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Health Impact: Solid Conclusions and Volatile Questions

VERT Focus Event

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Loretta Müller, PhD, loretta.mueller@insel.ch
Pediatric Pulmonology, University Children‘s Hospital Bern, Inselspital Bern

Solid Conclusions

1. Ambient air pollution exposure causes diseases and kills
2. The composition of the ambient air pollution matters
3. Toxicological potential as function of dose and exposure risk

Volatile Questions

1. What are the systemic impacts of air pollution?
2. Exposome: Interaction between exposure and the human body?
3. How do new technologies affect the exposure and the health?

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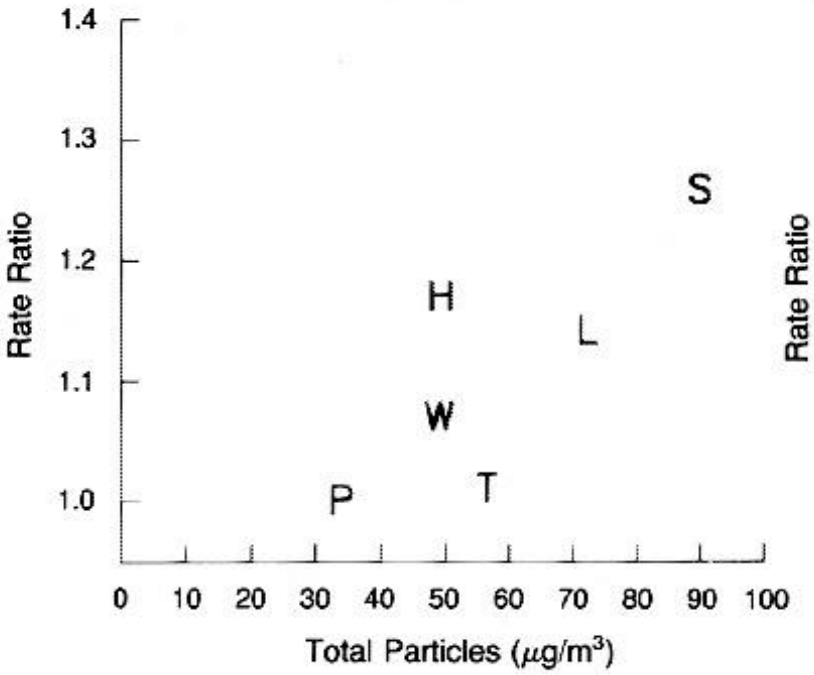
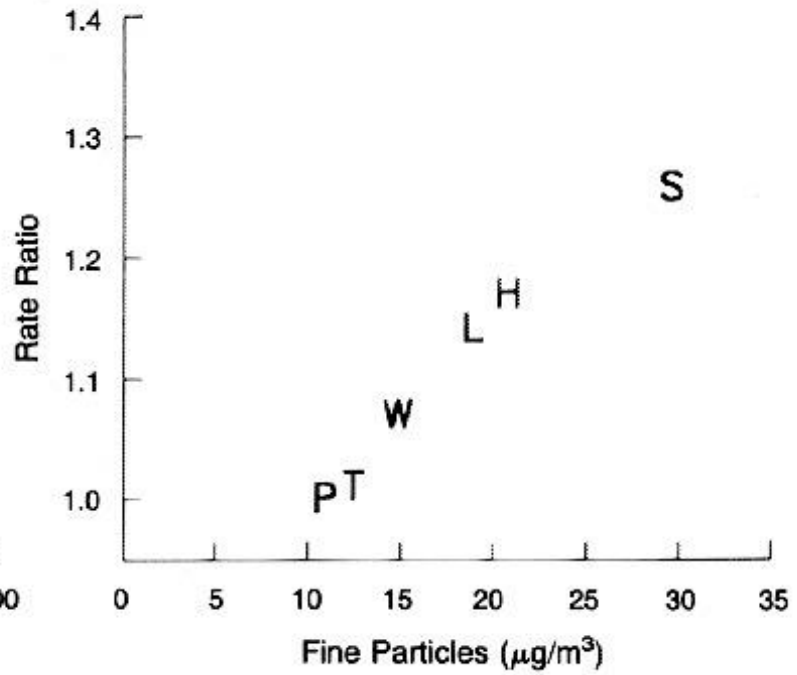
Harvard Six Cities Mortality Study

- 8111 adults followed up from 1974 to 1989
- Mortality risk ratios calculated for various air pollutants
  (Adjusted for age, sex, smoking, occupational exposure, education, BMI, chronic disease)

Mortality Risk Ratio



$PM_{10/15}$

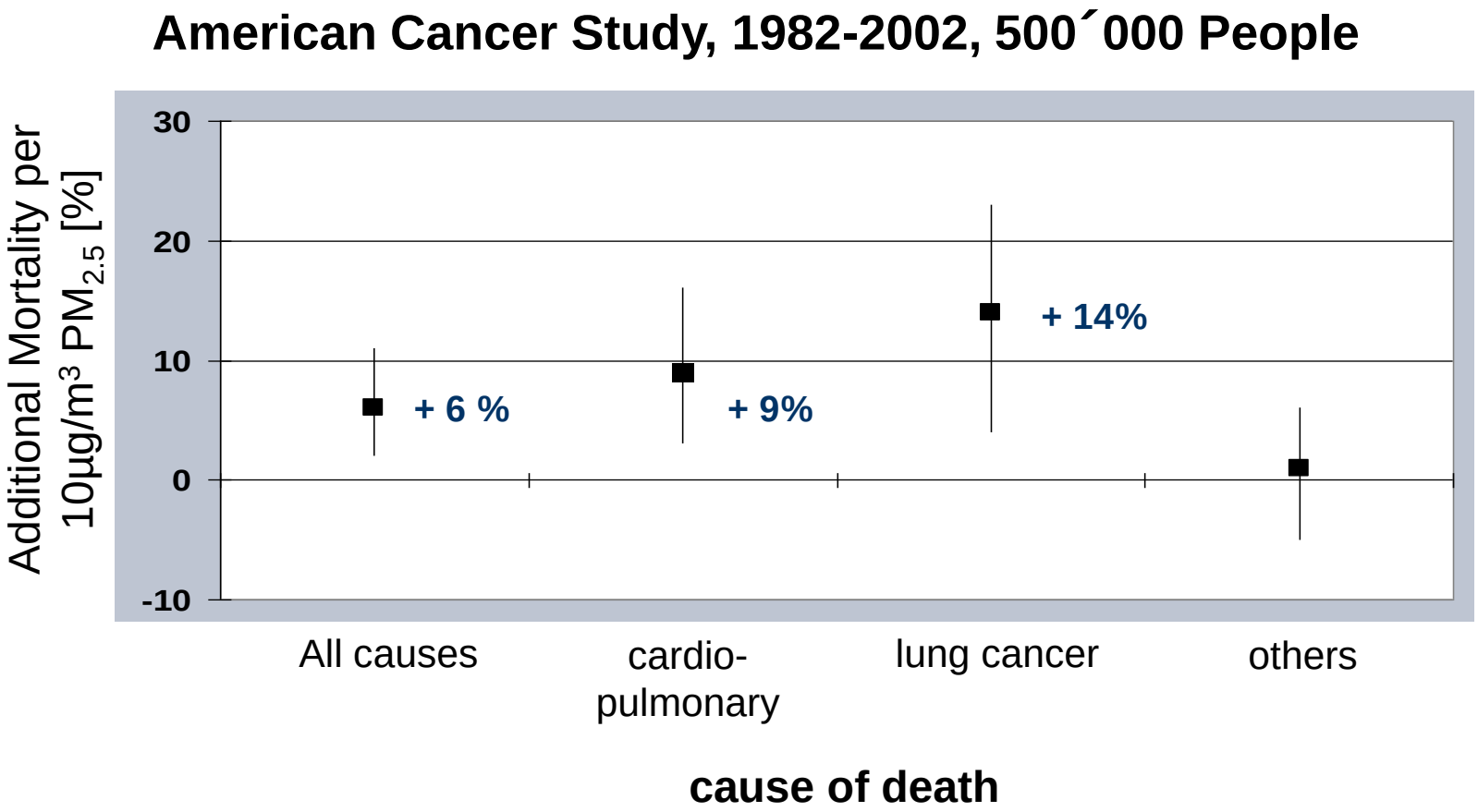


$PM_{2.5}$

PM=particulate matter

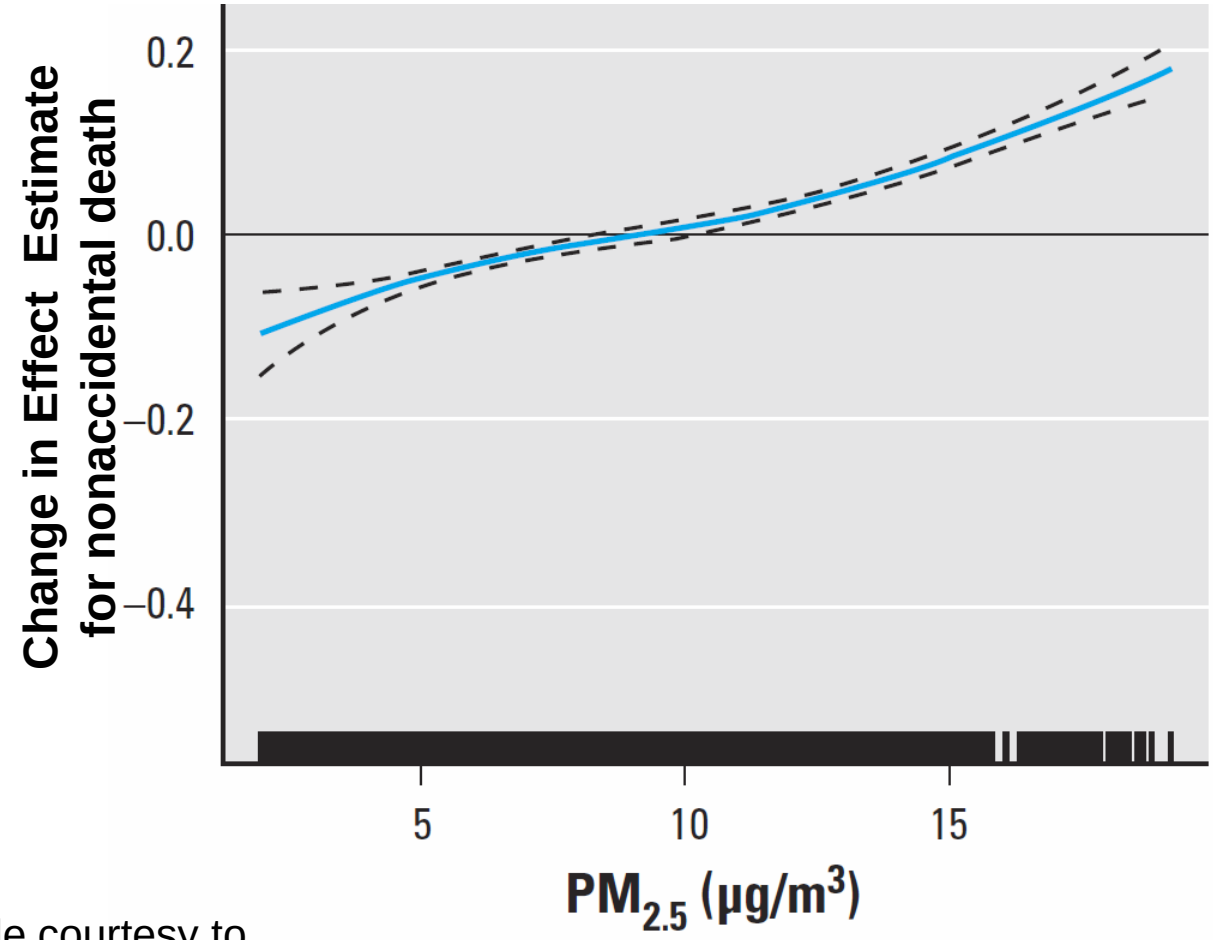
Dockery et al, NEJM, 1993

Increased Mortality due to $PM_{2.5}$



Pope et al, JAMA, 2002

Exposure-response functions at very low concentrations



- Cohort of 2.1 million Canadian adults
- Data from 1991-2001

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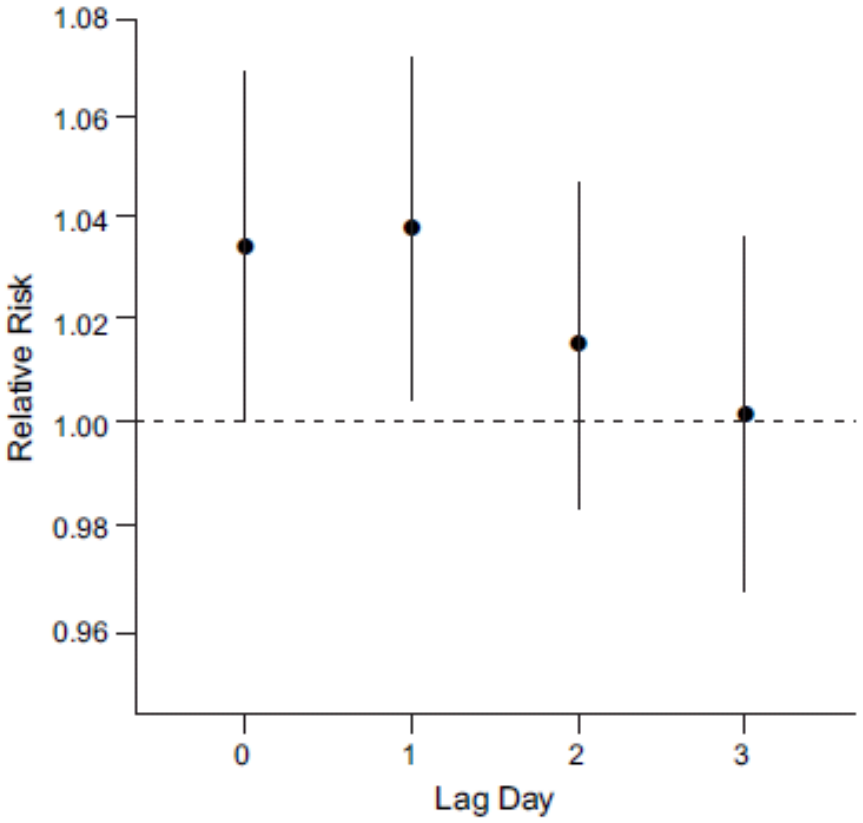
Crouse et al, EHP, 2012

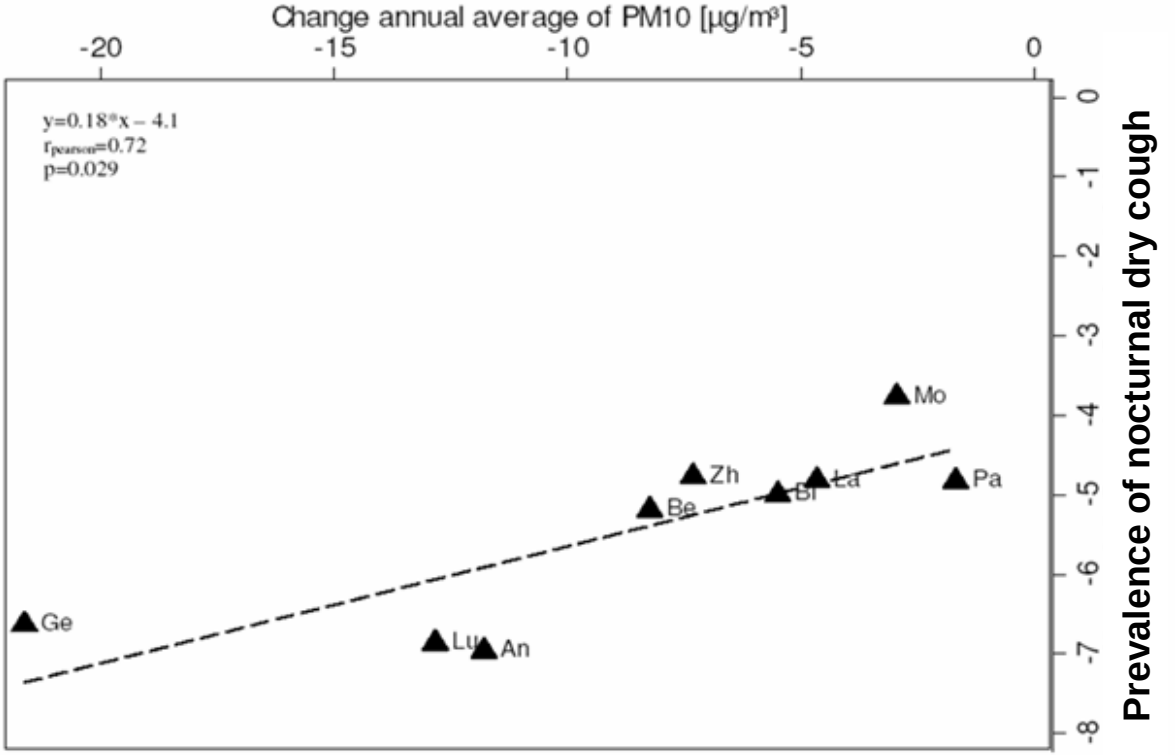
More out-of-hospital cardiac arrests



More out-of-hospital cardiac arrests due to **increase of $PM_{2.5}$ concentration of 10µg/m³** in New York City

Silverman et al, American Journal of Epidemiology, 2010

Impact on respiratory infections

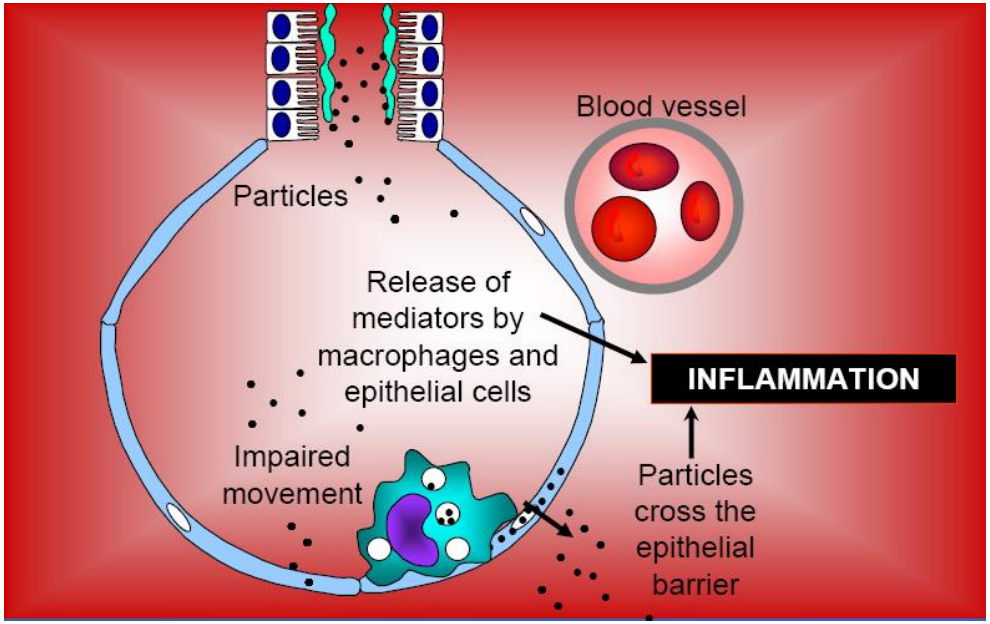


Reduction of respiratory infections in children after decline of PM_{10} concentrations (1992-2001, Switzerland)

Bayer-Oglesby et al, 2005, EHP

Cell and whole organ toxicity of fine particles

- Induce oxidative stress
- Activate the immune system
- Ultrafines translocate to other organs
- Pro-thrombotic effects
- Induce atherosclerosis
- Inflammatory responses in the brain as well as other organs and tissues



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Ambient Aerosols

- Gases
- Primary particles
- Organic compounds
- Soot particles
- Metals
- Secondary particles
- Crustal material
- Biological material
- ……

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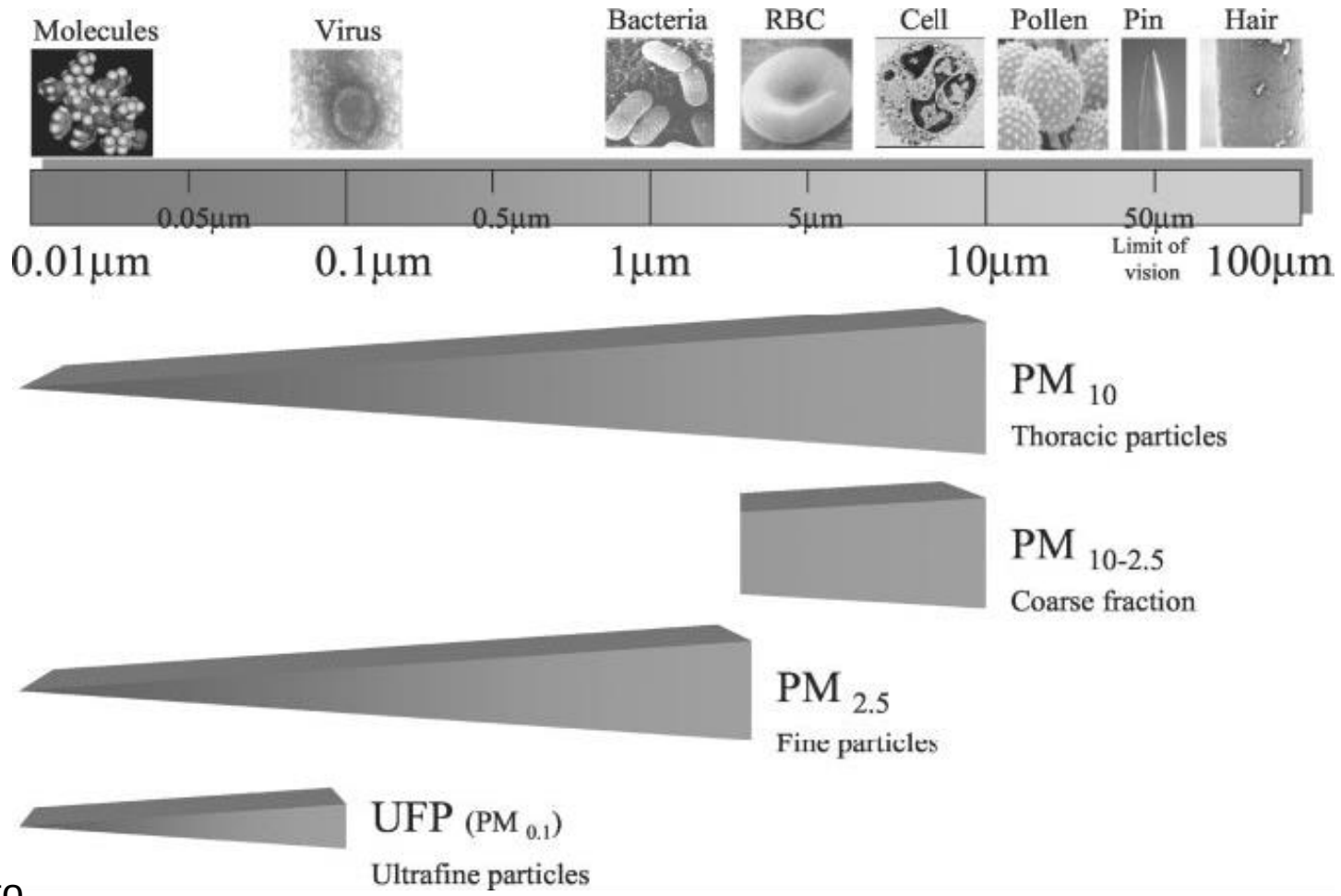
Ambient PM is defined by its size



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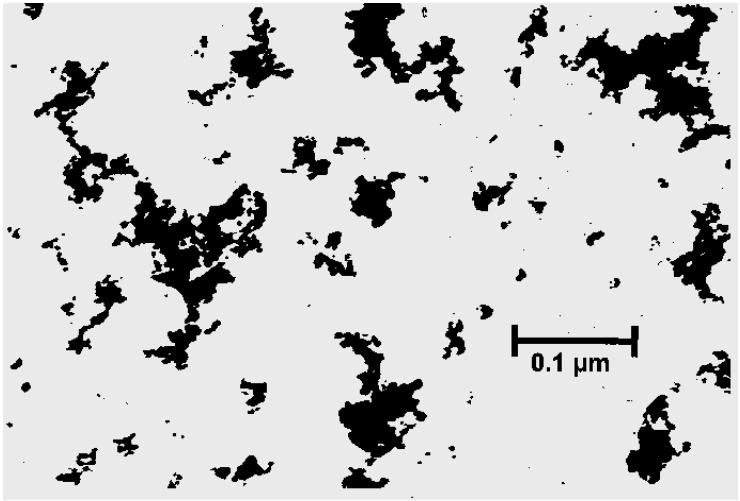
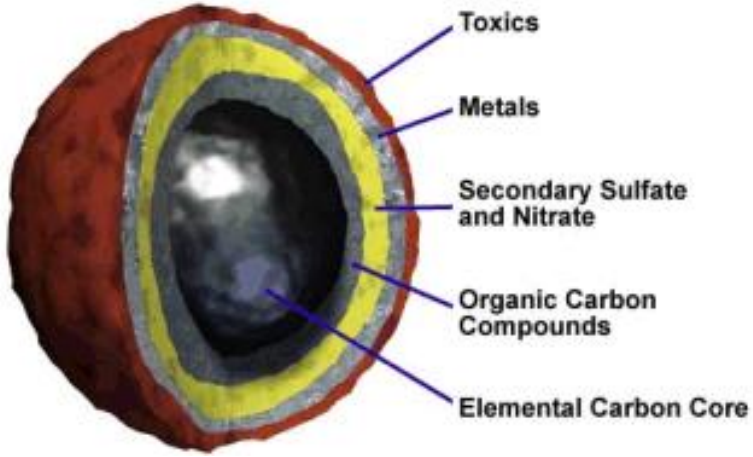
Brook et al, Circulation 2004

PM composition related to health effects

- PM Composition
  - Black carbonaceous particles
  - Secondary organic aerosols
  - Secondary inorganic aerosols
- Coarse particles
- Ultrafine particles





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Particle deposition and clearance depends on size

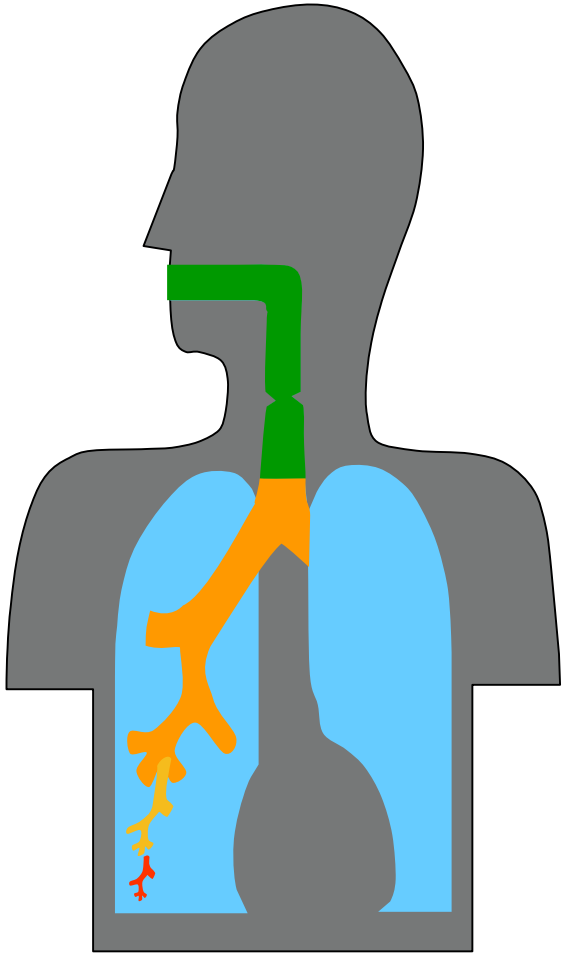
> The smaller the particles the deeper they penetrate into the lung:

Inhalable Particles:
Upper airways and nasal cavaties
(PM10. Ø < 10 µm)

Fine Particles:
lower air ways and alveoli

(PM2.5. Ø < 2.5 µm)
Clearance:

Mucociliar transport. macrophages.
translocation into the blood (< 200 nm)



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Particle uptake and toxicity varies

- Particle uptake depends on
  - Size
  - Surface charge
  - Surface coating

- Particle toxicity depends on
  - Health status of the person
  - Previous injuries/diseases
  - Particle clearance
  - Translocation into blood circulation and other organs

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What is the basis for health effects?

- risk = f(hazard, exposure)
  - Hazard = danger or harm of an air pollutant (e.g. toxicity of PM)
  - Expsoure = contact with the hazard

- effect = f(dose, exposure time/time after exposure)
  - Additionally: health status of the person
    previous diseases/injuries
    exposure to other pollutants/stressors

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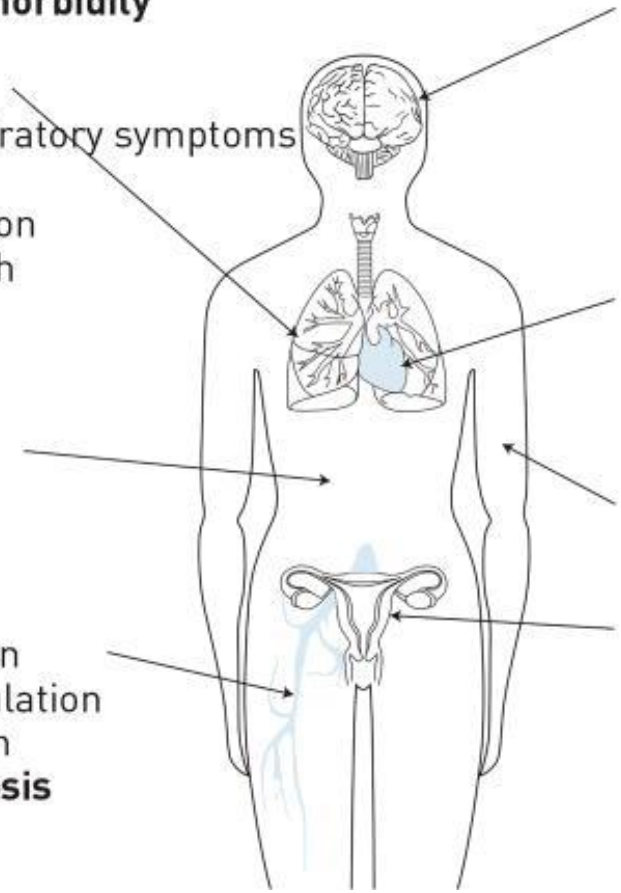
Systemic Health Effects of Air Pollution

Respiratory disease mortality
Respiratory disease morbidity
Lung cancer
Pneumonia
Upper and lower respiratory symptoms
Airway inflammation
Decreased lung function
Decreased lung growth

Insulin resistance
Type 2 diabetes
Type 1 diabetes
Bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood coagulation
Systemic inflammation
Deep venous thrombosis



Stroke
Neurological development
Mental health
Neurodegenerative diseases

Cardiovascular disease mortality
Cardiovascular disease morbidity
Myocardial infarction
Arrhythmia
Congestive heart failure
Changes in heart rate variability
ST-segment depression

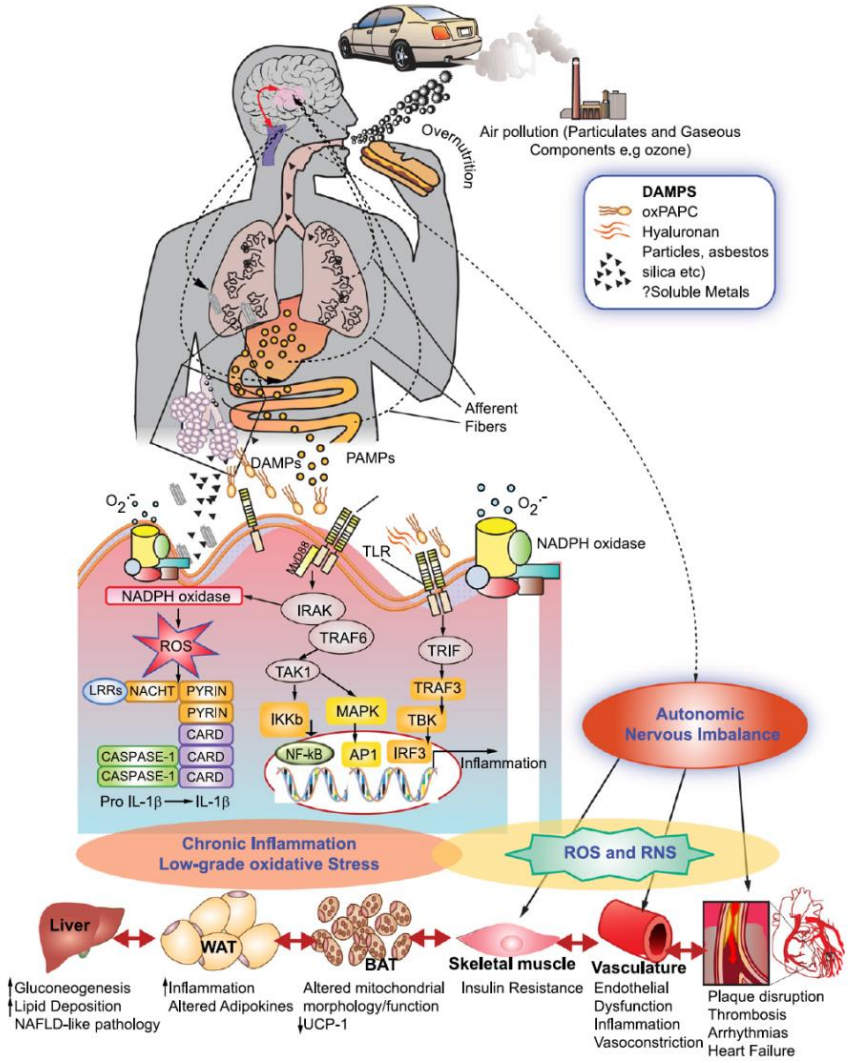
Skin ageing

Premature birth
Decreased birthweight
Decreased fetal growth
Intrauterine growth retardation
Decreased sperm quality
Pre-eclampsia

Thurston et al, ERS/ATS policy statement, ERJ, 2017

The complex interplay of environmental exposures in diabetes and neurodevelopment

- Interaction between environmental exposures and overnutrition
- Multiorgan involvement
- Inflammation and oxidative stress
- Activation of the autonomic nervous system



Rajagopalan & Brook Diabetes 2012

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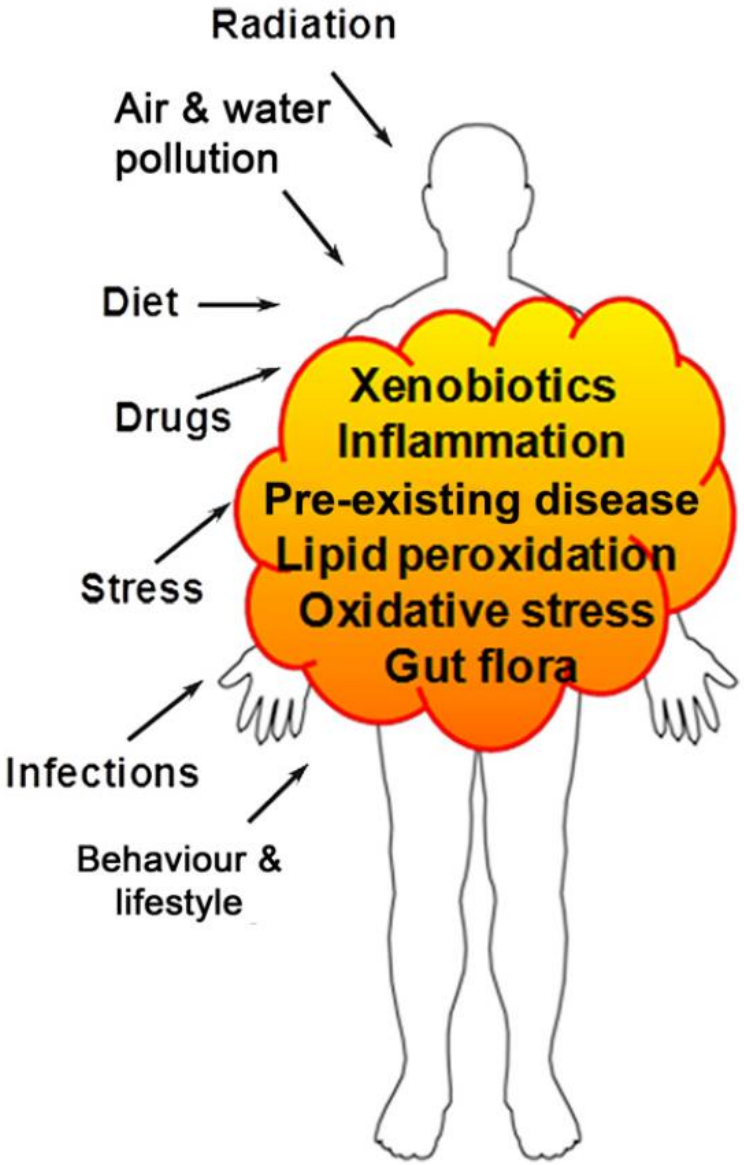
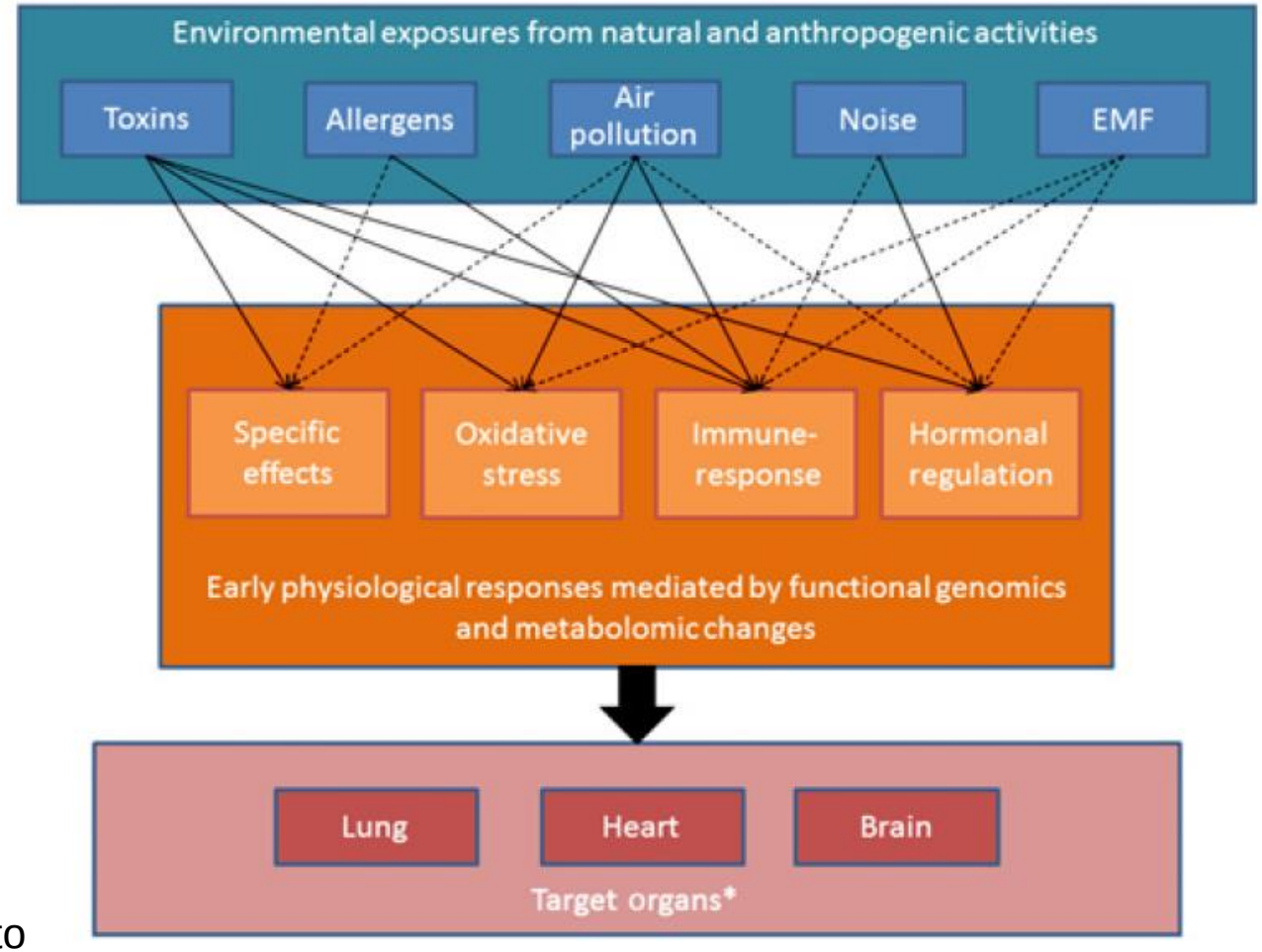
The Exposome

- Comprehensive assessment of exogenous and endogenous exposures
- Novel technologies
- Interdisciplinary approaches
- Unbiased assessments



Rappaport, JECH, 2012

Understanding the link between Environment and Health



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Peters et al. JECH 2012

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Air Pollution Exposure may change in Future

- Novel technologies (e.g. e-mobility, new engine technologies, energy efficient cities) will change exposures
- Ageing societies, migration, life-style and socioeconomic changes will alter susceptibility, vulnerability and co-exposure patterns
- Should we assess the toxicity potential of new technologies before the market introduction? If yes, how?

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Acknowledgement

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