# *Luftföroreningarnas hälsokonsekvenser*

# *- omfattning, orsaker och utveckling*

***Bertil Forsberg***
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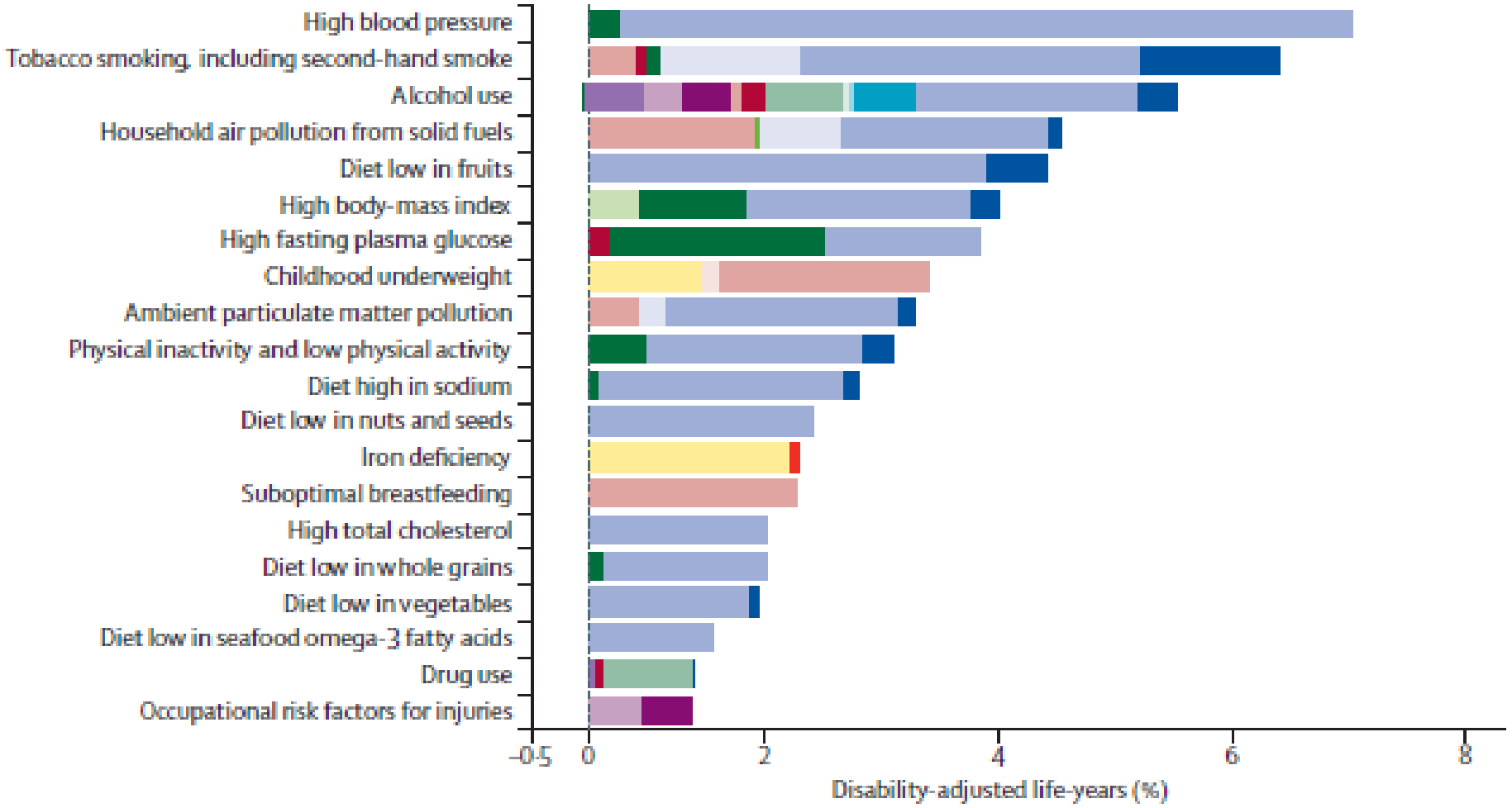
# Luftföroreningar viktiga enligt Global Burden of Disease

(Lancet 2012;380:2224-60)



# Air pollution: Europe's avoidable health risk

Corbis

**430 000 förtida dödsfall /år i Europa pga partiklar**

**7 miljoner förlorade levnadsår**

There is now no doubt that air pollution, and especially fine particulate matter (PM2·5), has many serious consequences for health and leads to avoidable premature deaths. A large body of evidence exists for short-term and long-term effects on cardiovascular diseases and respiratory diseases—including chronic obstructive pulmonary disease, asthma, and lung cancer. Newly emerging evidence suggests possible effects on premature births, lung-function development in children, and accelerated progression of atherosclerosis and cognitive impairment. Even more worrying is that these effects may exist at low levels of air pollution and that there is no safe threshold level, rather a linear concentration-response relationship.

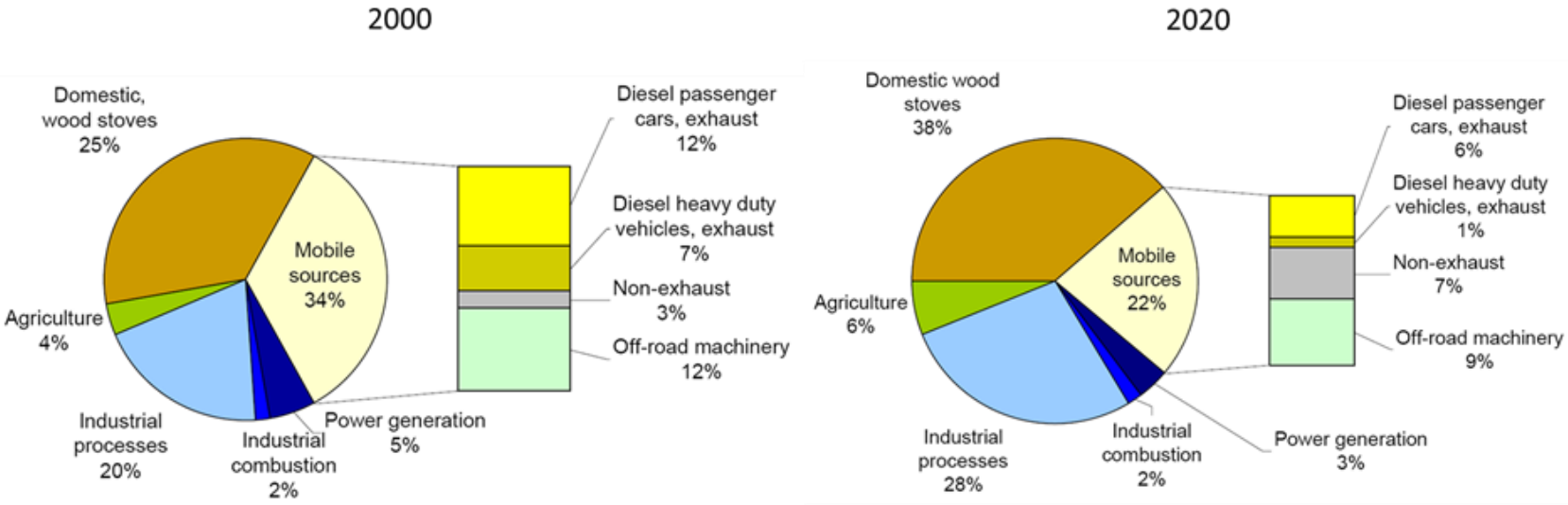
The current EU limit for PM2·5 at 25 μg/m³ annual average is already higher than the WHO Air Quality Guidelines (10 μg/m³), a discrepancy that needs urgent attention but this might not be enough. As the EU has declared 2013 "The Year of the Air", there is hope that air pollution—the most important environmental risk factor for the health of Europeans—will get the attention it deserves.

However, discussions need to go beyond health. A new report, *The unpaid health bill: how coal power plants make us sick*, released by the Health and Environment Alliance on March 7, points out the underappreciated source of air pollution from coal power plants. It estimates that 18 200 premature deaths per year and up to €42·8 billion in health-related costs are attributable to coal power generation. The number of coal power plants has been decreasing for decades but they are now increasing again with 500 new plants under discussion. They emit PM, but also toxic heavy metals such as mercury. Germany, Poland, and Romania's coal power plants are responsible for half of all estimated health impacts, and of course health effects do not respect borders. The report calls for phasing out of coal power in Europe by 2040 and for an immediate moratorium on the construction of new plants.

Tackling air pollution is an important example where Europe-wide joined-up thinking is urgently needed. Energy, climate change, and health—some of the most important issues of the 21st century—must be considered together in all relevant policies. ■ *The Lancet*

For the **report on coal power plants** see http://www.env-health.org/IMG/pdf/heal_report_the_unpaid_health_bill_how_coal_power_plants_make_us_sick_final.pdf

# Småskalig vedeldning får allt större betydelse för primära emissioner av PM2.5 i Europa (EU)

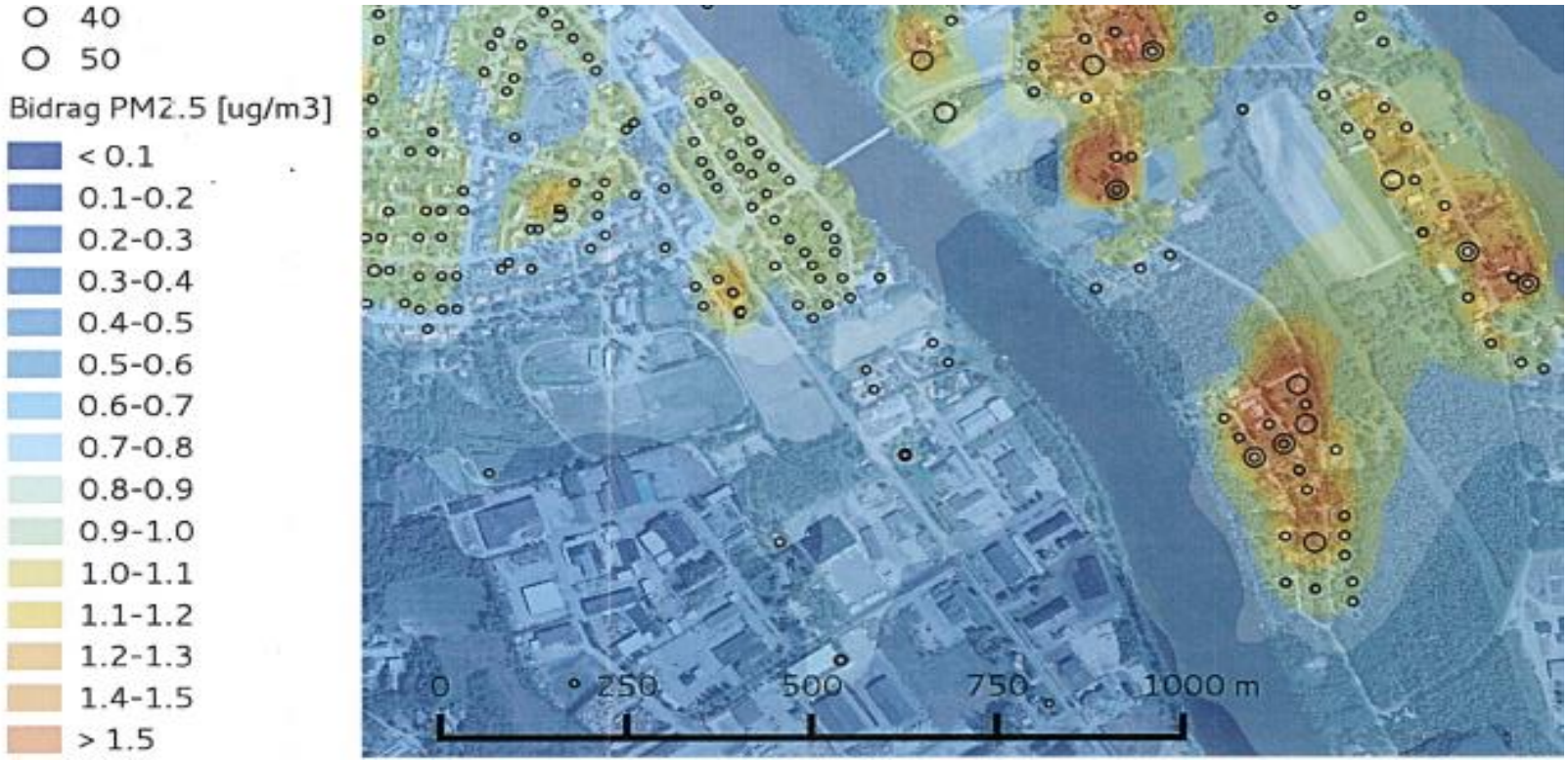



**65 milj kaminer, pannor, spisar etc inom EU**

# Småskaliga vedeldningens betydelse för dödlighet via *utomhusluften* globalt (WHO, 2015)

| | Deaths from OAP due to household: | | DALYs from OAP due to household: | |
|---|---|---|---|---|
| **Region** | Heating | Cooking | Heating | Cooking |
| **Eastern Europe** | 21,000 | 0 | 410,000 | 0 |
| **Central Europe** | 20,000 | 0 | 340,000 | 0 |
| **Western Europe** | 20,000 | 2 | 290,000 | 24 |
| **East Asia** | 19,000 | 130,000 | 390,000 | 2,600,000 |
| **South Asia** | 10,000 | 200,000 | 310,000 | 6,000,000 |
| **High-income North America** | 9,200 | 0 | 160,000 | 0 |
| **North Africa and Middle East** | 4,700 | 5,800 | 130,000 | 160,000 |
| **Central Asia** | 4,200 | 78 | 110,000 | 2,000 |
| **High-income Asia Pacific** | 3,200 | 530 | 49,000 | 8,200 |
| **Southeast Asia** | 1,700 | 18,000 | 42,000 | 450,000 |
| ***Global*** | ***110,000*** | ***370,000*** | ***2,200,000*** | ***9,900,000*** |

# Modellerat bidrag från vedeldning till årsmedelhalten av PM2.5 i Umeå



# PM ger 3500 + 1800 förtida dödsfall per år i Sverige

Bertil Forsberg, Hans-Christen Hansson, Christer Johansson, Hans Areskoug, Karin Persson and Bengt Järvholm

## Comparative Health Impact Assessment of Local and Regional Particulate Air Pollutants in Scandinavia

The ongoing program Clean Air for Europe (CAFE) is an initiative from the EU Commission to establish a coordinated effort to reach better air quality in the EU. The focus is on particulate matter as it has been shown to have large impact on human health. CAFE requested that WHO make a review of the latest findings on air pollutants and health to facilitate assessments of the different air pollutants and their health effects. The WHO review project on health aspects of air pollution in Europe confirmed that exposure to particulate matter (PM), despite the lower levels we face today, still poses a significant risk to human health. Using the recommended uniform risk coefficients for health impact assessment of PM, regardless of sources, premature mortality related to long-range transported anthropogenic particles has been estimated to be about 3500 deaths per year for the Swedish population, corresponding to a reduction in life expectancy of up to about seven months. The influence of local sources is more difficult to estimate due to large uncertainties when linking available risk coefficients to exposure data, but the estimates indicate about 1800 deaths brought forward each year with a life expectancy reduction of about 2–3 months. However, some sectors of the population are exposed to quite high locally induced concentrations and are likely to suffer excessive reductions in life expectancy. Since the literature increasingly supports assumptions that combustion related particles are associated with higher relative risks, further studies may shift the focus for abatement strategies. CAFE sets out to establish a general cost effective abatement strategy for atmospheric particles. Our results, based on studies of background exposure, show that long-range transported sulfate rich particles dominate the health effects of PM in Sweden. The same results would be found for the whole of Scandinavia and many countries influenced by transboundary air pollution. However, several health studies, including epidemiological studies with a finer spatial resolution, indicate that engine exhaust particles are more damaging to health than other particles. These contradictory findings must be understood and source specific risk estimates have to be established by expert bodies, otherwise it will not be possible to find the most cost effective abatement strategy for Europe. We are not happy with today's situation where every strategy to reduce PM concentrations is estimated to have the same impact per unit change in the mass concentration. Obviously there is a striking need to introduce more specific exposure variables and a higher geographical resolution in epidemiology as well as in health impact assessments.

### INTRODUCTION

The WHO review project, initiated by the EU Commission Clean Air for Europe (CAFE), on health aspects of air pollution in Europe confirmed that exposure to particulate matter (PM), despite the lower levels we see today, still poses a significant risk to human health (1, 2). In particular, the long-term effect on mortality is a serious impact. The review further concluded that it has not been possible to establish a causal relationship between PM-related health effects and one single PM component, even though a number of epidemiological and toxicological studies suggest that some types of emissions are more strongly associated with health effects, especially motor vehicle exhausts and other combustion products. Despite these indications, the WHO reports do not propose any source or compound-specific risk coefficients for PM. The lack of source-specific relative risks have also resulted in the recommendation by a WHO expert meeting to use one single risk coefficient for anthropogenic PM in the

### AIM

Due to the lack of data about how different PM components act in a complex mixture, experts still do not judge it possible to precisely quantify the contributions from the main sources and components, to the effects on human health (1, 2). Thus, PM in health impact assessments is usually handled as a uniform pollutant, regardless of the contribution from different sources, and assuming the same effect on mortality. This is probably not a correct assumption, but is a pragmatic compromise while waiting for sufficient knowledge that will allow the use of indicators other than particle mass and/or source specific relative risks. The aim of this study is to describe the level of mortality in Sweden today and in the near future will be affected by regional and local PM when using this common assumption.

### PM10 CONCENTRATIONS

**Forsberg et al**
**Ambio, 2005;34:11-19**

# Beräkning för Sverige 2010

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exposure to N
and estimated
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Malin Gustafsson, I
Stefan Åström, H

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[1] Umeå University

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Research Inst

Table 13 Estimated excess mortality due to exposure to $PM_{10}$ from *road dust* in the Swedish population in 2010 (all ages).

| $PM_{10}$ concentration [µg/m³] | Mean $PM_{10}$ [µg/m³] | Number of people | Percentage of population | Excess number of deaths |
|---|---|---|---|---|
| 0 | 0.0 | 2 765 281 | 29.0 | 0 |
| 0 - <1 | 0.5 | 2 167 907 | 22.7 | 18 |
| 1 - <2 | 1.5 | 1 788 399 | 18.7 | 40 |
| 2 - <3 | 2.5 | 1 396 215 | 14.6 | 53 |
| 3 - <4 | 3.4 | 687 938 | 7.2 | 36 |
| 4 - <5 | 4.4 | 325 286 | 3.4 | 22 |
| 5 - <6 | 5.4 | 100 042 | 1.0 | 8 |
| 6 - <7 | 6.4 | 89 022 | 0.9 | 9 |
| 7 - <8 | 7.5 | 61 277 | 0.6 | 7 |
| 8 - <9 | 8.2 | 92 440 | 1.0 | 12 |
| 9 - <10 | 9.5 | 25 357 | 0.3 | 4 |
| 10 - <11 | 10.0 | 13 804 | 0.1 | 2 |
| 11 - <12 | 11.6 | 15 509 | 0.2 | 3 |
| 12 - <13 | 12.5 | 0 | 0.0 | 0 |
| 13 - <14 | 13.2 | 18 069 | 0.2 | 4 |
| **Total** | **1.3** | **9 546 546** | **100** | **218** |

# PM2.5 ger ca 3500 dödsfall per år

**Table 12** Estimated excess mortality due to exposure to total $PM_{2.5}$ in the Swedish adult population (age 30+) in 2010.

| $PM_{2.5}$ concentration [µg/m³] | Mean $PM_{2.5}$ [µg/m³] | Number of people | Percentage of population | Excess number of deaths |
|---|---|---|---|---|
| 0- <2 | | 0 | 0 | 0 |
| 2- <4 | 3.4 | 329 191 | 5.4 | 40 |
| 4 - <6 | 5.1 | 1 353 155 | 22.2 | 384 |
| 6 - <8 | 6.9 | 1 587 504 | 26.1 | 714 |
| 8 - <10 | 9.0 | 1 269 257 | 20.8 | 811 |
| 10 - <12 | 10.9 | 817 579 | 13.4 | 667 |
| 12 - <14 | 12.9 | 360 094 | 5.9 | 363 |
| 14 - <16 | 15.0 | 128 159 | 2.1 | 155 |
| 16 - <18 | 16.7 | 119 037 | 2.0 | 164 |
| 18 - <20 | 19.2 | 58 719 | 1.0 | 95 |
| 20 - <22 | 20.6 | 36 553 | 0.6 | 65 |
| 22 - <24 | 22.7 | 22 017 | 0.4 | 34 |
| >24 | 27.0 | 17 380 | 0.3 | 42 |
| **Total** | **8.3** | **6 093 373** | **100** | **3 534** |

mortality is a serious impact. The review further concluded that it has not been possible to establish a causal relationship between PM-related health effects and one single PM component, even though a number of epidemiological and toxicological studies suggest that some types of emissions are more strongly associated with health effects, especially motor vehicle exhausts and other combustion products. Despite these indications, the WHO reports do not propose any source or compound-specific risk coefficients for PM. The lack of source-specific relative risks have also resulted in the recommendation by a WHO expert meeting to use one single risk coefficient for anthropogenic PM in the CAFE assessment built on the RAINS model (http://www.iiasa

as a uniform pollutant, regardless of the contribution from different sources, and assuming the same effect on mortality. This is probably not a correct assumption, but is a pragmatic compromise while waiting for sufficient knowledge that will allow the use of indicators other than particle mass and/or source specific relative risks. The aim of this study is to describe the level of mortality in Sweden today and in the near future will be affected by regional and local PM when using this common assumption.

**PM10 CONCENTRATIONS**

**Ambio, 2005;34:11-19**

Journal of Exposure Science and Environmental Epidemiology (2015) 25, 524–531

www.nature.com/jes

ORIGINAL ARTICLE

# Potential health impacts of changes in air pollution exposure associated with moving traffic into a road tunnel

Hans Orru[1,2], Boel Lövenheim[3], Christer Johansson[3,4] and Bertil Forsberg[1]

A planned 21 km bypass (18 km within a tunnel) in Stockholm is expected to reduce ambient air exposure to traffic emissions, but same time tunnel users could be exposed to high concentrations of pollutants. For the health impacts calculations in 2030, the change in annual ambient $NO_X$ and $PM_{10}$ exposure of the general population was modelled in $100 \times 100\,m^2$ grids for Greater Stockholm area. The tunnel exposure was estimated based on calculated annual average $NO_X$ concentrations, time spent in tunnel and number of tunnel users. For the general population, we estimate annually 23.7 (95% CI: 17.7–32.3) fewer premature deaths as ambient concentrations are reduced. At the same time, tunnel users will be exposed to $NO_X$ levels up to $2000\,\mu g/m^{-3}$. Passing through the whole tunnel two times on working days would correspond to an additional annual $NO_X$ exposure of $9.6\,\mu g/m^3$. Assuming that there will be ~55,000 vehicles daily each way and 1.3 persons of 30–74 years of age in each vehicle, we estimate the tunnel exposure to result in 20.6 (95% CI: 14.1–25.6) premature deaths annually. If there were more persons per vehicle, or older and vulnerable people travelling, or tunnel dispersion conditions worsen, the adverse effect would become larger.

*Journal of Exposure Science and Environmental Epidemiology* (2015) **25,** 524–531; doi:10.1038/jes.2015.24; published online 29 April 2015

**Keywords:** epidemiology; exposure modelling; particulate matter; personal exposure

# Vägtrafik kan lokalt och temporärt ge höga PM10-halter

## Estimated Short-Term Effects of Coarse Particles on Daily Mortality in Stockholm, Sweden

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Stockholm, Sweden

BACKGROUND: Although serious health effects associated with particulate matter (PM) with aerodynamic diameter ≤ 10 μm ($PM_{10}$) and ≤ 2.5 μm ($PM_{2.5}$; fine fraction) are documented in many studies, the effects of coarse PM ($PM_{2.5–10}$) are still under debate.

OBJECTIVE: In this study, we estimated the effects of short-term exposure of $PM_{2.5–10}$ on daily mortality in Stockholm, Sweden.

METHOD: We collected data on daily mortality for the years 2000 through 2008. Concentrations of $PM_{10}$, $PM_{2.5}$, ozone, and carbon monoxide were measured simultaneously in central Stockholm. We used additive Poisson regression models to examine the association between daily mortality and $PM_{2.5–10}$ on the day of death and the day before. Effect estimates were adjusted for other pollutants (two-pollutant models) during different seasons.

RESULTS: We estimated a 1.68% increase [95% confidence interval (CI): 0.20%, 3.15%] in daily mortality per 10-μg/m$^3$ increase in $PM_{2.5–10}$ (single-pollutant model). The association with $PM_{2.5–10}$ was stronger for November through May, when road dust is most important (1.69% increase; 95% CI: 0.21%, 3.17%), compared with the rest of the year (1.31% increase; 95% CI: –2.08%, 4.70%), although the difference was not statistically significant. When adjusted for other pollutants, particularly $PM_{2.5}$, the effect estimates per 10 μg/m$^3$ for $PM_{2.5–10}$ decreased slightly but

inflammation and acute tox
says (Steerenberg et al. 2006
European *in vitro* studies have
mineral particles the composit
reactivity appeared to be mos
the proinflammatory potential
(Schwarze et al. 2007).

*$PM_{2.5–10}$ sources and its*
*$PM_{10}$.* A directive from the E
(EU; European Commission
the total mass of all $PM_{10}$ irre
morphology, chemistry, and h
the urban environment, differe
tribute differently to total PM
variation in the size distributi
ted particles (Johansson et al.

# Effekterna är fler än tidigare analyser har beaktat

ehp ENVIRONMENTAL HEALTH PERSPECTIVES

ADVANCE PUBLICATION

Altmetric 7

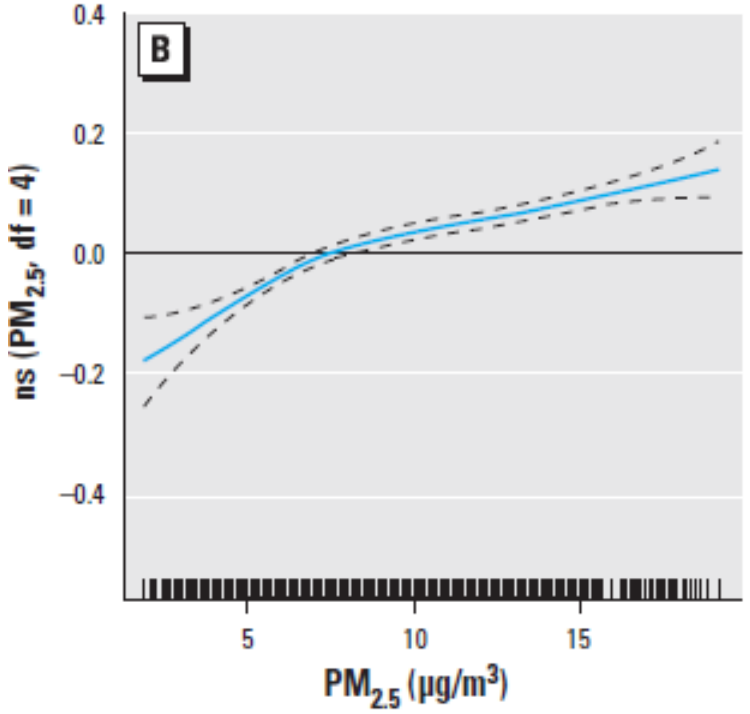
*Environ Health Perspect*; DOI:10.1289/ehp.1408322

**Traffic-Related Air Pollution and Dementia Incidence in Northern Sweden: A Longitudinal Study**

Anna Oudin,[1] Bertil Forsberg,[1] Annelie Nordin Adolfsson,[2] Nina Lind,[3] Lars Modig,[1] Maria Nordin,[3] Steven Nordin,[3] Rolf Adolfsson,[2] and Lars-Göran Nilsson[4,5]

# Samband konstateras vid mycket låga halter av PM2.5

REVIHAAP: Åmv av PM2.5 har betydelse för dödligheten även vid halter under 10 µg/m3




Crouse et al, 2012

# Sot har gjort comeback (BC/EC)

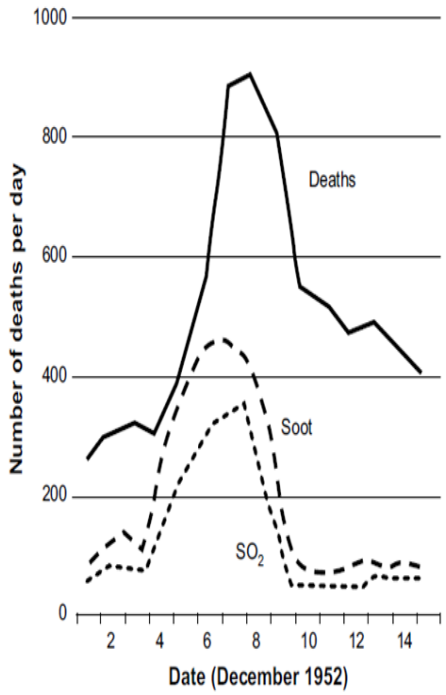



Fig. 2. The 1952 smog in London. The episode lasted 4 days, pollution levels rose to unprecedented levels and more than 4000 extra death occurred.

TEMA MILJÖ OCH HÄLSA

LUFTFÖRORENINGAR

LÄS MER Engelsk sammanfattning
http://ltarkiv.lakartidningen.se

**Läkartidningen 48/2007**

# SOTPARTIKLAR GÖR LUFTEN FARLIG – IGEN

Idén med gränsvärden för luftförorening-ar gav ett bedrägligt skydd och bromsade forskningen. En nedre tröskelgräns kan inte påvisas. Nu riktas forskningen mot konsekvensberäkningar och effekter på hjärta och kärl.

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En tillbakablick över 100 år, eller bara hälften så länge, visar att

# Ökad dödlighet vid långtidsexp mätt som PM2.5 resp EC
## (Janssen et al, 2011)

**Table 3.** RR for mortality related to long-term exposure to $PM_{2.5}$ and EC per 1 µg/m$^3$.

| Reference | Cohort | Correlation ($R$) PM–BCP[a] | Cause | RR (95% CI) $PM_{2.5}$ | RR (95% CI) EC |
|---|---|---|---|---|---|
| Filleul et al. 2005[b,c] | 14,284 adults; age 25–59 years; France | 0.87[d] | Natural causes[e] | 1.010 (1.004, 1.016) | 1.06 (1.03, 1.09) |
| | | | Cardiopulmonary | 1.012 (1.002, 1.023) | 1.05 (0.98, 1.11) |
| | | | Lung cancer | 1.000 (0.983, 1.019) | 1.03 (0.93, 1.14) |
| Lipfert et al. 2006 | 70,000 male U.S. veterans | 0.54 | All causes | 1.006 (0.993, 1.020) | 1.18 (1.05, 1.33) |
| Beelen et al. 2008[b] | 120,852 adults; age 55–69 years; the Netherlands | 0.82 | Natural causes[e] | 1.006 (0.997, 1.015) | 1.05 (1.00, 1.10) |
| | | | Respiratory | 1.007 (0.972, 1.043) | 1.20 (0.99, 1.45) |
| | | | Cardiovascular | 1.004 (0.990, 1.019) | 1.04 (0.95, 1.12) |
| | | | Lung cancer | 1.006 (0.980, 1.033) | 1.03 (0.89, 1.18) |
| | | | Other | 1.008 (0.996, 1.021) | 1.04 (0.97, 1.11) |
| Smith et al. 2009 | 500,000 adults; age 20–87 years; USA | NA | All causes | 1.006 (1.002, 1.010) | 1.06 (1.01, 1.11) |
| | | | Cardiopulmonary | 1.012 (1.008, 1.018) | 1.11 (1.03, 1.19) |
| Pooled effect (random)[f] | | | All causes | 1.007 (1.004, 1.009) | 1.06 (1.04, 1.09) |

**Typiskt 10 ggr högre riskökning per 1 µg/m3 för EC**

# Ozon nästa förorening att omvärderas?

- Ökar i städer när NOx-utsläppen ändras
- Långtidseffekter på dödligheten framkommer
- Flera studier av födelseutfall ser samband med för tidig födsel och havandeskaps-förgiftning (Olsson et al 2012; 2013; 2015).

**Vart tjugonde fall av havandeskaps-förgiftning kan förklaras av ozonhalten under 1:a trimestern**

**Key messages**

- This large European study adds to the evidence that preterm birth may be caused by $O_3$ exposure, and that the effect may be greater among asthmatic mothers.
- This is one of the first studies to show an association between $O_3$ and pre-eclampsia.

# Slutsatser?

- Effekterna är mer omfattande än vanligen uppfattat
- Orsakerna (källorna) finns långt borta och hos själva
- Utvecklingen går inte alltid rätt väg (t ex diesel - NO2 – O3 eller småskalig vedeldning)

Tack för uppmärksamheten!