 ± 80.3
$PM_{2.5}$, mass (μg/m^3)	105.5 ± 44.1	45.2 ± 27.0	80.4 ± 72.5
CO (ppm)	3.6 ± 1.4	2.8 ± 1.0	2.7 ± 0.7
NO_2 (ppb)	36.4 ± 12.3	30.3 ± 12.2	37.1 ± 17.0
NO (ppb)	176.1 ± 84.8	156.0 ± 77.2	268.0 ± 55.5
Temperature (°C)	[illegible] ± 4.4	28.8 ± 2.0	25.0 ± 2.2
[illegible]	[illegible] ± 9.5	41.7 ± 6.6	24.8 ± 5.8

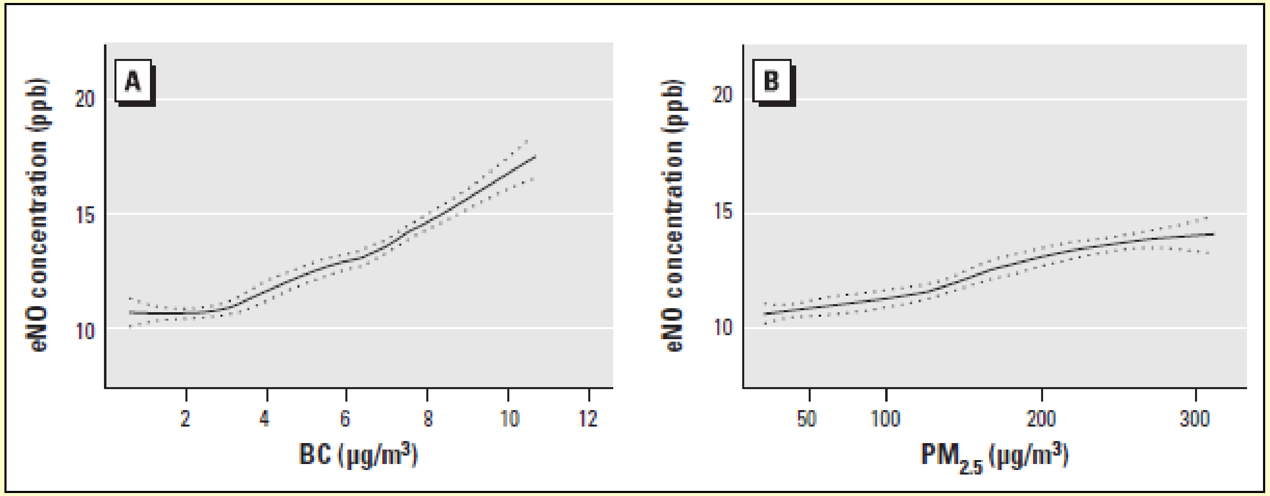
Table 4. Estimated percent changes (95% CIs) in 5-min HRV indices in lagged $PM_{2.5}$ moving averages.

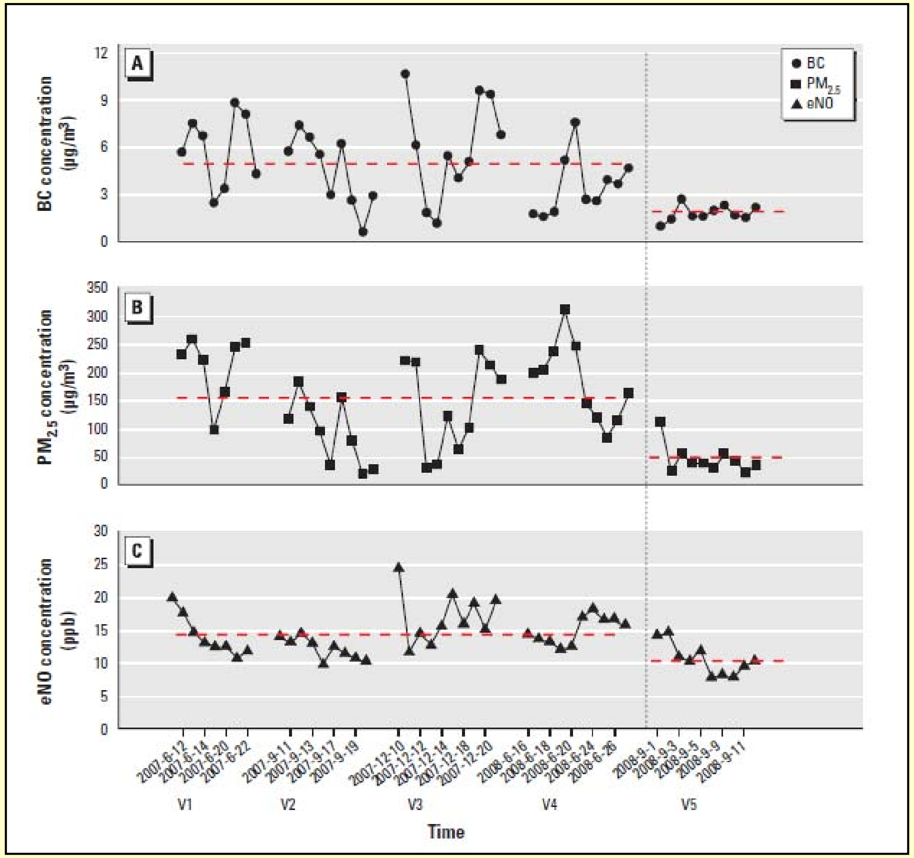
Variable	30-min moving average: All data	30-min moving average: Excluding outlying exposure values[a]	2-hr moving average: All data	2-hr moving average: Excluding outlying exposure values[a]
5-min SDNN	–2.2 (–3.8 to –0.6)**	–3.5 (–5.7 to –1.2)**	–1.1 (–3.3 to 1.1)	–1.6 (–4.2 to 1.1)
5-min LF power	–2.8 (–6.6 to 1.0)	–5.8 (–10.7 to –0.5)*	–4.2 (–9.0 to 0.8)	–4.8 (–10.6 to 1.3)
5-min HF power	–4.1 (–7.6 to –0.5)*	–7.1 (–11.6 to –2.4)**	–6.2 (–10.7 to –1.5)*	–7.8 (–13.1 to –2.3)**

Effect estimates are percent changes for per IQR (69.5 μg/m^3) increase of $PM_{2.5}$ moving averages, adjusted for age, time of day, log_{10}-transformed heart rate, and linear and quadratic terms of moving averages of real-time temperature/RH corresponding to the $PM_{2.5}$.

Beijing Olympics 2008

- Lin *et al*. Acute respiratory inflammation in children and black carbon in ambient air before and during the 2008 Beijing Olympics. *EHP*, 2011, 119, 1507-12
  - Panel study, 36 children (10.6 y)
  - 5 periods in 2007-2008
  - FENO





Beijing Olympics 2008

- Rich *et al*. Association between changes in air pollution levels during the Beijing Olympics and biomarkers of inflammation and thrombosis in healthy young adults. *JAMA*, 2012, 307, 2068-78.
    - Panel study, 125 medical residents (63 M, 62 F), mean 24 y
    - 6 visits (before, during, after)
    - ECG, BP, blood: CRP, fibrinogen, WBC, vWf, sCD40L, sCD62P

- + editorial Dominici & Mittleman, *JAMA* 2012, 307, 2100-1

Beijing Olympics 2008

Table 1. Distributions of 24-Hour Mean Concentrations of Pollutants, Temperat... Relative Humidity

Pollutant and Period[a]	No. of 24-h Periods	Mean (SD) [Range]
$PM_{2.5}$, μg/m³		
Entire study	100	85.2 (51.9) [14.6-268.2]
Before	35	100.9 (38.8) [24.4-219.1]
Sulfur... Before	35	7.6 (4.5) [2.0-21.0]
During	24	3.1 (1.6) [0.9-7.7]
After	32	6.6 (3.6) [0.9-14.9]
Carbon monoxide, ppm		
Entire study	100	0.91 (0.50) [0.10-2.67]

Figure. Daily Ambient $PM_{2.5}$ Levels in 20 US Cities With Large Populations, June 2, 2008, to October 31, 2008

Dominici & Mittleman, *JAMA* 2012, 307, 2100-1

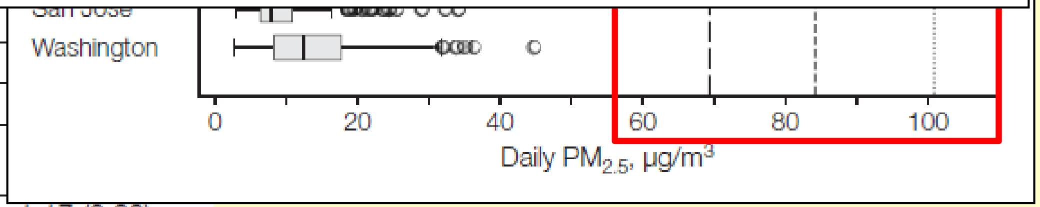


Table 3. Biomarker Concentrations by Period and Between-Period Change in Participant-Specific Biomarker Concentrations, Adjusted for Temperature and Relative Humidity

	Olympic Period, Mean (95% CI)			Between-Period Percentage Change			
Biomarker, Units	Before	During	After	Before to During, Mean (95% CI), %	*P* Value[b]	During to After, Mean (95% CI), %	*P* Value[b]
sCD62P, ng/mL[a]	6.29 (5.97 to 6.63)[a]	4.16 (3.86 to 4.48)[a]	5.36 (5.10 to 6.05)[a]	−34.0 (−38.4 to −29.2)	<.001	33.7 (17.7 to 51.8)	<.001
sCD40L, ng/mL[a]	1.86 (1.79 to 1.94)[a]	1.76 (1.66 to 1.86)[a]	1.92 (1.77 to 2.07)[a]	−5.7 (−10.5 to −0.7)	.03	9.1 (−3.7 to 23.5)	.17
von Willebrand factor, %	106.4 (98.5 to 114.4)	92.6 (82.6 to 102.5)	79.5 (66.9 to 92.1)	−13.1 (−18.6 to −7.5)	<.001	−14.2 (−29.9 to 1.6)	.19
Heart rate/min	66.5 (65.0 to 68.1)	65.4 (63.8 to 67.0)	66.1 (64.2 to 68.1)	−1.7 (−3.4 to −0.1)	.04	1.1 (−2.5 to 4.9)	.54
Fibrinogen, mg/dL	250 (242 to 258)	250 (240 to 259)	261 (249 to 273)	0.1 (−2.5 to 2.2)	.90	4.3 (−1.7 to 10.2)	.21
Blood pressure, mm hg							
Systolic	102.5 (99.9 to 105.2)	100.9 (97.4 to 104.4)	110.5 (105.9 to 115.0)	−1.8 (−3.9 to 0.4)	.10	10.7 (2.8 to 18.6)	.01
Diastolic	60.2 (57.9 to 62.6)	60.1 (57.0 to 63.1)	60.1 (56.2 to 64.0)	−0.3 (−3.0 to 2.5)	.86	0.1 (−9.7 to 9.9)	.99
White blood cell count, μL	5290 (5050 to 5540)	5400 (5100 to 5700)	5210 (4890 to 5530)	2.2 (−2.3 to 6.6)	.34	−3.9 (−11.5 to 3.6)	.44

Abbreviations: sCD40L, soluble CD40 ligand; soluble P-selectin sCD62P
[a] Biomarker was log-transformed. Geometric means and its 95% confidence interval.
[b] Significance is established if *P* value <.003, the individual significance level needed to maintain a family-...

Rich *et al*. *JAMA*, 2012, 307, 2068-78

N ENGL J MED 360;4 NEJM.ORG JANUARY 22, 2009

Fine-Particulate Air Pollution and Life Expectancy in the United States

C. Arden Pope III, Ph.D., Majid Ezzati, Ph.D., and Douglas W. Dockery, Sc.D.

ABSTRACT

BACKGROUND

Exposure to fine-particulate air pollution has been associated with increased morbidity and mortality, suggesting that sustained reductions in pollution exposure should result in improved life expectancy. This study directly evaluated the changes in life expectancy associated with differential changes in fine particulate air pollution that occurred in the United States during the 1980s and 1990s.

METHODS

We compiled data on life expectancy, socioeconomic status, and demographic characteristics for 211 county units in the 51 U.S. metropolitan areas with matching data on fine-particulate air pollution for the late 1970s and early 1980s and the late 1990s and early 2000s. Regression models were used to estimate the association between reductions in pollution and changes in life expectancy, with adjustment for changes in socioeconomic and demographic variables and in proxy indicators for

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RESULTS

A decrease of 10 μg per cubic meter in the concentration of fine particulate matter was associated with an estimated increase in mean (±SE) life expectancy of 0.61±0.20 year (P=0.004). The estimated effect of reduced exposure to pollution on life expectancy was not highly sensitive to adjustment for changes in socioeconomic, demographic, or proxy variables for the prevalence of smoking or to the restriction of observations to relatively large counties. Reductions in air pollution accounted for as much as 15% of the overall increase in life expectancy in the study areas.

CONCLUSIONS

A reduction in exposure to ambient fine-particulate air pollution contributed to significant and measurable improvements in life expectancy in the United States.

Role of physicians and health professionals*

* European Respiratory Society (ERS)

"Air quality and health"

Künzli *et al*.

http://www.ersnet.org/index.php/publications/reference-books.html

Role of physicians and health professionals

Target 1: abatement of ambient air pollution

- Sustained improvement of air quality through reduction of emissions
- Stringent air-quality regulations

“The opinion of health professionals can be influential in the decision-making process”

Table A1.2. Clean air policy targets set by different authorities

Source	SO_2 µg·m^{-3}				NO_2 µg·m^{-3}			PM10 µg·m^{-3}		PM2.5 µg·m^{-3}		Ozone µg·m^{-3}	
	1 year	24 hr	1 hr	10 m	1 year	24 hr	1 hr	1 year	24 hr	1 year	24 hr	8 hr	1 hr
WHO [21]		20		500	40		200	20	50[a]	10	25[a]	100	
European Union (revised 2008) [50]		125[a]	350[f]		40		200[e]	40	50[b]	25		120[f]	
Switzerland [51]	30	100[d]			30	80[d]		20	50[d]				120[d]
France [52]	50	125[a]	350[f]		40		200[e]	40	50[b]				
Sweden [53]		100	200		40	60	90	40	50				
UK [54]		125[a]	350[f]	266[b]	40		200[e]	40	50[b]	25		100	
Japan [55]		105	262			113			100				118[c]
USA [56]	78	366			100			50	150	15	65	157	
California [57]		105[c]	655				470[c]	20	50	12	65	137	180[c]

[a]: Not to be exceeded more than 3 days per year; [b]: Not to be exceeded more than 35 days per year; [c]: Photochemical oxidants; [d]: Not to be exceeded more than one time per year; [e]: Not to be exceeded more than 18 times a year; [f]: Not to be exceeded more than 24 times a year. Modified from [21].

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

Role of physicians and health professionals

Target 2: reducing indoor pollution of outdoor origin

- Opening windows only outside rush hour times and hours with high O_3
- Air-conditioning ??
- Air-filtering devices ??

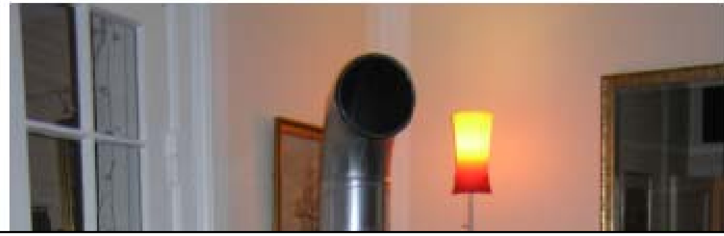
Indoor Particles Affect Vascular Function in the Aged

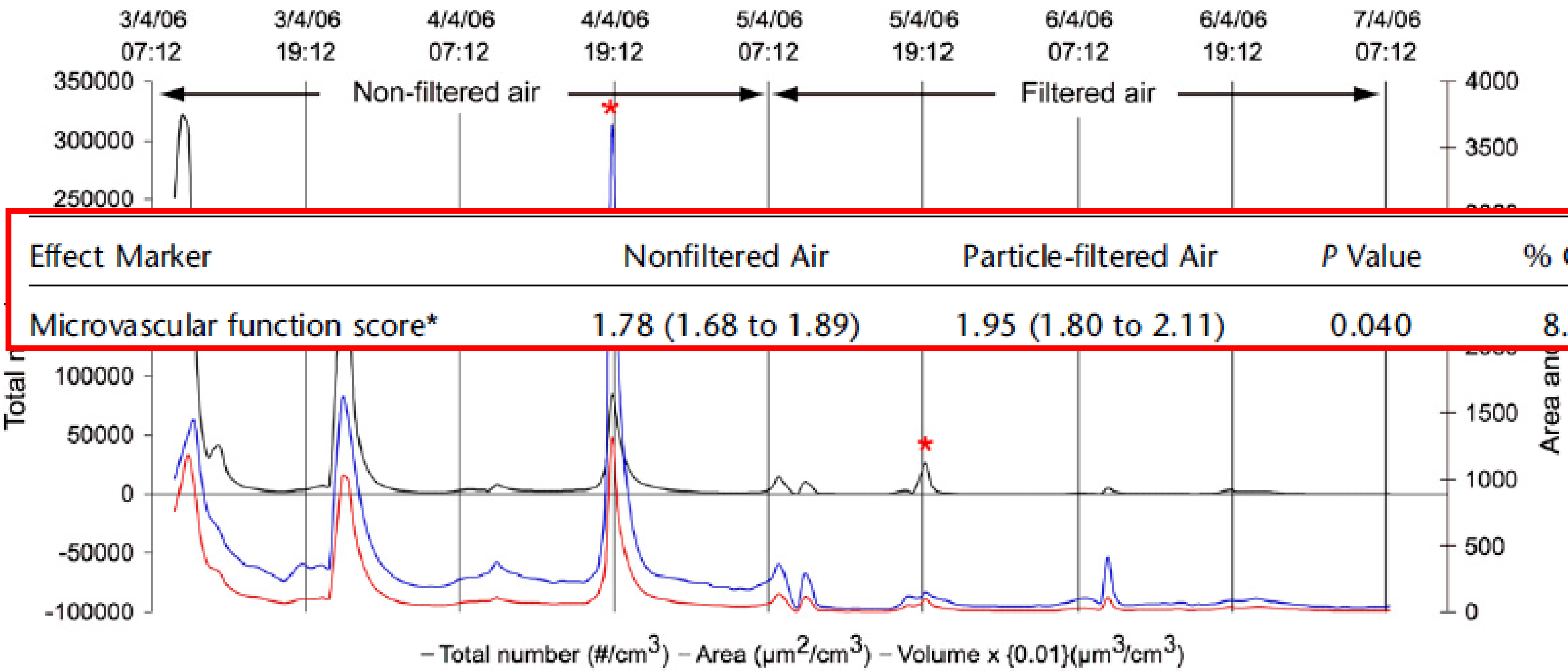
An Air Filtration–based Intervention Study

Elvira Vaclavik Bräuner[1], Lykke Forchhammer[1], Peter Møller[1], Lars Barregard[2], Lars Gunnarsen[3], Alireza Afshari[3], Peter Wåhlin[4], Marianne Glasius[4], Lars Ove Dragsted[5], Samar Basu[6], Ole Raaschou-Nielsen[7], and Steffen Loft[1]

Am J Respir Crit Care Med Vol 177. pp 419–425, 2008

Methods: A total of 21 nonsmoking couples participated in a randomized, double-blind, crossover study with two consecutive 48-hour exposures to either particle-filtered or nonfiltered air (2,533–4,058 and 7,718–12,988 particles/cm^3, respectively) in their homes.





Effect Marker	Nonfiltered Air	Particle-filtered Air	*P* Value	% Change (*95% CI*)[a]
Microvascular function score*	1.78 (1.68 to 1.89)	1.95 (1.80 to 2.11)	0.040	8.1 (0.4 to 16.3)

Figure 1. Number concentration ($NC_{10–700\ nm}$; *black line*), $Area_{10–700\ nm}$; (*red line*), and Vol- ... *e line*) ... g 48 ... d 48 ... on of the indoor air in one of the included homes. Peaks in $NC_{10–700\ nm}$ (*asterisks*) occurred during candle burning and cooking, as indicated.

Role of physicians and health professionals

Target 3: modifying personal exposure or dose

- Location matters: highest exposure to traffic-related pollutants within 50-100 m of busy roads
  - Moving house ?
  - Day care & schools
  - Walking, jogging, sports

  ! "Environmental equity"
- Time and activity matters
  - Sports outside rush hours
  - Sports in the morning (summer smog)
- Masks ?

Role of physicians and health professionals

Target 4: clinical action and preventive treatment

- Counselling about air-pollution (including active and passive smoking)
- Preventive interventions
  - Antioxidants and vitamins: some experimental and epidemiological evidence of beneficial effects of antioxidant vitamin supplements (→ healthy diet)
  - Optimize asthma treatment
  - Statins

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

B. Brunekreef*,#, I. Annesi-Maesano¶,+, J.G. Ayres§, F. Forastiereƒ, B. Forsberg**, N. Künzli##,¶¶, J. Pekkanen++,§§ and T. Sigsgaardƒƒ

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

2) Outdoor air pollution is one of the biggest environmental health threats in Europe today, leading to significant reductions of life expectancy and productivity.

3) Fine particles and ozone are the most serious pollutants. There is an urgent need to reduce their concentrations significantly.

Ten principles for clean air

4) Roadside pollution poses serious health threats that cannot be adequately addressed by regulating fine particle mass or ozone. Other metrics such as ultrafine particles and black carbon need to be considered in future research and so inform further regulation.

5) Non-tailpipe emissions (from brakes, tyres and road surfaces, etc.) pose a health threat for road users and subjects living close to busy roads.

6) Real-world emissions of nitrogen dioxide from modern diesel engines are much higher than anticipated. This may expose many road users, and subjects living on busy roads, to short-term peak concentrations during rush hours and periods of stagnating weather that may impact on health, although to what extent requires further research.

Ten principles for clean air

7) Global warming will lead to more heatwaves, during which air pollution concentrations are also elevated and during which hot temperatures and air pollutants act in synergy to produce more serious health effects than expected from heat or pollution alone.

8) Combustion of biomass fuel produces toxic pollutants. This is true for controlled fires, such as in fireplaces, woodstoves and agricultural burning, as well as for uncontrolled wildfires. There is a need to assess the real health impacts of air pollution from these sources in many areas in Europe to inform on the need for better control.

Ten principles for clean air

9) Compliance with current limit values for major air pollutants in Europe confers no protection for public health. In fact, very serious health effects occur at concentrations well below current limit values, especially those for fine particles.

10) EU policies to reduce air pollution are needed that ultimately lead to air that is clean and no longer associated with significant adverse effects on the health of European citizens. The benefits of such policies outweigh the costs by a large amount.