GÖTEBORGS UNIVERSITET

HEALTH EFFECTS OF AIR POLLUTION FOR THE NORDIC WORKSHOP ON AIR POLLUTION - OLD'S, NEW'S, AND SOME TO DO'S

LEO STOCKFELT, *M.D, PHD*
RESEARCH GROUP LEADER, ENVIRONMENTAL MEDICINE AND TOXICOLOGY
DEPARTMENT OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE
SAHLGRENSKA UNIVERSITY HOSPITAL AND UNIVERSITY OF GOTHENBURG
LEO.STOCKFELT@AMM.GU.SE

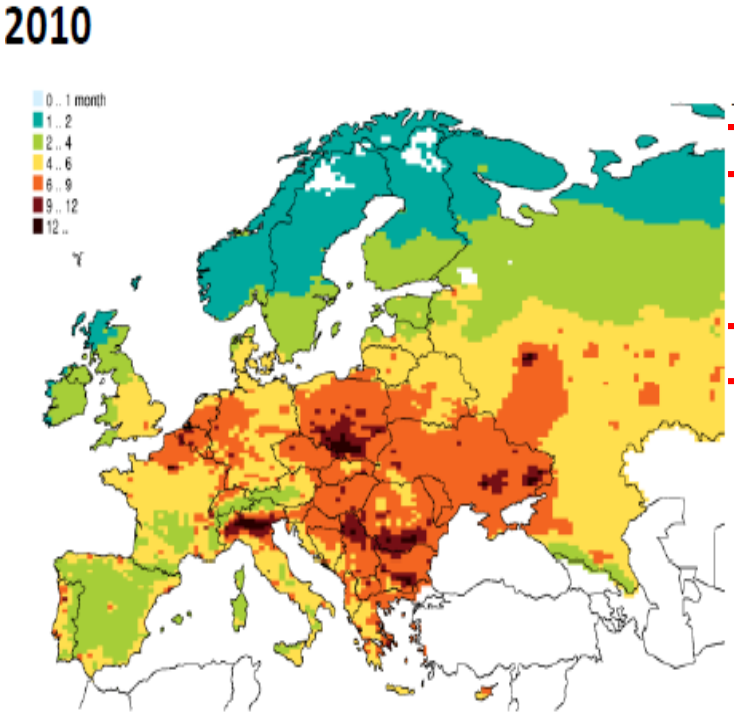
Olds: Air pollution is the single largest environmental health risk

In Sweden

Around 5000 premature deaths/year due to PM (Forsberg 2005)

In Europe

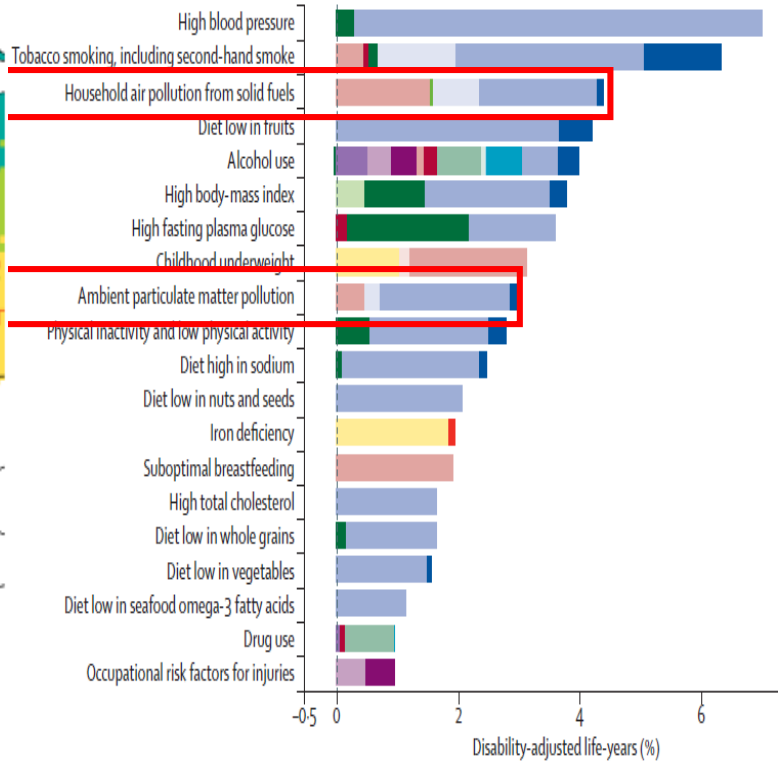
Around 430.000 premature deaths/year due to PM2.5 in 2010



Loss in average statistical life expectancy (months) year 2010 due to identified anthropogenic $PM_{2.5}$

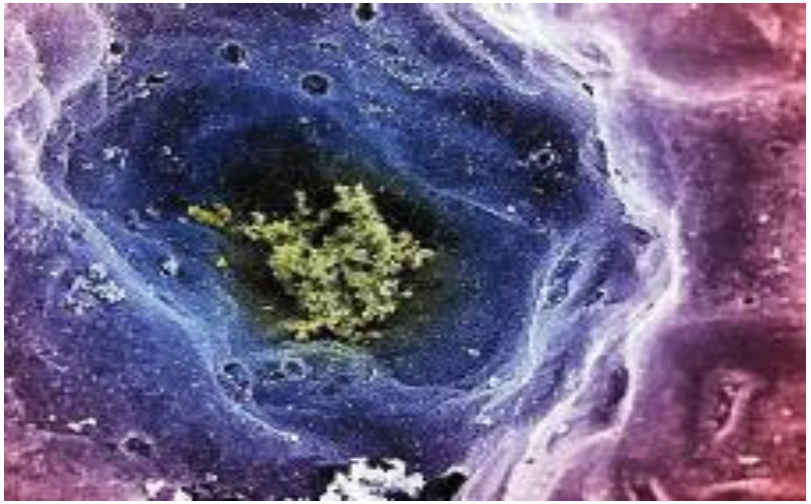
Globally

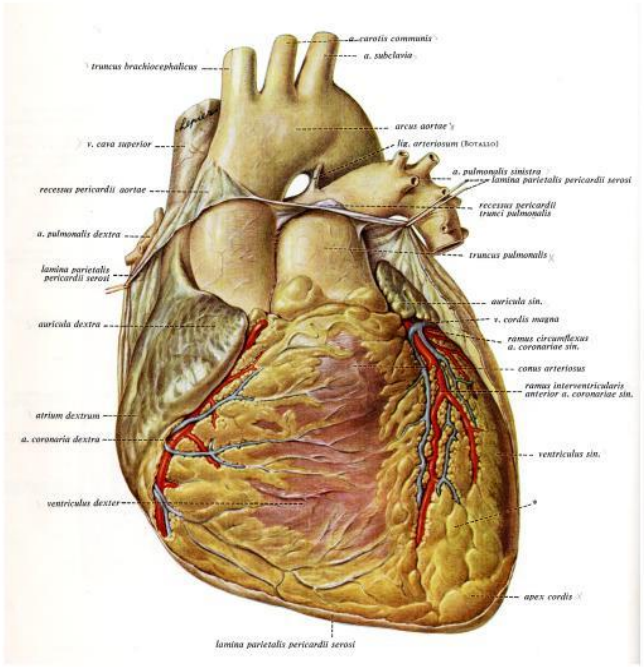
Around 5 million deaths/ year (GBD – Stanaway 2018), or more (Vodonos/Burnett 2018)



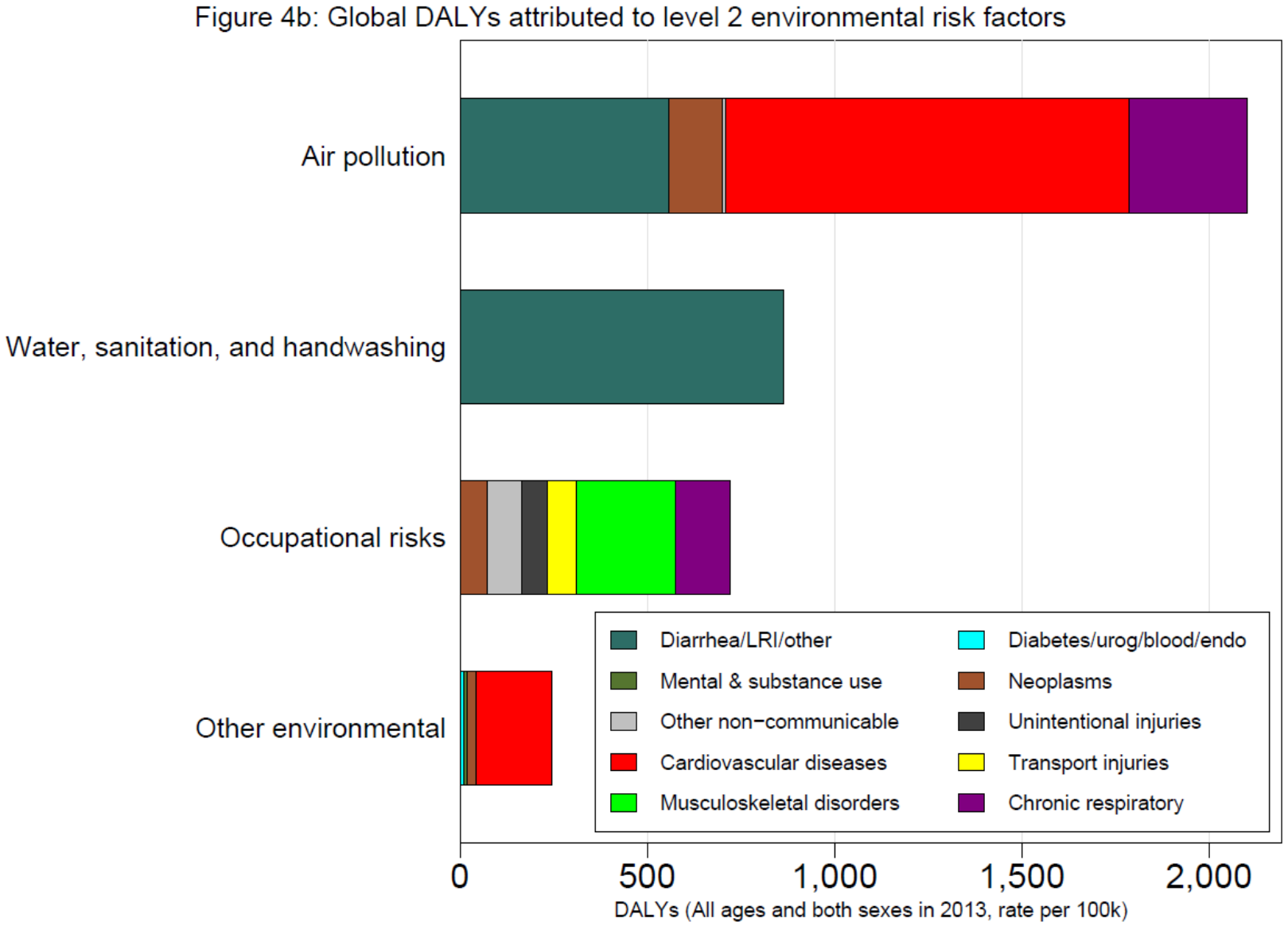
GÖTEBORGS UNIVERSITET

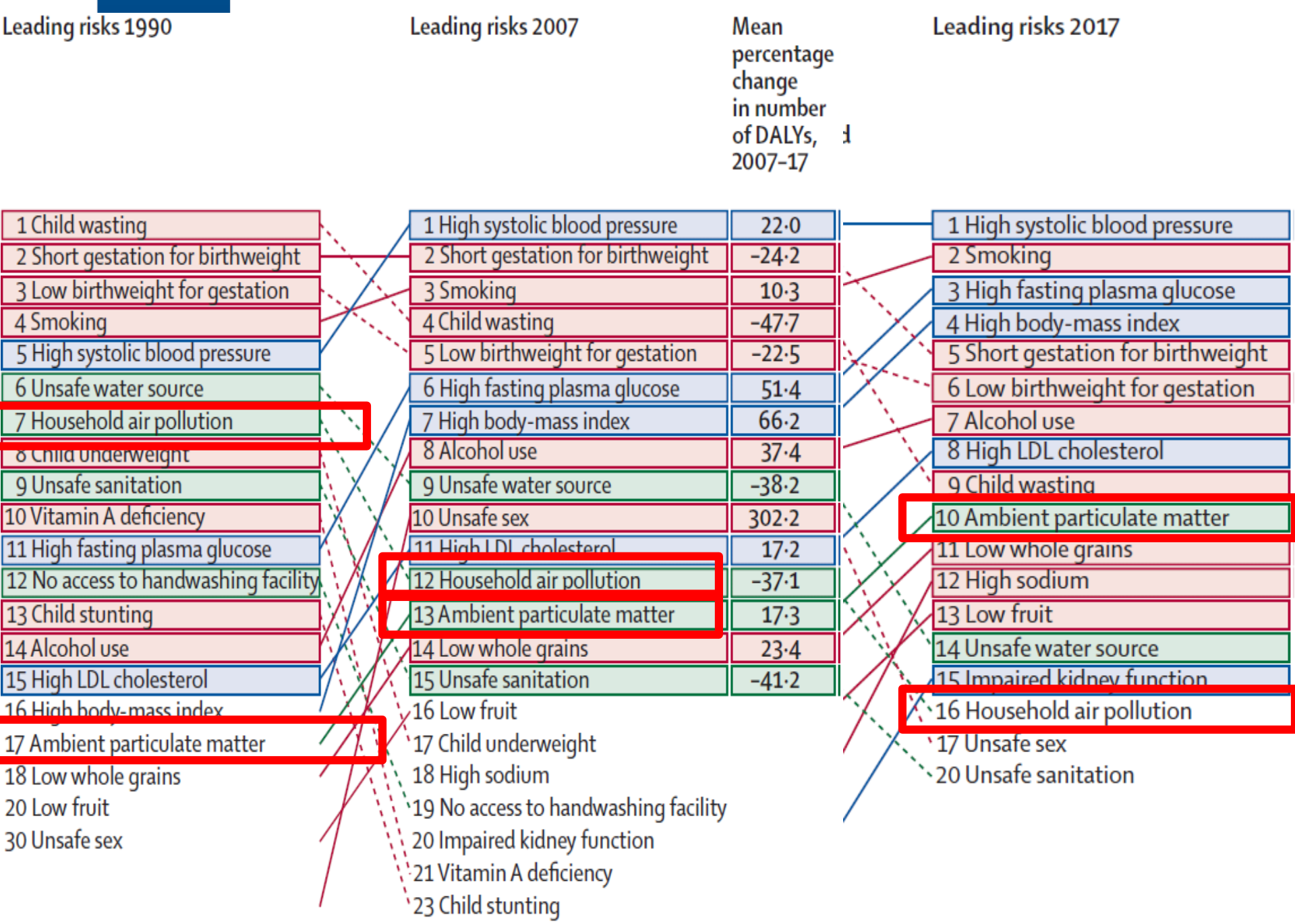
Mostly due to cardiovascular and pulmonary morbidity and mortality



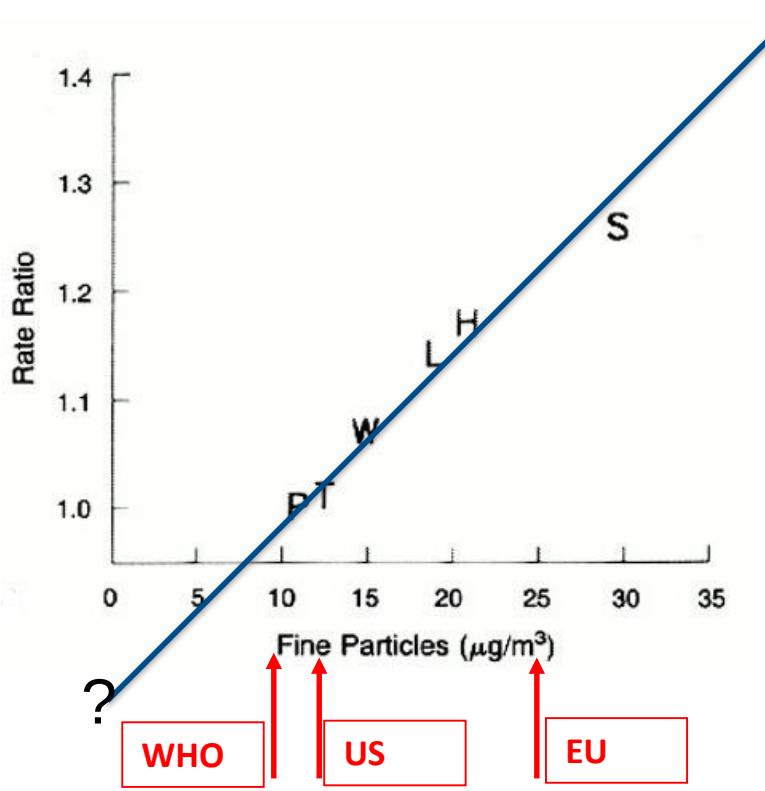


Global Burden of Disease, Stanaway 2018 (”low” estimate)



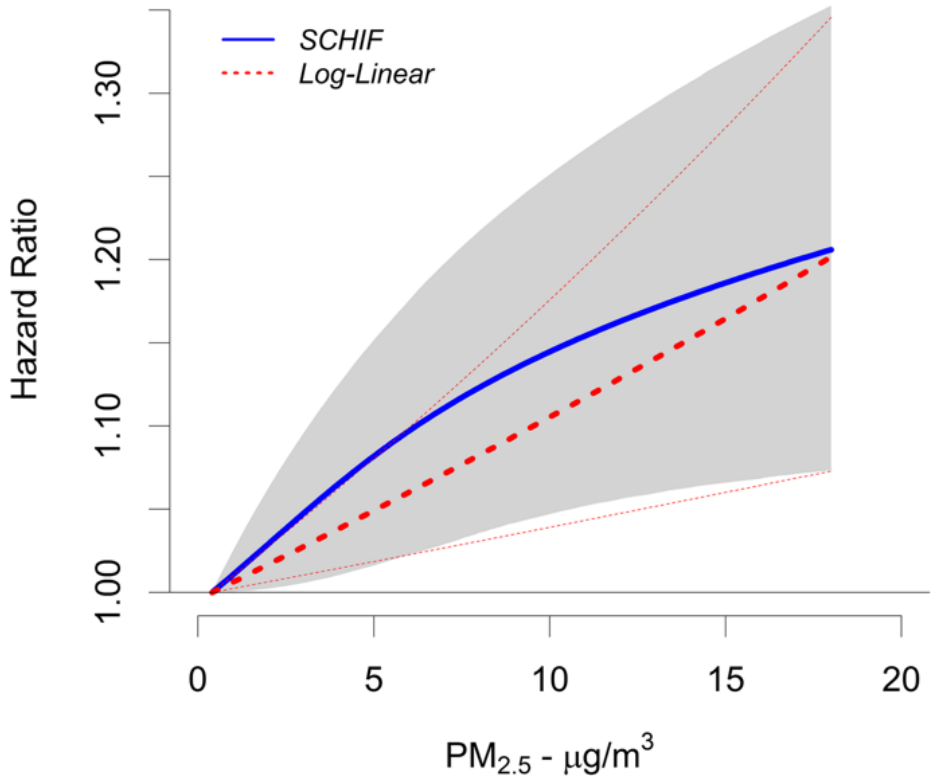

Leading risks 1990
Leading risks 2007
Mean percentage change in number of DALYs, 2007–17
Leading risks 2017
1 Child wasting
2 Short gestation for birthweight
3 Low birthweight for gestation
4 Smoking
5 High systolic blood pressure
6 Unsafe water source
7 Household air pollution
8 Child underweight
9 Unsafe sanitation
10 Vitamin A deficiency
11 High fasting plasma glucose
12 No access to handwashing facility
13 Child stunting
14 Alcohol use
15 High LDL cholesterol
16 High body-mass index
17 Ambient particulate matter
18 Low whole grains
20 Low fruit
30 Unsafe sex
1 High systolic blood pressure 22·0
2 Short gestation for birthweight -24·2
3 Smoking 10·3
4 Child wasting -47·7
5 Low birthweight for gestation -22·5
6 High fasting plasma glucose 51·4
7 High body-mass index 66·2
8 Alcohol use 37·4
9 Unsafe water source -38·2
10 Unsafe sex 302·2
11 High LDL cholesterol 17·2
12 Household air pollution -37·1
13 Ambient particulate matter 17·3
14 Low whole grains 23·4
15 Unsafe sanitation -41·2
16 Low fruit
17 Child underweight
18 High sodium
19 No access to handwashing facility
20 Impaired kidney function
21 Vitamin A deficiency
23 Child stunting
1 High systolic blood pressure
2 Smoking
3 High fasting plasma glucose
4 High body-mass index
5 Short gestation for birthweight
6 Low birthweight for gestation
7 Alcohol use
8 High LDL cholesterol
9 Child wasting
10 Ambient particulate matter
11 Low whole grains
12 High sodium
13 Low fruit
14 Unsafe water source
15 Impaired kidney function
16 Household air pollution
17 Unsafe sex
20 Unsafe sanitation

The association is sort of linear - and there is no safe level



How low can we go?

How low can we go?



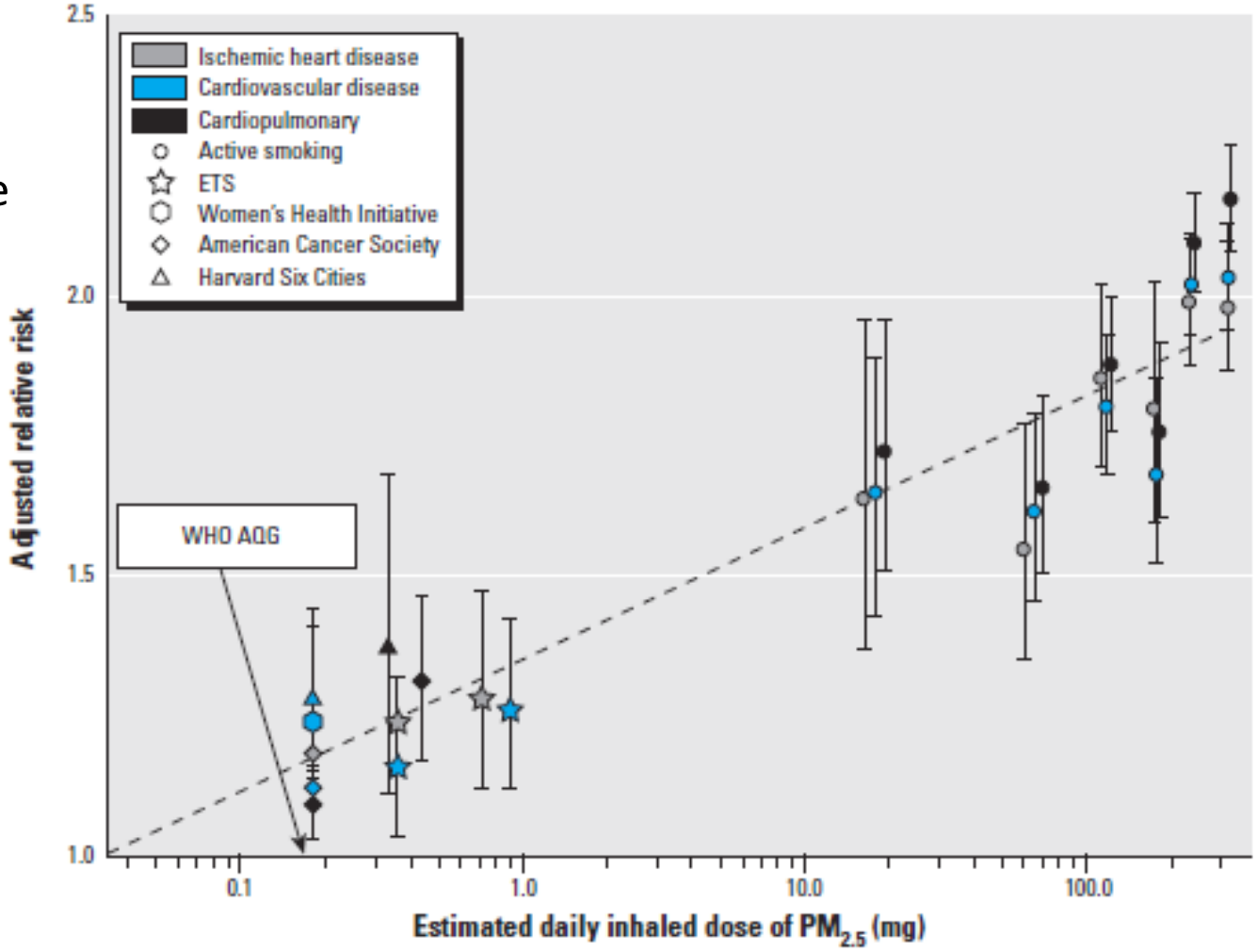
Christidis 2019: association between PM2.5 and mortality at mean conc 5,9 µg/m3. ”We estimated a supra-linear concentration-response curve extending to concentrations below 2 µg/m^3”

Linear? ”Mind the Gap” -Smith & Peel 2010, EHP (Pope before)

Ambient AP estimates higher than for indoor AP, smoking or occupational exposure

Is increased exposure more dangerous at low levels compared to high? (and thus reductions more effective at low levels…?)

The Global Burden of disease uses an Integrated Exposure Response



News: – higher ERF at low levels?

- Higher ER-functions in new studies at low exposure levels?
  - Different ER at low exp, or better studies (less non-differential misclassification)?
- ACS (between cities) 6% per 10 µg/m3
- ACS in Los Angeles (within) 17% per 10 µg/m3
- ESCAPE (meta, within cohorts) 14% per 10 µg/m3
  - (But also low and weak estimates in some publications)
- South East USA (Wang et al, 1 km) 21% per 10 µg/m3
- ACS (Turner et al) 26% per 10 µg/m3 near source, 4% for regional
- DDCH Hvidtfeldt 2019 13 (5-21) % per 5 µg/m3
- SCAC II 13% per 5 µg/m3
- ELAPSE (393 000 Europeans) linear 13 (11-16)% per 5 µg/m3

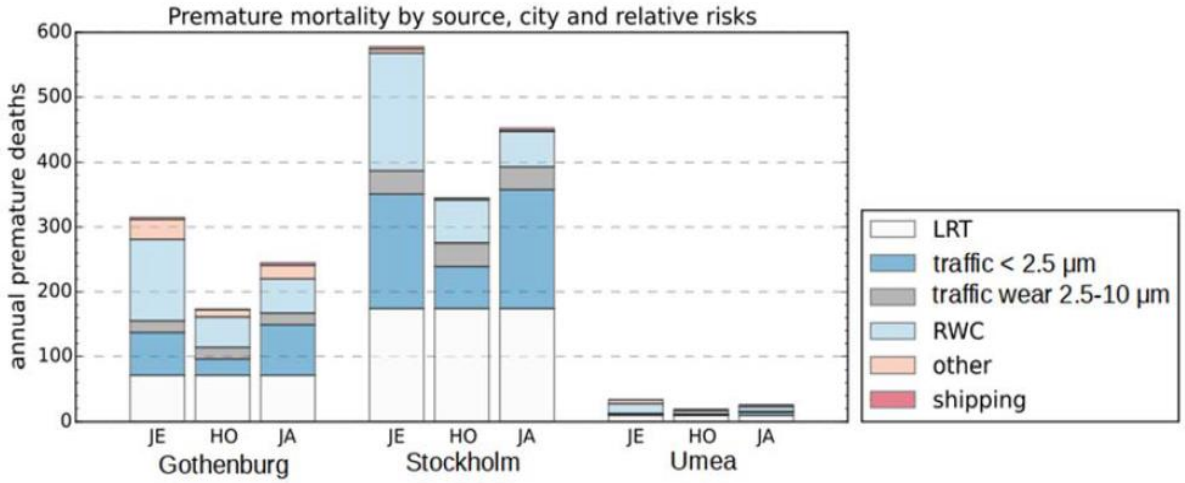
ERFs ARE VERY IMPORTANT FOR HEALTH IMPACT ESTIMATIONS

EX: SCAC HIA for mortality results depend on ER for fine PM

Article

Health Impact of PM_{10}, $PM_{2.5}$ and Black Carbon Exposure Due to Different Source Sectors in Stockholm, Gothenburg and Umea, Sweden

David Segersson [1,*], Kristina Eneroth [2], Lars Gidhagen [1], Christer Johansson [2,3], Gunnar Omstedt [1], Anders Engström Nylén [2] and Bertil Forsberg [4]



17 or 6%
per 10 µg/m3

GÖTEBORGS UNIVERSITET

Deaths per year in Stockholm associated with long-term PM2.5 exposure (from Bertil Forsberg)

ERF	Local traffic	Vehicle exhaust	Traffic wear
6 % per 10 µg/m3	62		
17 % per 10 µg/m3	175	39	136
26 % per 10 µg/m3	268	60	208

Does this make sense?

GÖTEBORGS UNIVERSITET

Also from SCAC: Coarse fraction important for daily number of deaths in stockholm (Olstrup et al, 2019)

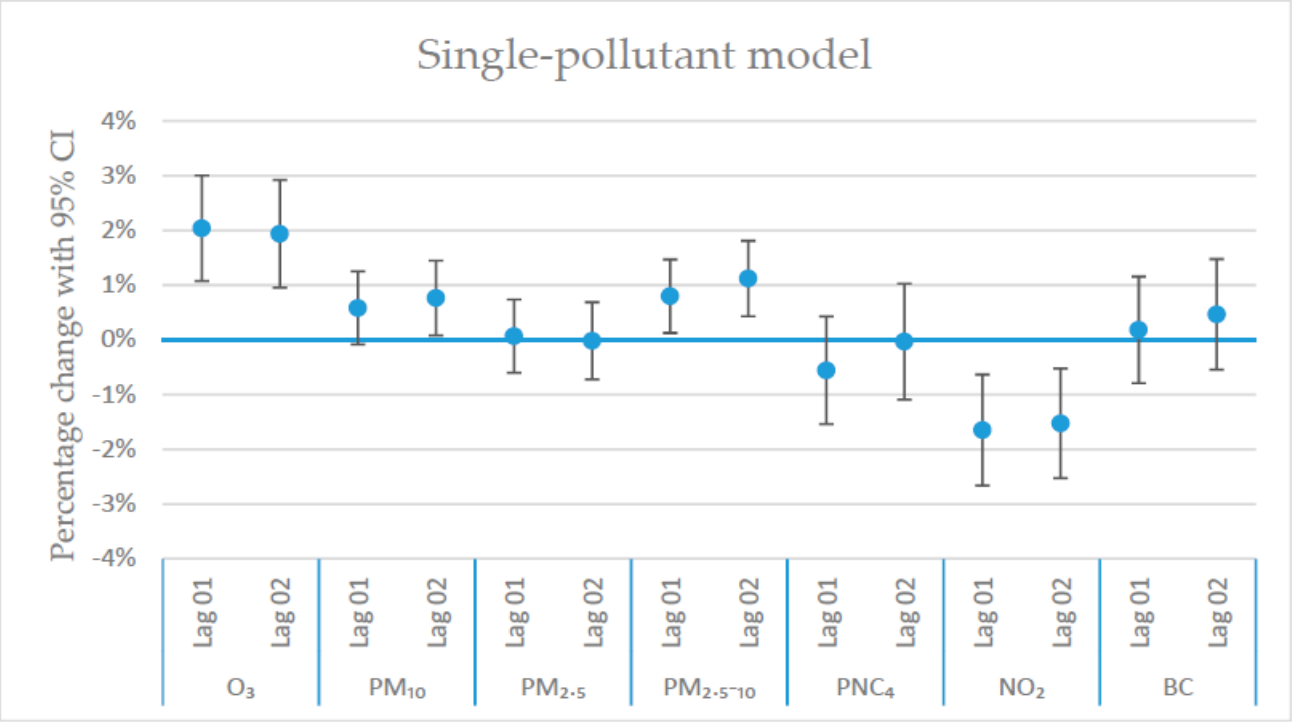


Figure 4. The estimated change in daily mortality (with 95% CI) for an IQR increase in concentration (lag01 and lag02) to the different air pollutants in a single-pollutant model.

GÖTEBORGS UNIVERSITET

BC BUT not NO2 tend to increase daily number of deaths in stockholm (Olstrup et al, 2019)

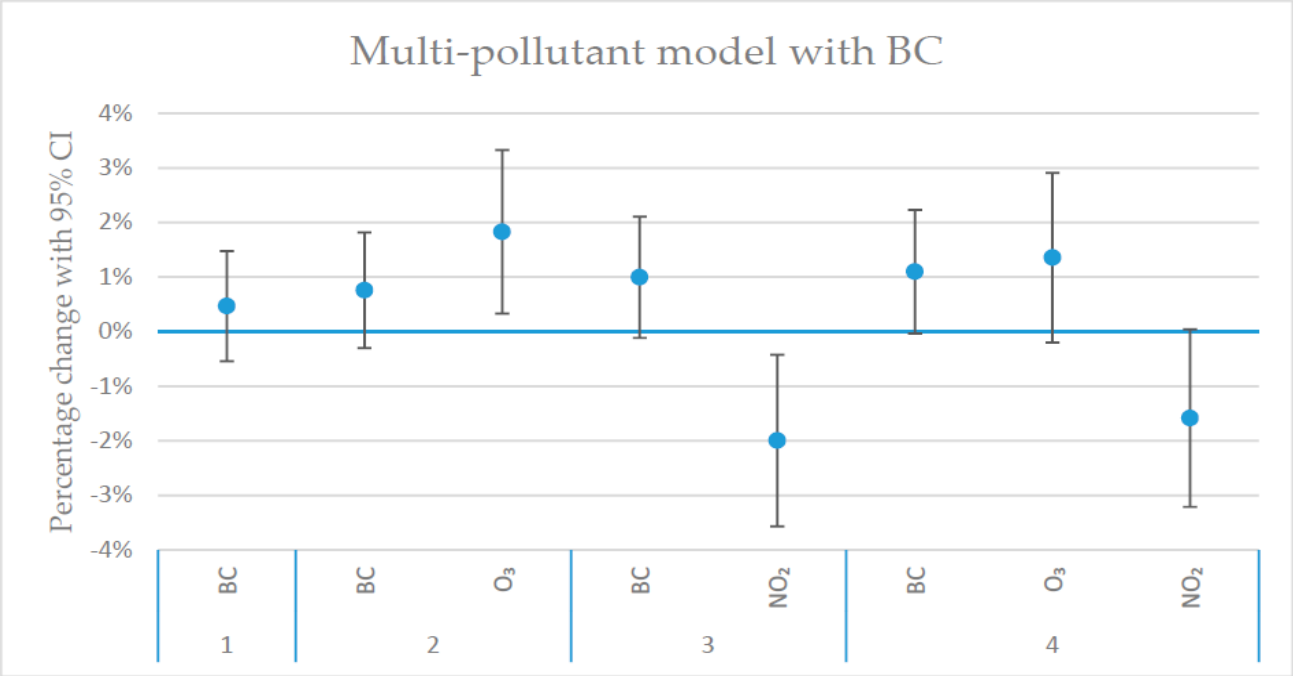


Figure 6. The estimated change in daily mortality (with 95% CI) for an IQR increase in concentration (lag02) of BC, O_3 and NO_2 in a multi-pollutant model. Model 1 (furthest to the left) represents the single-pollutant estimate of BC. Model 2 and 3 represent two-pollutant models, with O_3 (Model 2), and with NO_2 (Model 3). In Model 4, both BC, O_3 and NO_2 are included.

GÖTEBORGS UNIVERSITET

NEWS: outcomes added each GBD round…

Environmental Risk Factor - Outcome pairs

Risk factor	Outcomes
Ambient $PM_{2.5}$ air pollution	Ischemic heart disease, Stroke, COPD, Lower respiratory infections, Lung Cancer, Type 2 Diabetes, Low Birthweight, Short gestation
Household air pollution	Ischemic heart disease, Stroke, COPD, Lower respiratory infections, Lung Cancer, Type 2 Diabetes, Cataracts, Low Birthweight, Short gestation
Ozone	COPD
Water, sanitation and hygiene	Diarrheal diseases; Lower respiratory infections
Lead	Intellectual disability, Chronic kidney disease, CVD (Ischemic heart disease, Stroke, hypertensive heart disease, atrial fibrillation, etc.)
Radon	Lung cancer
Temperature (cold, hot)	IHD, LRI, Stroke, drowning, etc.

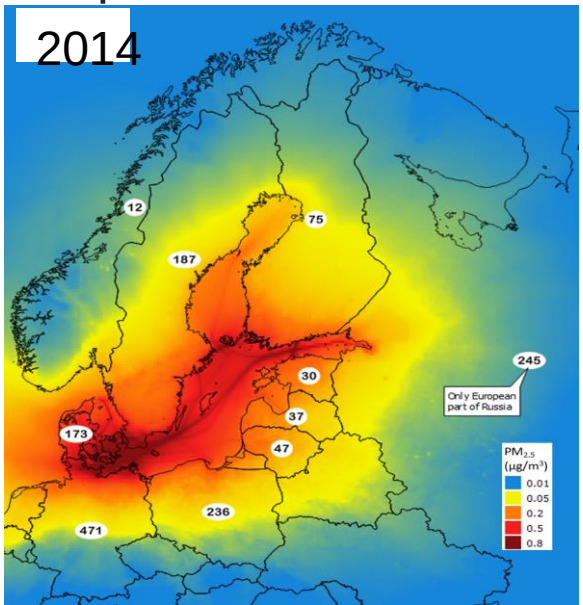
IHME | UNIVERSITY of WASHINGTON

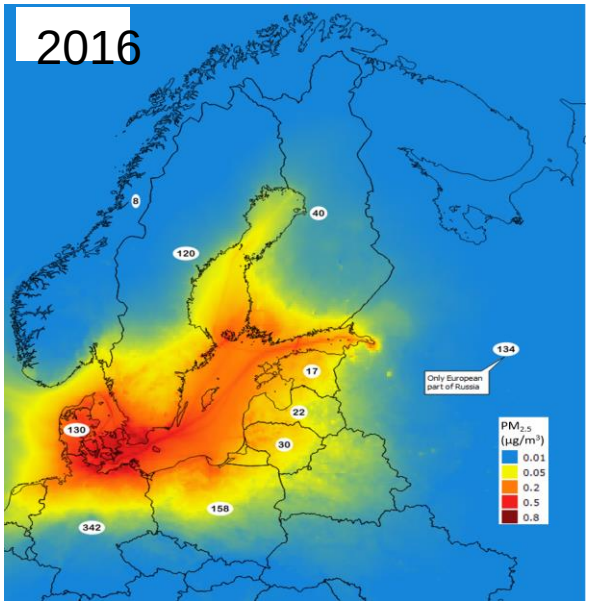
Institute for Health Metrics and Evaluation

But most of the disease burden is due to mortality

Interventions work

- Wood stove exchange in New Zealand (Johnston et al 2013), in Launceston but not Hobarth. Reduced PM10 from 24->18 µg/m3 in summer and 44->27 in winter, and mortality decreased compared with control.
- Mortality due to PM2.5 from shipping decreased by 1/3 in Sweden and the Baltic countries after new fuel sulphur restrictions in 2015 (Ekström 2019, Barregard 2019)
- Cost-Benefit Analyses (CBA)s show that many interventions to reduce air pollution have been and will be profitable.





CO-benefits (climate change, noise, health)

- **"Net health benefits of active transport are substantial, irrespective of context"**
- **"Projected health gains of increases in PA exceed detrimental effects of traffic incidents and air pollution exposure"**

Preventive Medicine 76 (2015) 103–114

Contents lists available at ScienceDirect

Preventive Medicine

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

Review

Health impact assessment of active transportation: A systematic review

Natalie Mueller [a,b,c,*], David Rojas-Rueda [a,b,c], Tom Cole-Hunter [a,b,c], Audrey de Nazelle [d], Evi Dons [e,f], Regine Gerike [g], Thomas Götschi [h], Luc Int Panis [e,i], Sonja Kahlmeier [h], Mark Nieuwenhuijsen [a,b,c]

[a] Centre for Research in Environmental Epidemiology (CREAL), C/Dr. Aiguader 88, 08003 Barcelona, Spain

Bild från N Mueller

Health impact of a mode shift to active transport

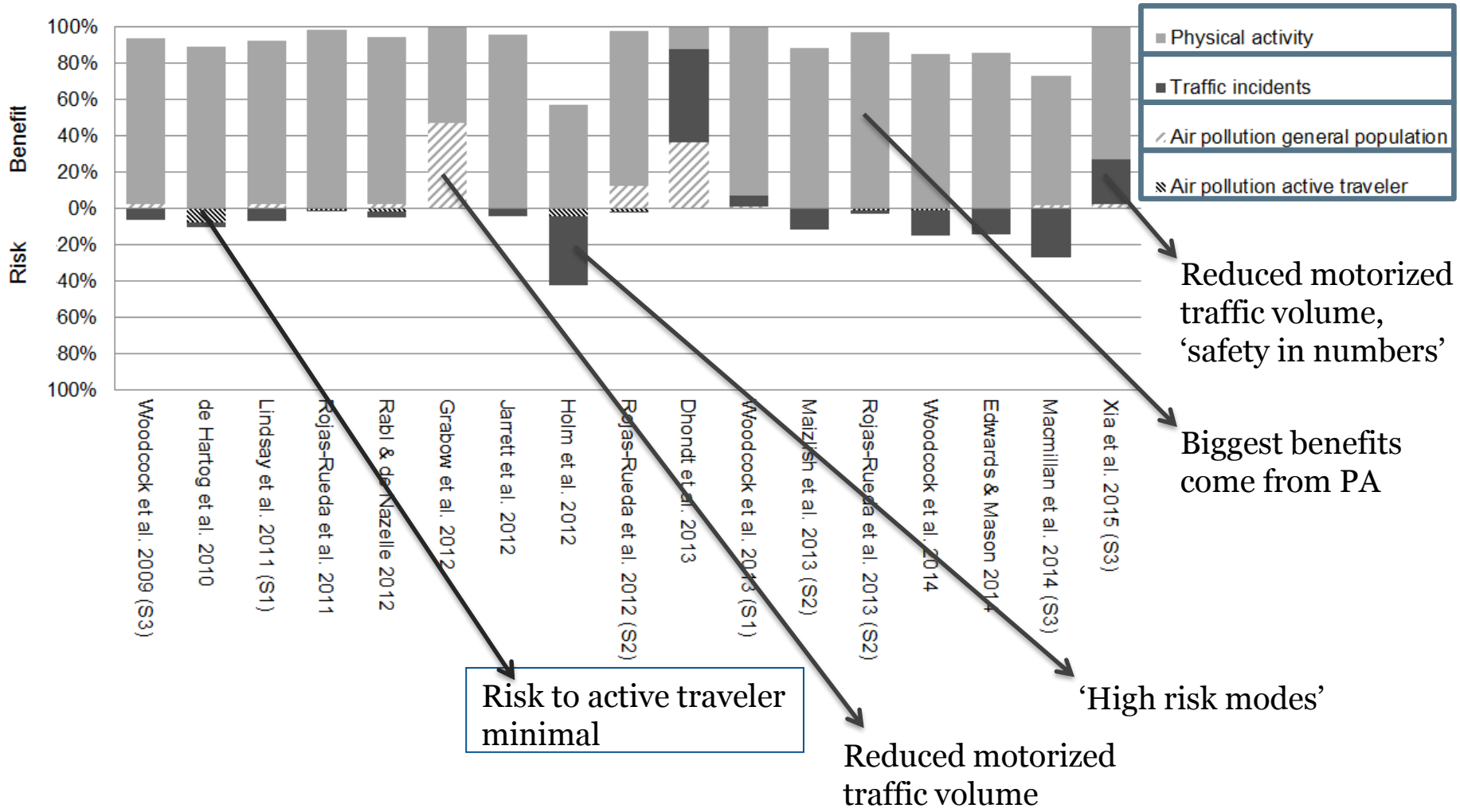
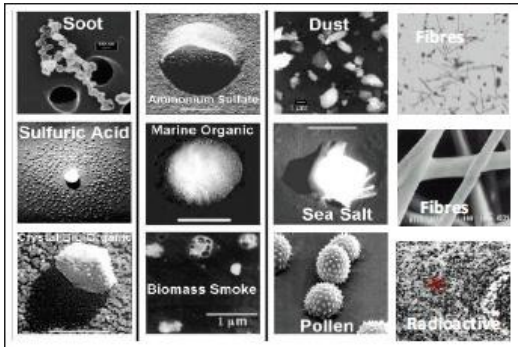


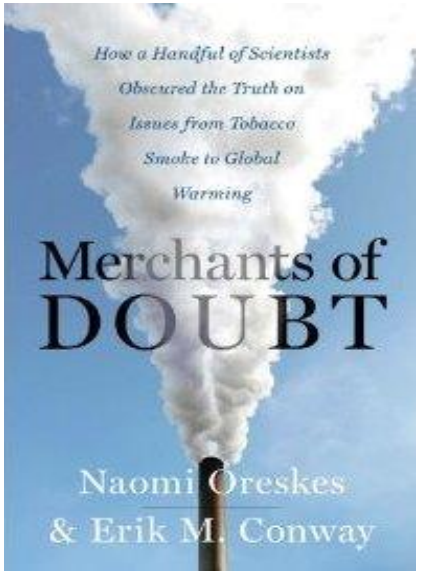
Bild från N Mueller

GÖTEBORGS UNIVERSITET

To do's and possible funding gaps:



- Sources and types of air pollution
  - We've mostly failed to differentiate between different types of air pollution in epidemiological studies
  - Slowly getting better through better exposure modeling
- Large collaborations needed: continuing the SCAC cooperation
- Epidemiological studies of mechanisms
  - "SCAPIS Miljö"
- Opportunistic studies of natural interventions
- Multiple environmental exposures
- Science communication – show the money
  - More HIA and CBA?

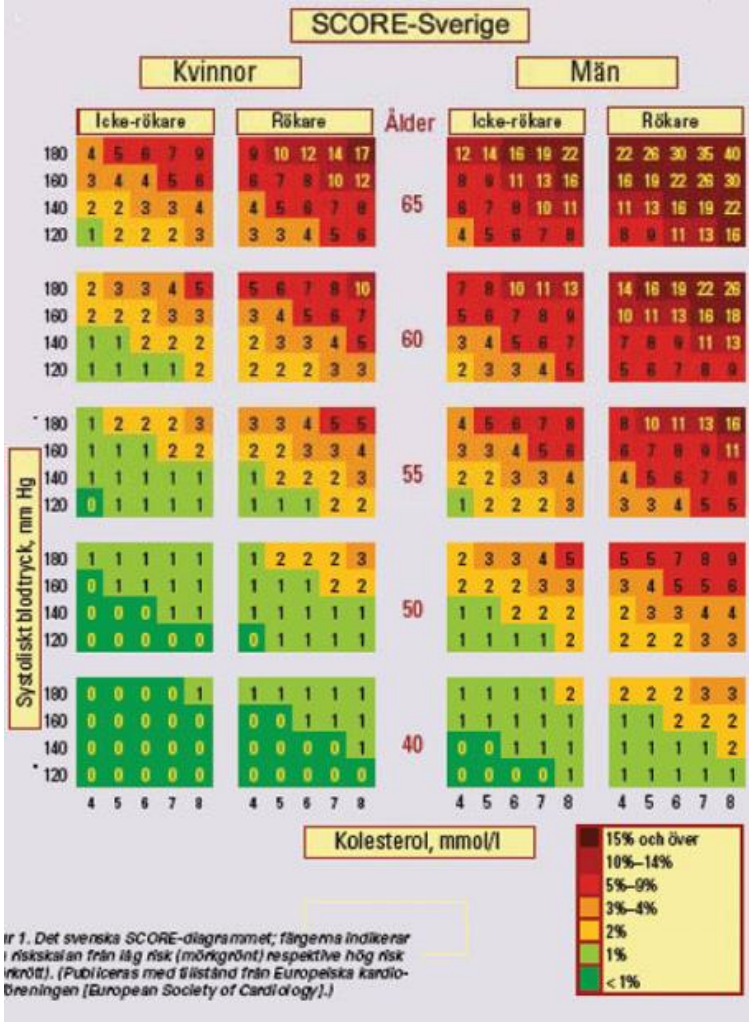



GÖTEBORGS
UNIVERSITET

Extra slides?

Summary

- Outdoor air pollution, especially PM, has negative health effects on cardiopulmonary diseases.
- Large population effects, small individual effects.
- Reducing air pollution has health benefits at all exposure levels.
- Asthmatics, children and those with pre-existing cardiovascular disease are sensitive.
- System solutions (city planning etc)



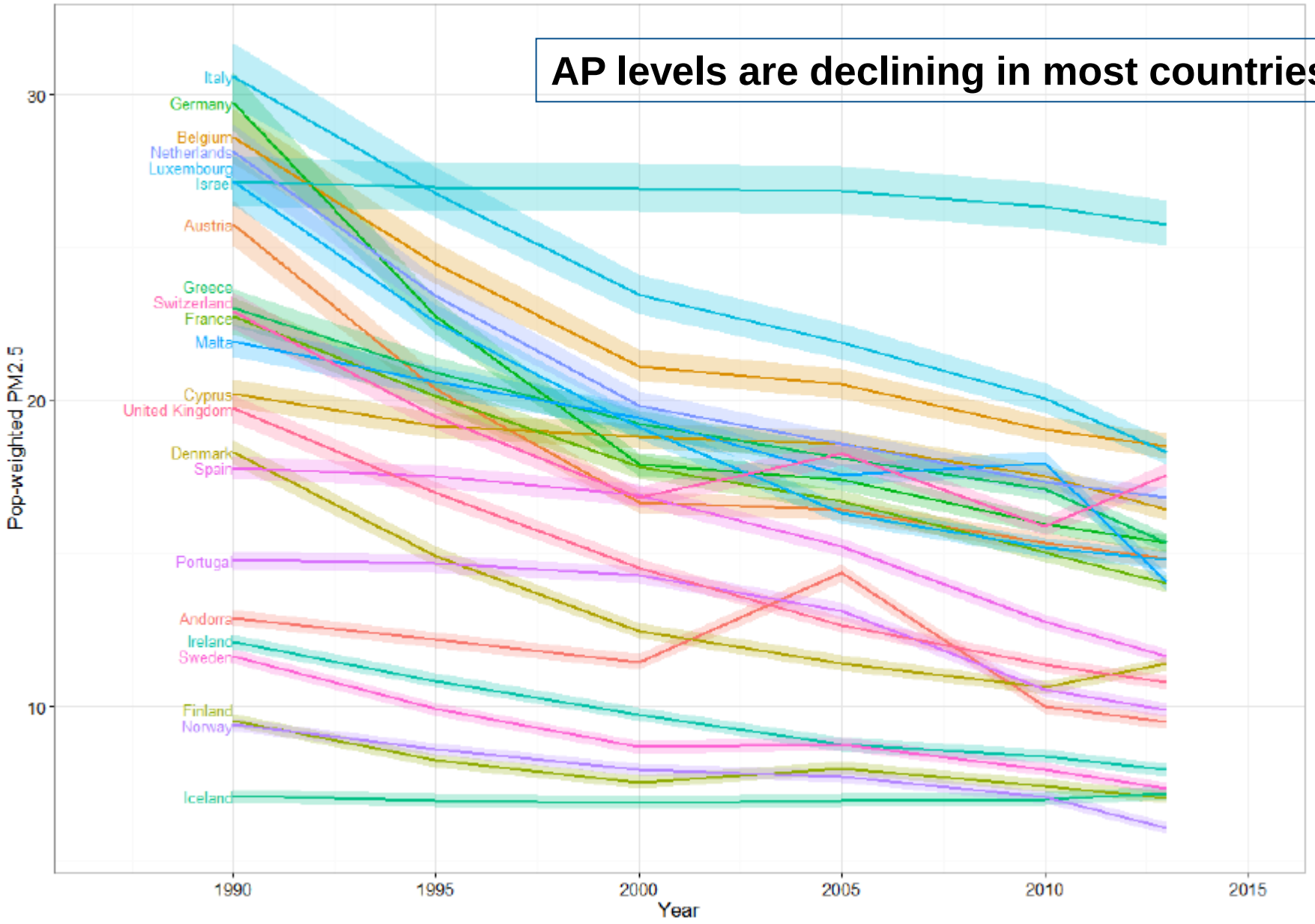


Figure S14. Europe, Western

(Brauer M et al, ES&T, 2016)

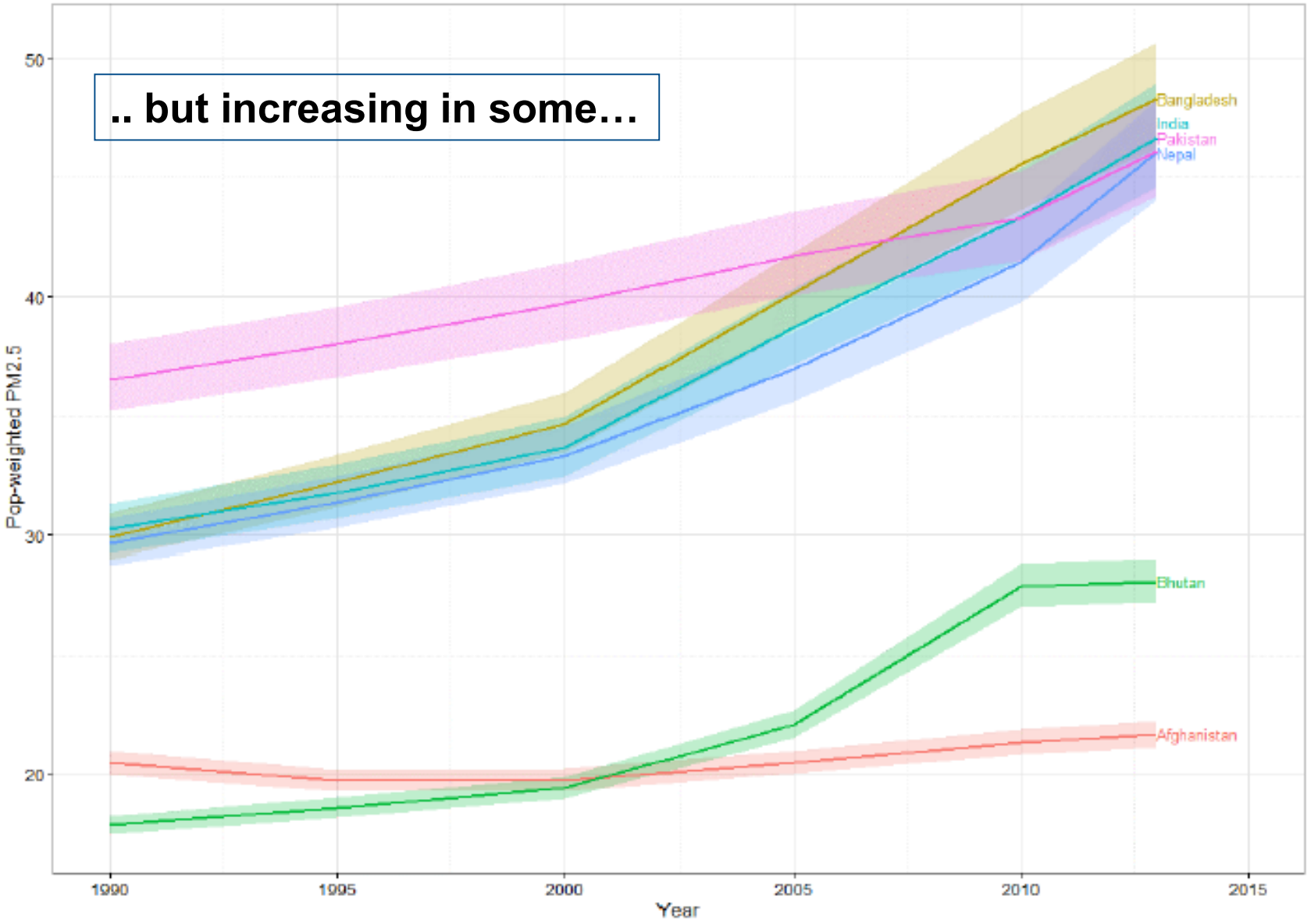


Figure S8. Asia, South

(Brauer M et al, ES&T, in press)

Air quality guidelines

Exposure		WHO	Swedish Aims	US NAAQS	South Africa NAAQS
PM10	1-day	50µg/m3	30µg/m3	150µg/m3	75µg/m3
PM2.5	1-day	25µg/m3	25µg/m3	35µg/m3	
PM10	1-year	20µg/m3	15µg/m3	50µg/m3	40µg/m3
PM2.5	**1-year**	**10µg/m3**	**10µg/m3**	**12/15µg/m3**	**20µg/m3**
NO2	1-year	40µg/m3	20µg/m3	53ppb	40 µg/m3 , 21ppb
O3	8-hour	100µg/m3	70µg/m3		120µg/m3
SO2	1-day	20µg/m3			50µg/m3

NB: Many people will die from air pollution exposure below current guidelines!

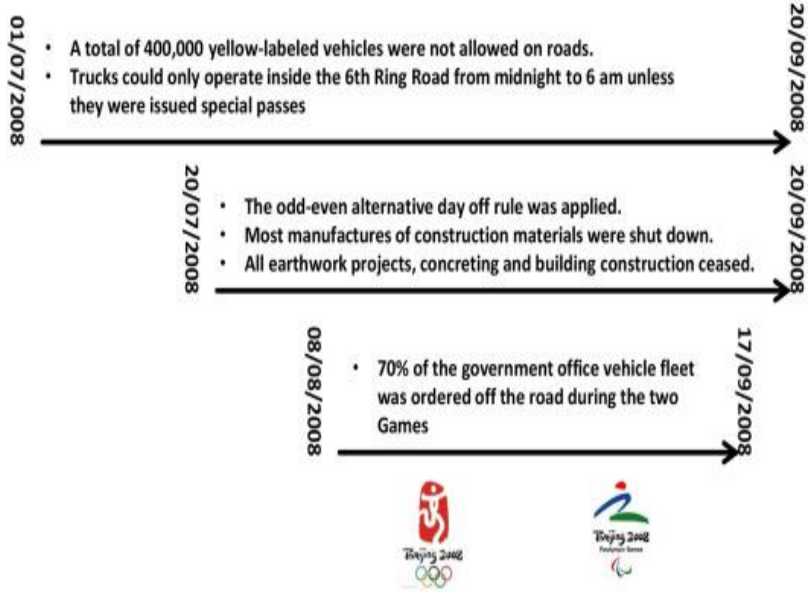
GÖTEBORGS UNIVERSITET

Summary of air pollution in GBD

- Stanaway 2018 estimates around 5 million premature deaths per year due to air pollution
  – 3 ambient PM2.5, 1,6 HAP, 0,5 Ozone
- 147 million DALYs
- Improvements 1990-2017
- 58% due to CVD, 19% due to COPD
- Some estimates such as Vodonos 2018 markedly higher – ongoing discussion

”News”: Interventions work:

Beijing Olympics 2008: Air pollution reduced, biomarkers of inflammation decreased as well as incidence of cardiovascular disease.



Chang Su et al. Environmental Research, 2015

News in the Global Burden of Disease

Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017

GBD 2017 Risk Factor Collaborators*

Capstone paper - Stanaway et al, Lancet 2018

Results also published in other journals

1990->2017 – due to environmental risk factors