Nationale Dagen voor Arbeidsgeneeskunde
Journées Nationales de Médecine du Travail
Brussels, 14 November 2019

Ambient air pollution. Relevant for occupational health?

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Outline

- Ambient air pollution (Belgium – World)
- Short-term effects
- Long-term effects
- Relevance for occupational health ?

30 November 2015

European Environment Agency

Many Europeans still exposed to harmful air pollution

Air pollution is the single largest environmental health risk in Europe. It shortens people's lifespan and contributes to serious illnesses such as heart disease, respiratory problems and cancer. A new report published today by the European Environment Agency (EEA) estimates that air pollution continues to be responsible for more than 430 000 premature deaths in Europe.

> **Despite continuous improvements in recent decades, air pollution is still affecting the general health of Europeans, reducing their quality of life and life expectancy.**
>
> EEA Executive Director Hans Bruyninckx

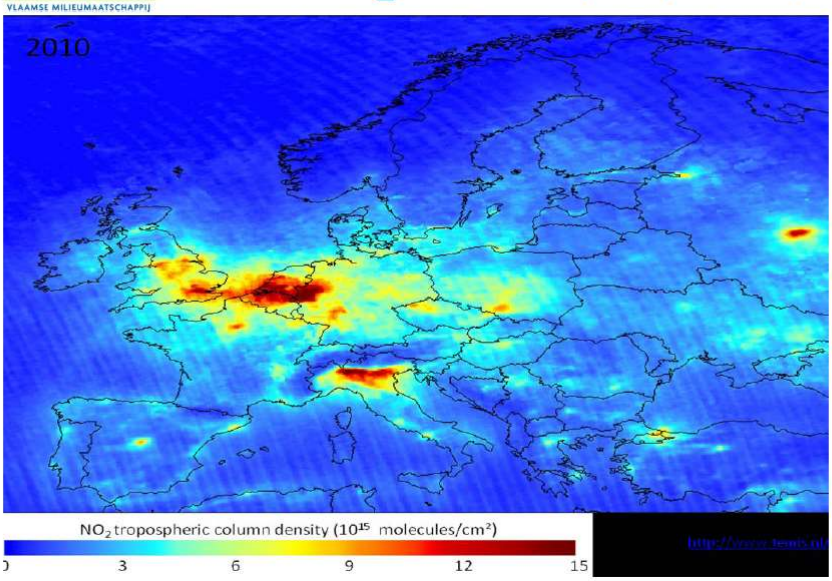
The EEA report 'Air quality in Europe — 2015 report' examines the European population's exposure to air pollutants and provides a snapshot of air quality based on data from official monitoring stations across Europe. It shows that most city dwellers continue to be exposed to air pollutants at levels deemed unsafe by the World Health Organization (WHO).

Main outdoor air pollutants

- Particulates:
  - PM_{10} = coarse + fine + ultrafine particles
  - $PM_{2.5}$ = fine + ultrafine particles
  - $PM_{0.1}$ = ultrafine particles ~ Black Carbon
- Gases:
  - NO_x
  - SO_2
  - O_3
  - …

Combustion processes

NO_2 in Europa (2010)



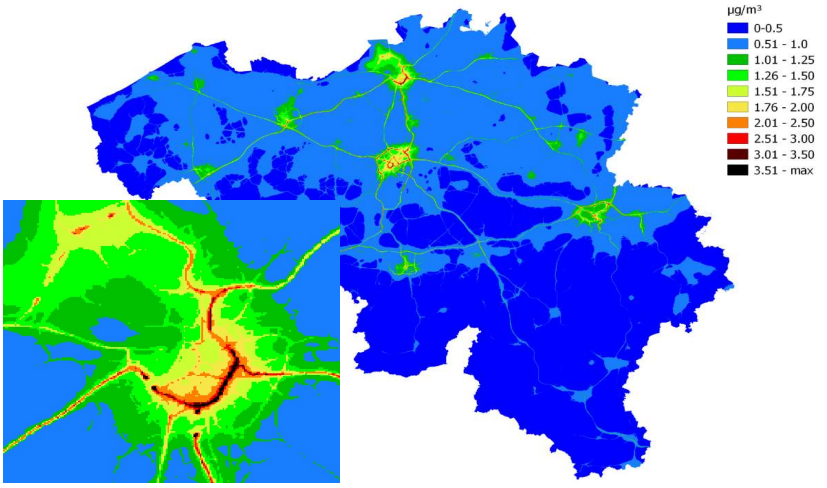
http://www.vmm.be/pub/presentaties-studiedag-fijn-stof/presentatie_04_TW.pdf

On-line information about air pollution in Belgium

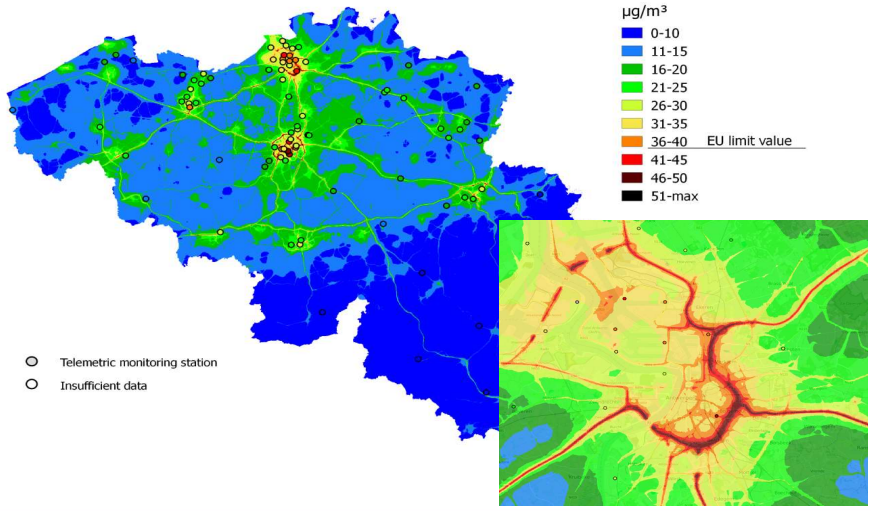
http://www.irceline.be/en

for Europe see: http://airindex.eea.europa.eu/

Annual mean Black Carbon (BC), 2014



Annual mean NO_2, 2014



CURIEUZE NEUZEN VLAANDEREN

Citizen Science project Antwerp, 2016

May 2018 : measurement of NO_2 in 20,000 locations in Flanders

https://curieuzeneuzen.be/in-english/

F. J. R. Meysman en S. De Craemer (2018) "CurieuzeNeuzen Vlaanderen: Het cijferrapport". 56 p. Universiteit Antwerpen.

CURIEUZE NEUZEN VLAANDEREN

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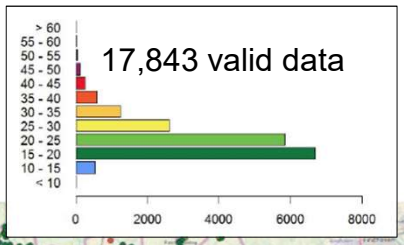

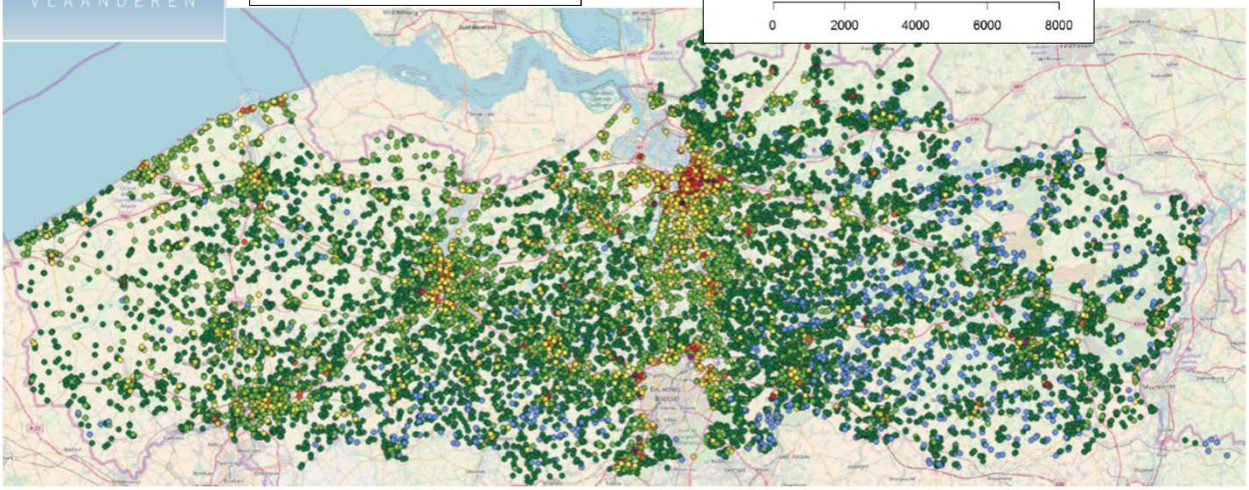

F. J. R. Meysman en S. De Craemer (2018) "CurieuzeNeuzen Vlaanderen: Het cijferrapport". 56 p. Universiteit Antwerpen.

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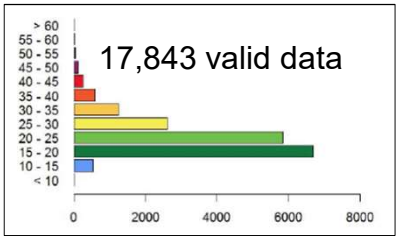
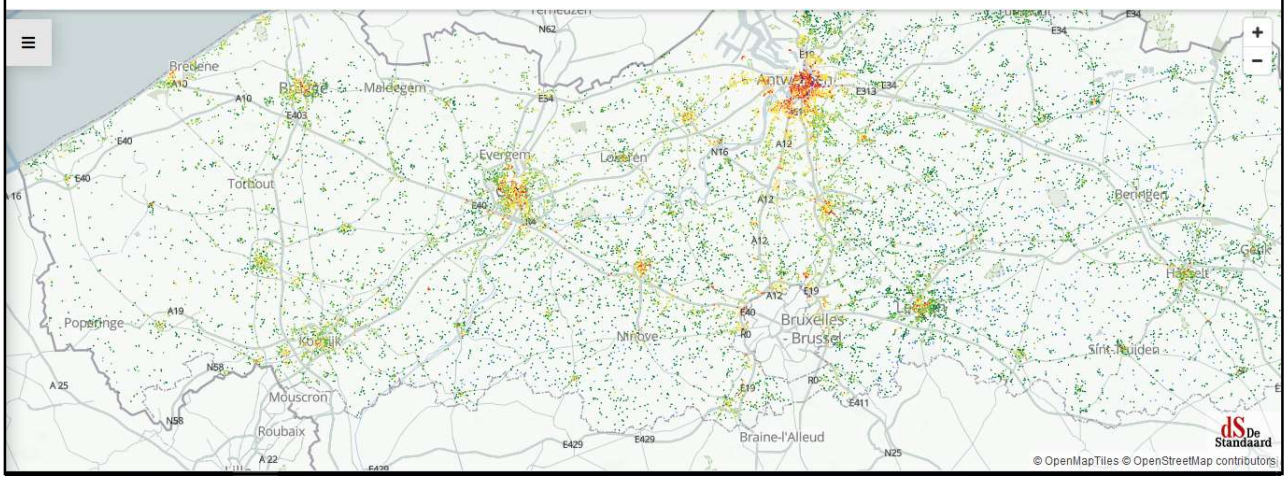
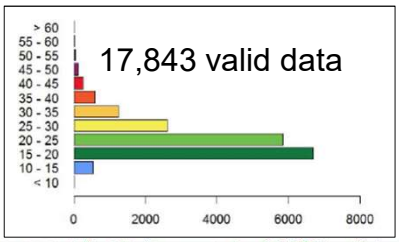
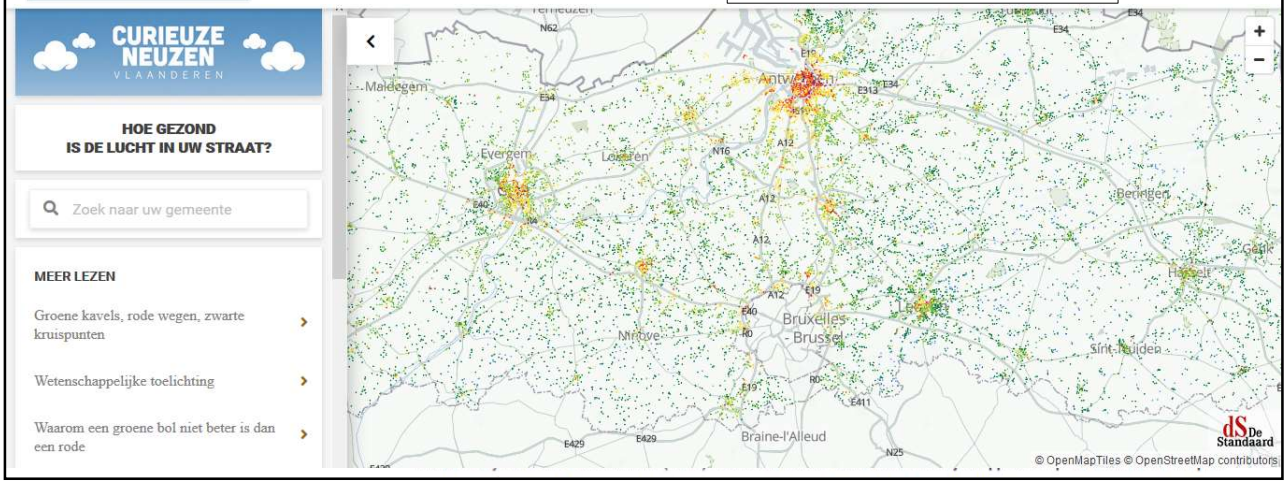




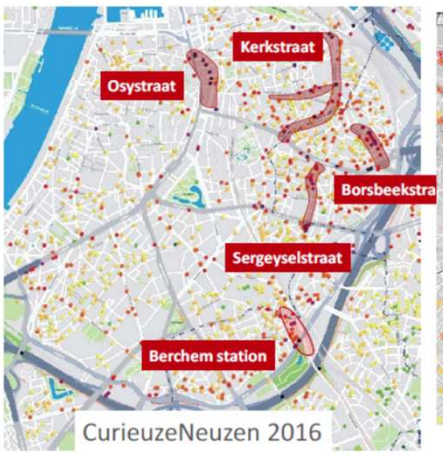
CURIEUZE NEUZEN VLAANDEREN

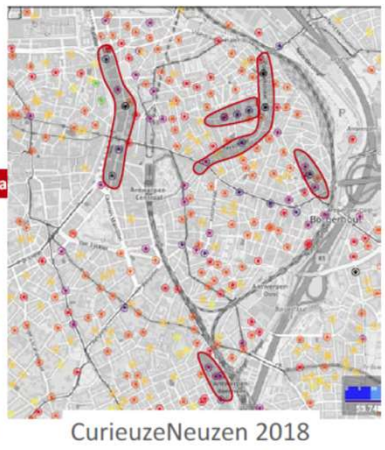
May 2018 : measurement of NO_2 in 20,000 locations in Flanders





Street Canyons

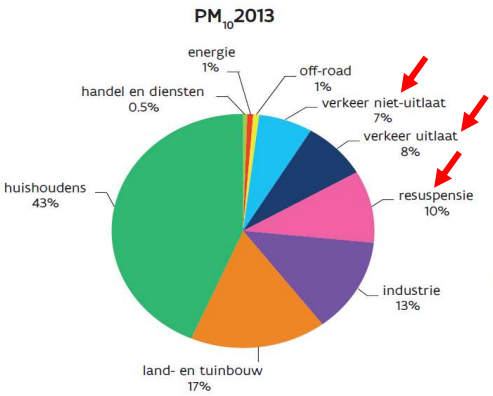




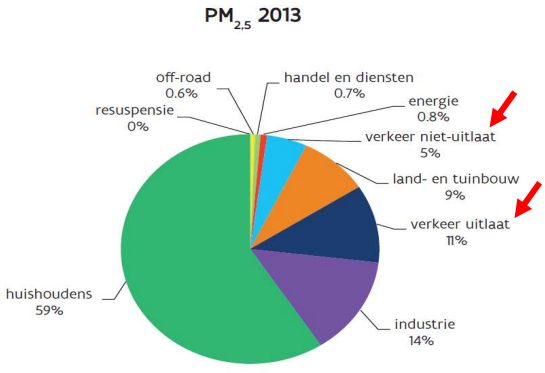
Figuur 35. Vergelijking van de "onzichtbare" street canyons in CurieuzeNeuzen 2016 Antwerpen met CurieuzeNeuzen 2018 Vlaanderen. Dezelfde starten vertonen dezelfde hoge NO_2 concentraties, met uitzondering van Sergeyselsstraat, die in mei 2018 volledig afgesloten was voor het verkeer.

F. J. R. Meysman en S. De Craemer (2018) "CurieuzeNeuzen Vlaanderen: Het cijferrapport". 56 p. Universiteit Antwerpen.

Sources *primary* PM10 and PM2.5

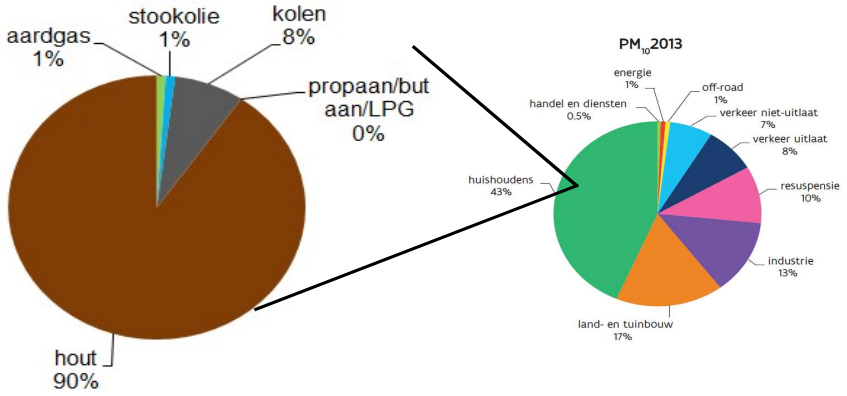


PM10, Traffic: 25%
(resuspension: 10%)



PM2.5 Traffic: 14%
(resuspension: 0%)

Primary Domestic Emissions PM10



PM10: 90% of domestic emissions = wood burning

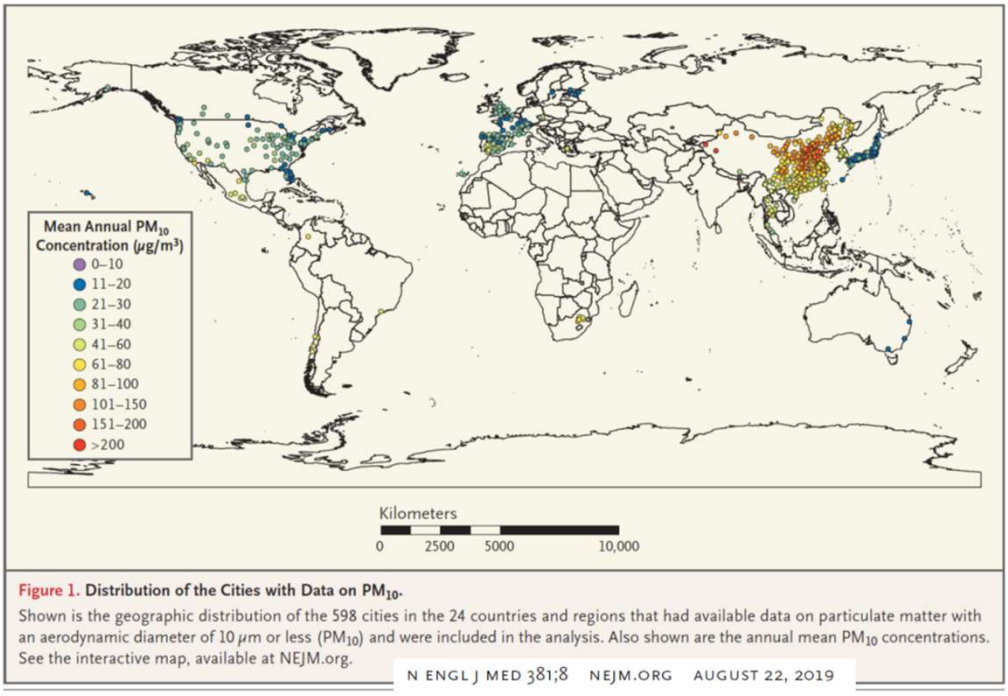


Figure 1. Distribution of the Cities with Data on PM_{10}.

Shown is the geographic distribution of the 598 cities in the 24 countries and regions that had available data on particulate matter with an aerodynamic diameter of 10 μm or less (PM_{10}) and were included in the analysis. Also shown are the annual mean PM_{10} concentrations. See the interactive map, available at NEJM.org.

N ENGL J MED 381;8 NEJM.ORG AUGUST 22, 2019

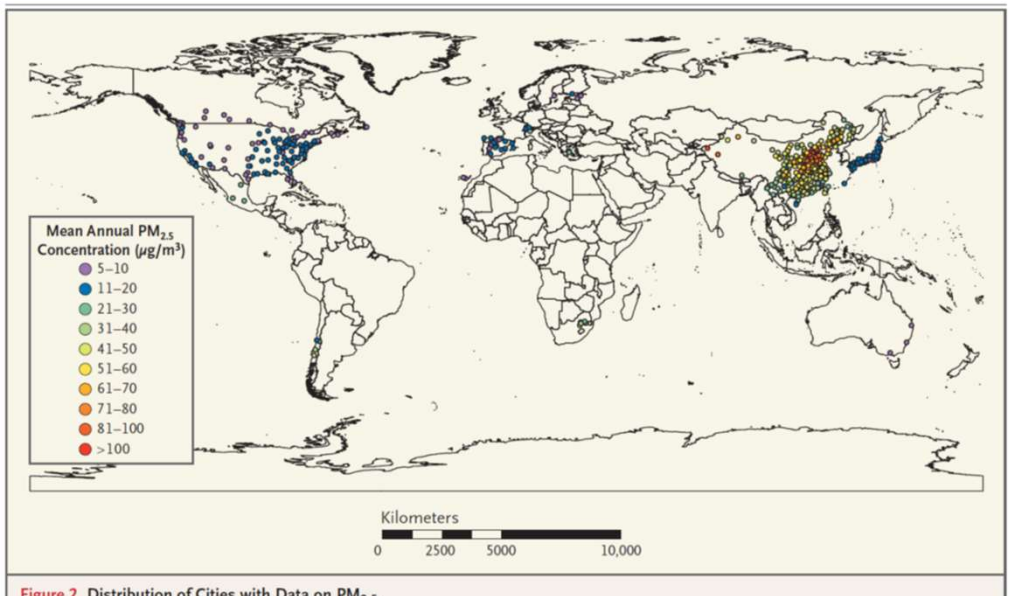


Figure 2. Distribution of Cities with Data on $PM_{2.5}$.
Shown is the geographic distribution of the 499 cities in the 16 countries and regions that had data on particulate matter with an aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$) and were included in the analysis. Also shown are the annual mean $PM_{2.5}$ concentrations. See the interactive map, available at NEJM.org.

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Air pollution and adverse health effects

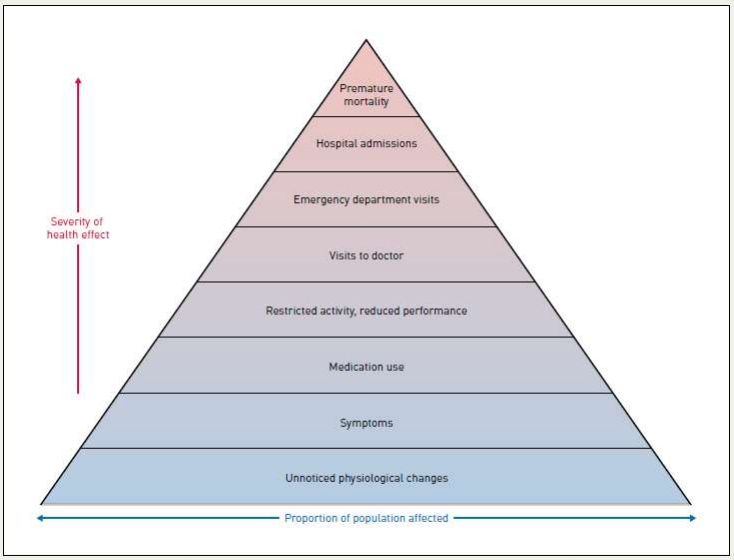


Figure 6a.1. Pyramid of health effects associated with air pollution [21].

deaths

hospital admissions

primary care visits

medication use

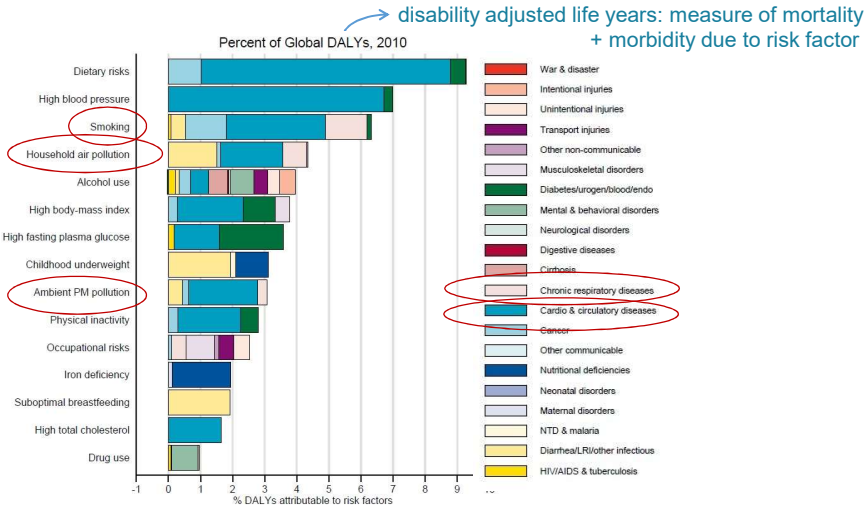
symptoms

growth & development

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

Premature mortality and disability

PM and human health

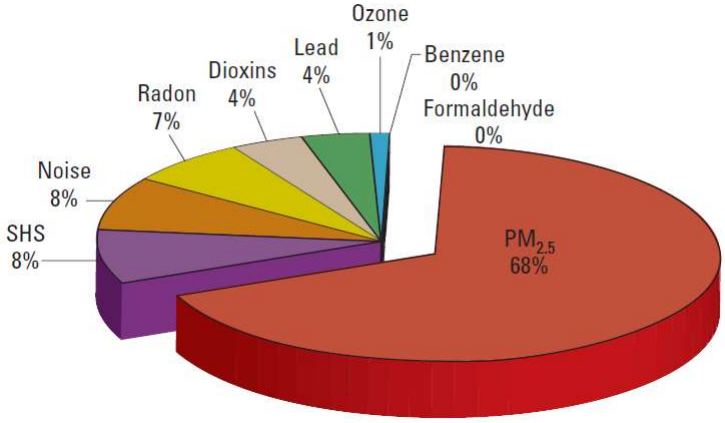


GBD Study 2010. *Lancet* 2012, 380, 2224-60

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

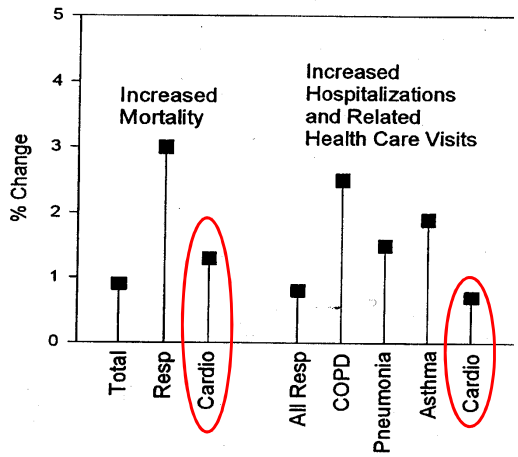


DALYs

Short term effects of pollutant particles

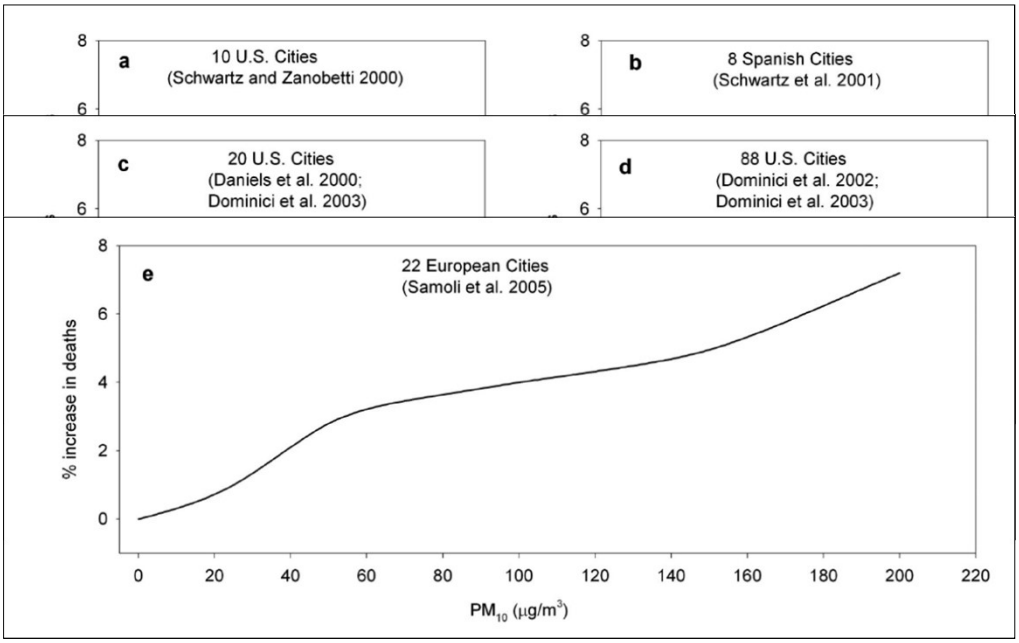
PM_{10} & mortality/morbidity (short term)

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



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

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



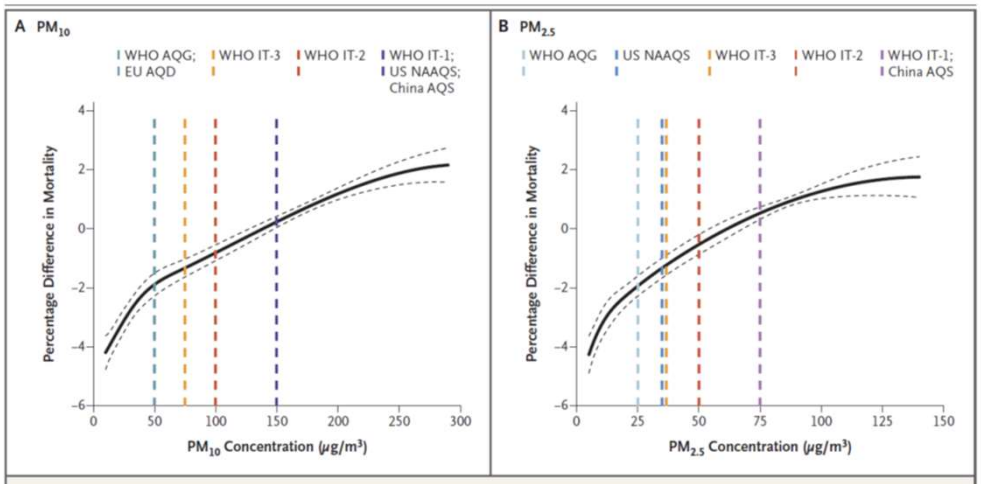


Figure 3. Pooled Concentration–Response Curves.

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).

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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

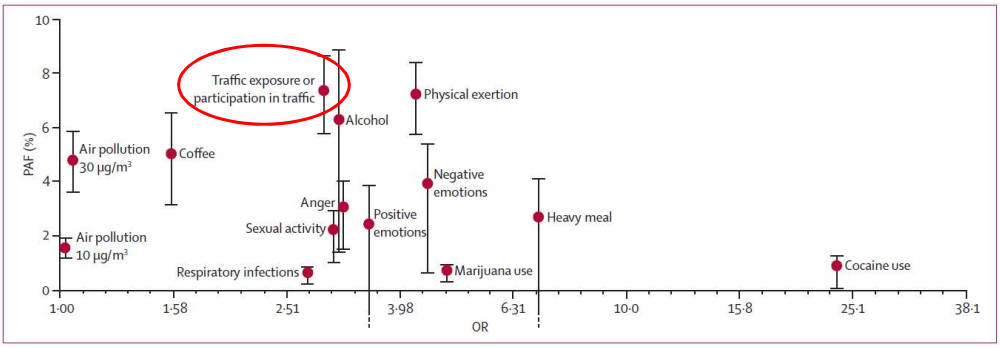
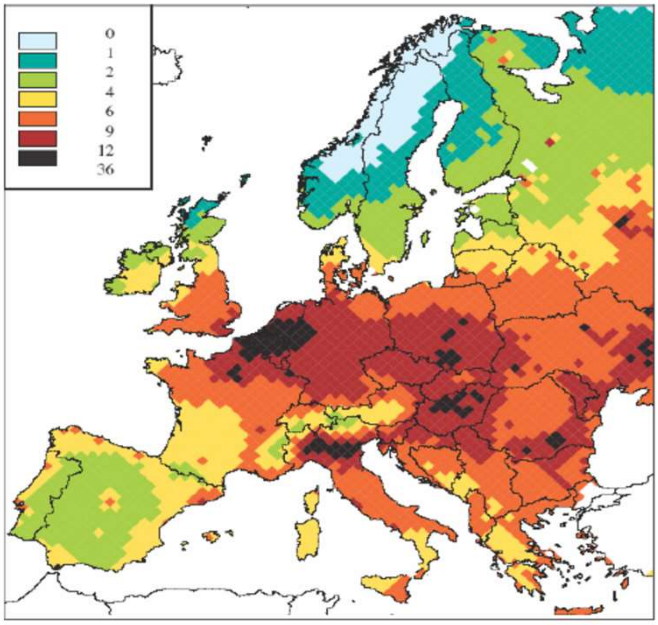


Figure 2: **Relation between OR and the PAF for each studies trigger**

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.

Long term effects of pollutant particles

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

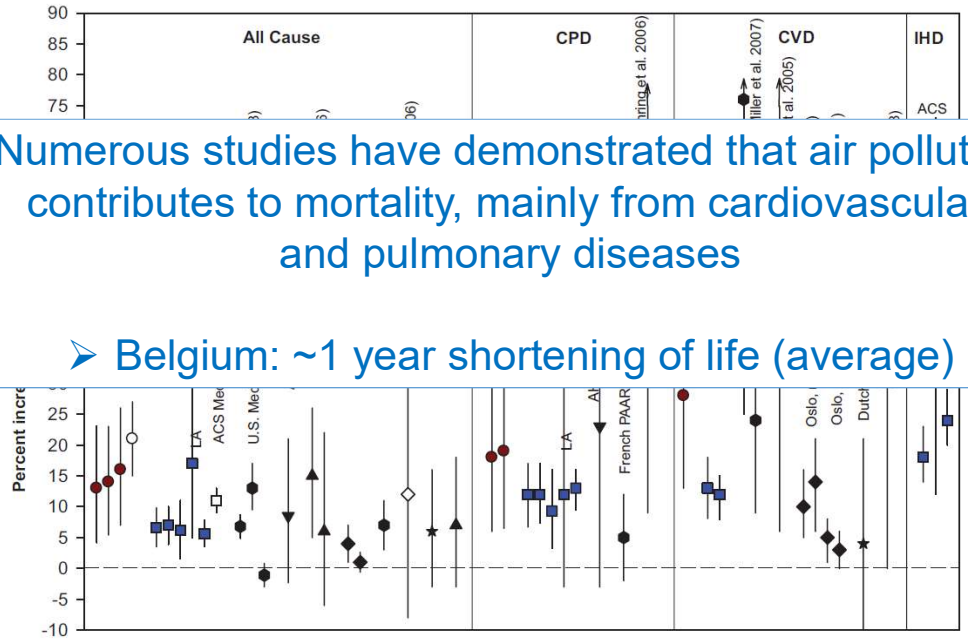


http://europa.eu.int/comm/environment/air/cafe/activities/pdf/cafe_scenario_report_2.pdf

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



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

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

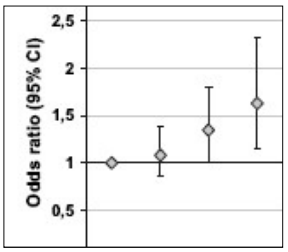
Figure 1. Risk estimates provided by several cohort studies per increment of 10 $\mu g/m^3$ in $PM_{2.5}$ or PM_{10}. CPD indicates cardiopulmonary disease; IHD, ischemic heart disease.

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

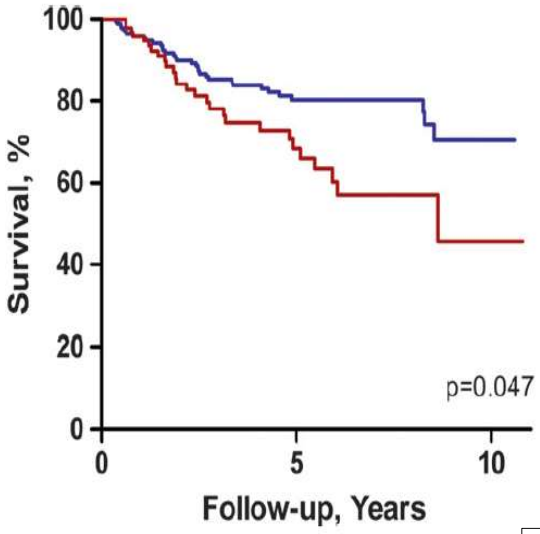
- Prospective cohort study, Germany:
  - 2000 - : 4494 persons, 45-74 y
  - Coronary artery calcification (CAC) by electron-beam CT
- Exposure: distance of residence to major roads
- OR for high CAC (> 75th percentile):
  - > 200 m from major road : 1 (reference)
  - 101-200 m : 1.08
  - 51-100 m : 1.34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



Relevance

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

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

Growth and development

Air pollution and growth of pulmonary function

> 150

tudy
~10y)
-up

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

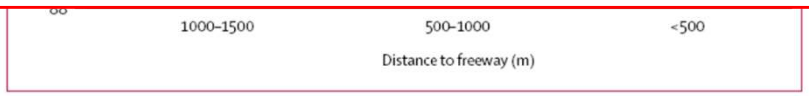


Figure: Percent-predicted lung function at age 18 years versus residential distance from a freeway
The horizontal line at 100% corresponds to the referent group, children living >1500 m from a freeway.

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

Air pollution and cognitive development

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

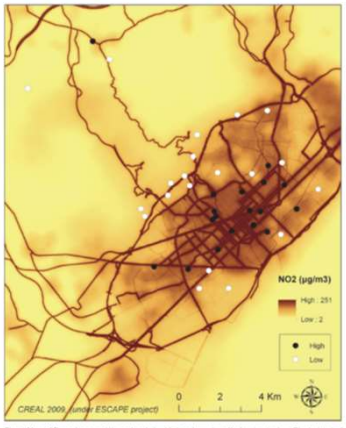


Fig 1. Map of Barcelona and the schools by high or low air pollution by design. Black dots indicate the locations of schools with high air pollution, and white dots indicate the locations of schools with low air pollution, based on NO_2 levels.

doi:10.1371/journal.pmed.1001792.g001

NO_2 µg/m^3

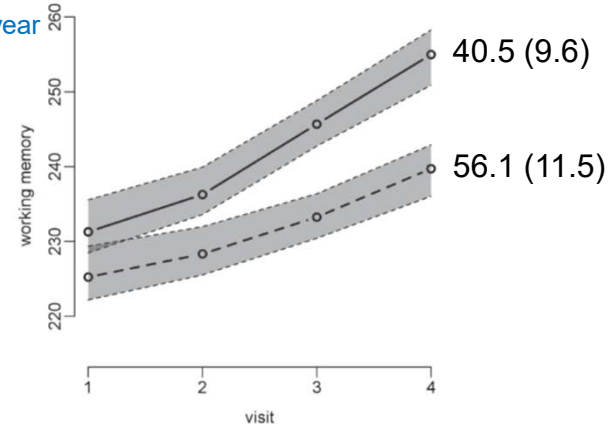


Fig 2. Working memory development by high- or low-traffic-air-pollution school. Dashed line = high traffic air pollution; continuous line = low traffic air pollution; gray shading indicates 95% CIs. Adjusted for age, sex, maternal education, residential neighborhood socioeconomic status, and air pollution 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

Air pollution and the brain (cognition, depression, dementia, …)

Chen *et al*. Living near major roads and the incidence of dementia, Parkinson's disease, and multiple sclerosis: a population-based cohort study. *Lancet* 2017, 389, 718-26

- Ontario, 4.4 million adults 20-50y + 2.2 million adults (55-85y) in 2001
- Residential address in 1996; average $PM_{2.5}$ 9.7 µg/m^3 [1.3-19.8]; NO_2 15.4 ppb [2.2-62]

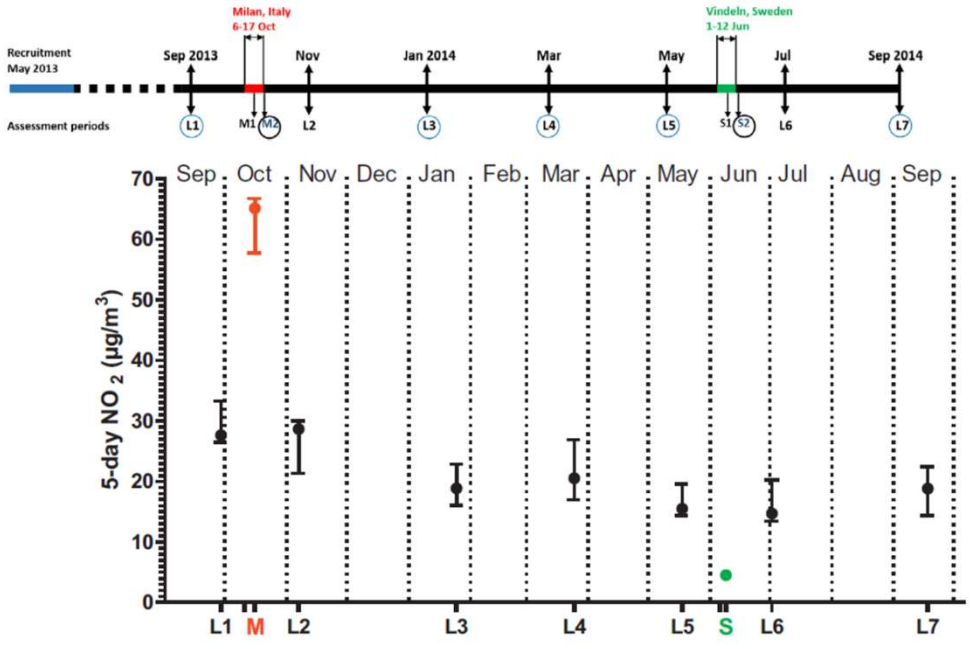
	Incidence of dementia (n=243611)‡ 2001-2012			Incidence of Parkinson's disease (n=31577)‡			Incidence of multiple sclerosis (n=9247)‡		
Distance to major roadways in 1996	HR	95% CI	p_{trend}	HR	95% CI	p_{trend}	HR	95% CI	p_{trend}
<50 m	1·07	1·06–1·08	0·0349	1·01	0·98–1·04	0·12	1·02	0·95–1·09	0·72
50–100 m	1·04	1·02–1·05	..	1·01	0·97–1·05	..	0·93	0·86–1·01	..
101–200 m	1·02	1·01–1·03	..	0·99	0·96–1·03	..	1·01	0·95–1·08	..
201–300 m	1·00	0·99–1·01	..	0·99	0·96–1·02	..	1·01	0·94–1·08	..
>300 m	Reference	..	..	Reference	..	..	Reference	..	..
Log(distance)§	0·91	0·89–0·92	..	0·99	0·97–1·01	..	1·00	0·98–1·02	..

Robust to multiple adjustments and sensitivity analyses

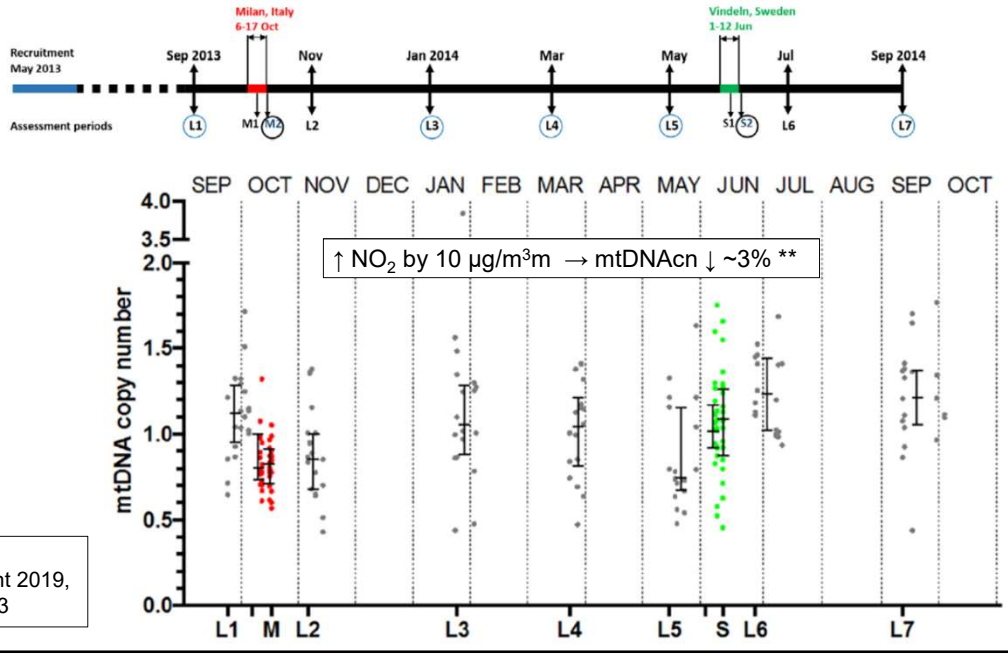
Relevance for occupational health?

- Traffic-related pollution
  - Daily commuting
  - Drivers: truck, bus, taxi, delivery vans, …
  - Police, toll, …
  - Road workers (building, maintenance, …)
- Travel to polluted areas
  - Occasional missions

GeFiSto study: 2x10 healthy subjects (58-76 y)



GeFiSto study: 2x10 healthy subjects (58-76 y)



Bai *et al*.
Environ Int 2019,
119, 47-53

GeFiSto study: 2x10 healthy subjects (58-76 y)

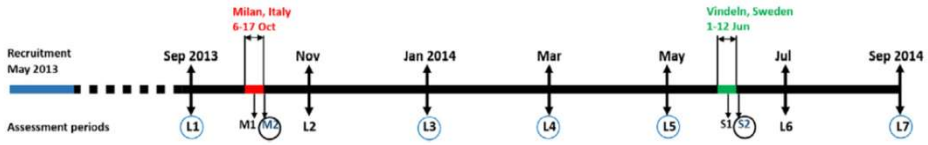


Table 3 Adjusted[a] changes (95% CI) in blood pressure and measures of arterial stiffness associated with an increase in five-day averages of PM_{10}, $PM_{2.5}$, or NO_2 concentrations (n observations = 220)

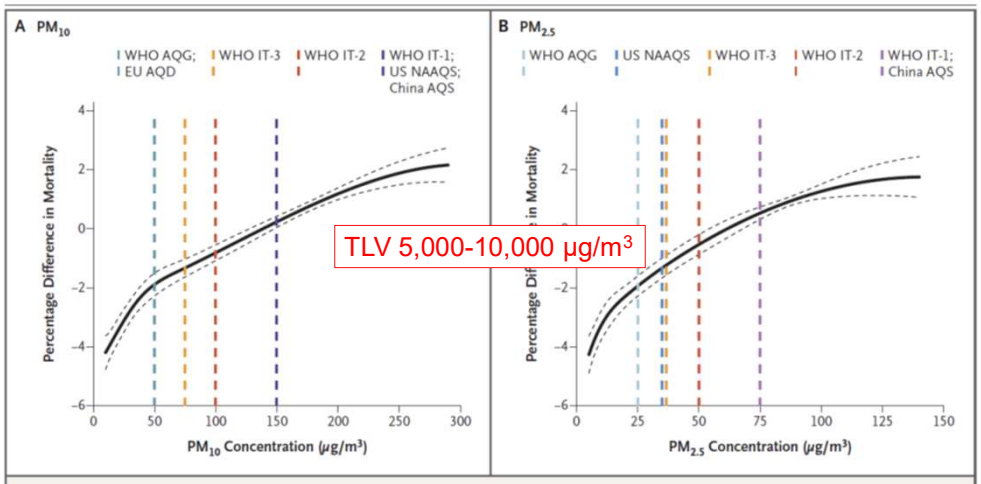
	Monitoring stations			Personal exposure
	PM_{10}	$PM_{2.5}$	NO_2	NO_2
	per 10 µg/m³	per 5 µg/m³	per 10 µg/m³	per 10 µg/m³
Blood pressure (unit change)				
Systolic, mm Hg	−0.01 (−2.16;2.15)	0.26 (−0.72;1.24)	−0.98 (−2.23;0.26)	−0.14 (−1.17;0.88)
Diastolic, mm Hg	−1.14 (−2.59;0.30)	−0.28 (−0.94;0.38)	−0.66 (−1.52;0.19)	−0.28 (−1.00;0.43)
Pulse pressure, mm Hg	1.11 (−0.43;2.65)	0.53 (−0.17;1.22)	−0.35 (−1.24;0.54)	0.11 (−0.62;0.83)
Carotid stiffness (% change)[b]				
PWV, m/s	**2.13 (0.80;3.47)**	**0.96 (0.32;1.59)**	0.78 (−0.05;1.61)	0.63 (−0.04;1.30)
DC, 10^{-3}/kPa	**−4.25 (−6.99;-1.51)**	**−1.91 (−3.21;-0.61)**	−1.58 (−3.28;0.12)	−1.31 (−2.69;0.07)
CC, mm²/kPa	**−4.65 (−7.05;-2.26)**	**−2.06 (−3.20;-0.91)**	**−2.05 (−3.54;-0.56)**	**−1.42 (−2.64;-0.20)**
YEM, kPa	**4.18 (1.10;7.25)**	**2.07 (0.60;3.53)**	1.56 (−0.34;3.45)	1.36 (−0.14;2.86)

[a]Adjusted for age at baseline, sex, heart rate, smoking status, having a cold, medication use for blood pressure, date, temperature, relative humidity
[b]Models additionally adjusted for arterial pressure
Bold indicates *p*-value< 0.05
PWV Pulse wave velocity, *DC* Distensibility coefficient, *CC* Compliance coefficient, *YEM* Young's elastic modulus

Scheers *et al*. Environ Health 2018, 17: 80

Relevance for occupational health?

- Traffic-related pollution
  - Daily commuting
  - Drivers: truck, bus, taxi, delivery vans, …
  - Police, toll, …
  - Road workers (building, maintenance, …)
- Travel to polluted areas
  - Occasional missions
  - Expats ?
- Occupational Exposure Limits *vs* Air Quality Guidelines?



TLV 5,000-10,000 µg/m^3

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).

N ENGL J MED 381;8 NEJM.ORG AUGUST 22, 2019

Thank you for your attention

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