

## **Health Effects of Ambient Ultrafine Particles – Do we know enough?**

18<sup>th</sup> ETH-Conference on Combustion Generated Nanoparticles,  
Zürich, 25. Juni 2014

Prof. Dr. Annette Peters

Helmholtz Zentrum München – German Research Center for Environmental  
Health, Institute of Epidemiology II, Neuherberg, Germany

Harvard School of Public Health, Department of Environmental Health,  
Boston, MA, USA

# Ambient Air Pollution – Worldwide Problem

---



**London, middle of XX century**



**Beijing, beginning of the XXI century**

# Health Effects of Ambient Ultrafine Particles

---

- Health Effects of Fine Particles
- Modes of Action of Particles Depend on their Size
- Health Effects of Ultrafine Particles
- Research Needs



# Review of evidence on health aspects of air pollution for guidance of EU policy

## **OBJECTIVE:**

**To provide the European Commission and its stakeholders with scientific evidence- based advice on health aspects of air pollution in support of the comprehensive review of air quality legislation due in 2013.**

Full WHO technical report was published in June 2013

<http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report>

# Health Effects of Particulate Air Pollution – REVIHAAP Conclusions (A1)

---

1. Short-term exposure to PM<sub>2.5</sub> on both mortality and morbidity
2. Long-term exposures to PM<sub>2.5</sub> on mortality and morbidity
3. Long-term exposure to PM<sub>2.5</sub> is a cause of both cardiovascular mortality and morbidity

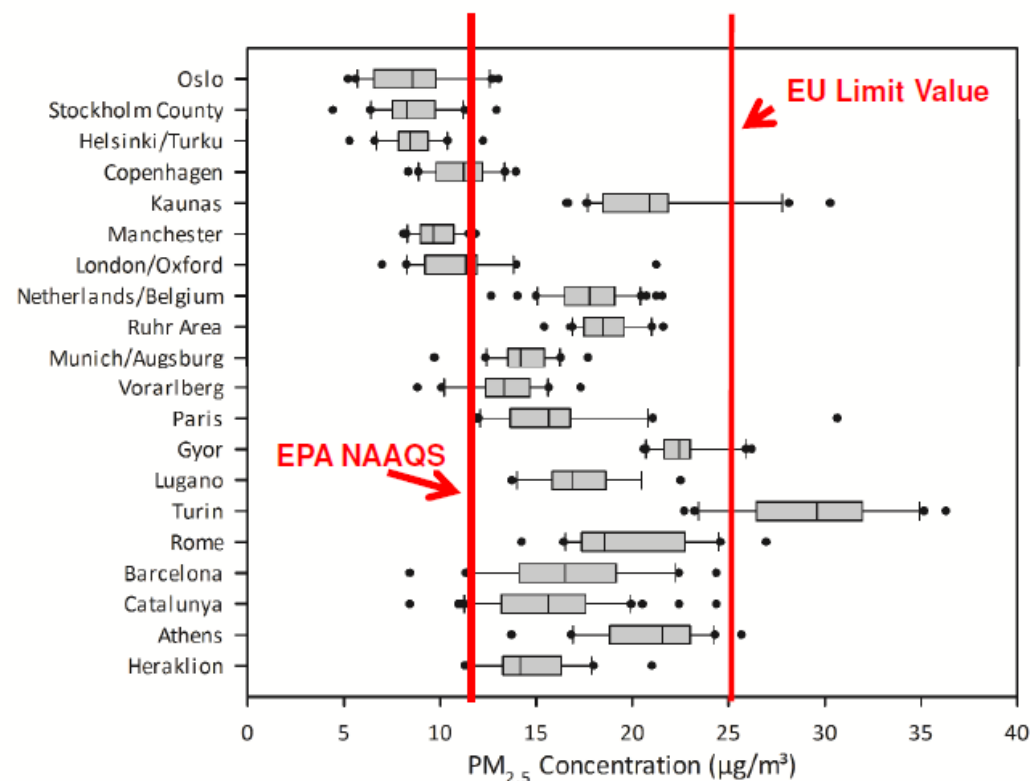


# ESCAPE: European Study of Cohorts for Air Pollution Effects

- Existing cohort studies
- Spatial variability of air pollution based on Geographic Information Systems
- Outcomes
  - Children's health
  - Respiratory health
  - Cardiovascular Health
  - Mortality



## PM2.5 results



Eeftens, Atm Env 2012

## ESCAPE: Fine Particles ( $5 \mu\text{g}/\text{m}^3$ ) and Total Mortality

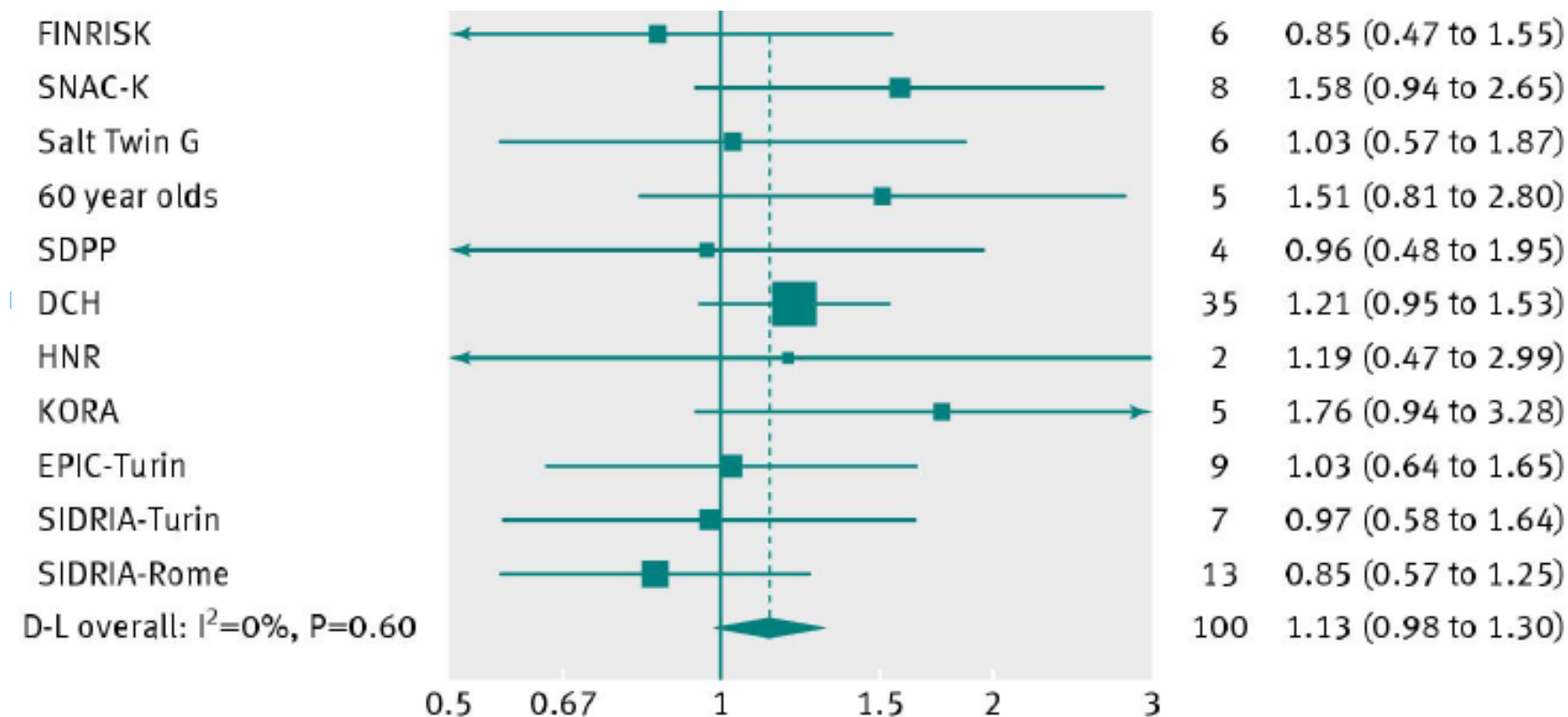
---

Threshold	N of cohorts	PM2.5
10 $\mu\text{g}/\text{m}^3$	9	1.02 (0.87-1.19)
15 $\mu\text{g}/\text{m}^3$	11	1.04 (0.98-1.11)
20 $\mu\text{g}/\text{m}^3$	17	1.07 (1.01-1.13)
25 $\mu\text{g}/\text{m}^3$	17	1.06 (1.00-1.12)
	19	1.07 (1.02-1.13)

The ACS study found a Relative Risk of  
 $1.030 / 5 \mu\text{g}/\text{m}^3$



# Risk for Incident Coronary Artery Disease for 5 $\mu\text{g}/\text{m}^3$ PM<sub>2.5</sub>



**Adjusted for:** Age (time variable), year of enrolment, sex, marital status, education, occupation, smoking status, smoking duration and smoking intensity, socioeconomic area-level variables

**Cesaroni et al. BMJ 2014**



# Health Effects of Ambient Ultrafine Particles

---

**Health effects of  
fine particles are consistently  
shown**



**The evidence today is  
substantially strengthened  
compared to the 2005 WHO  
guidelines**



# Health Effects of Ambient Ultrafine Particles

---

- Health Effects of Fine Particles
- Modes of Action of Particles Depend on their Size
- Health Effects of Ultrafine Particles
- Research Needs



# Health Effects of Particulate Air Pollution – REVIHAAP Conclusions (A2)

---

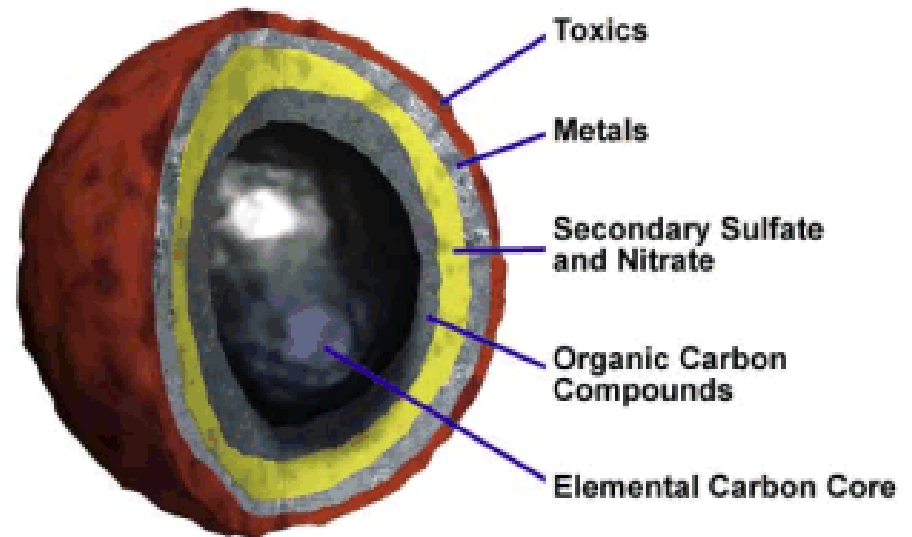
Epidemiological and toxicological studies have shown  $PM_{2.5}$  and  $PM_{10}$  comprises fractions suggesting a role for both the **chemical composition** (such as transition metals and combustion-derived primary and secondary organic particles) and **physical properties** (size, particle number and surface area)



# PM Composition related to Health Effects

---

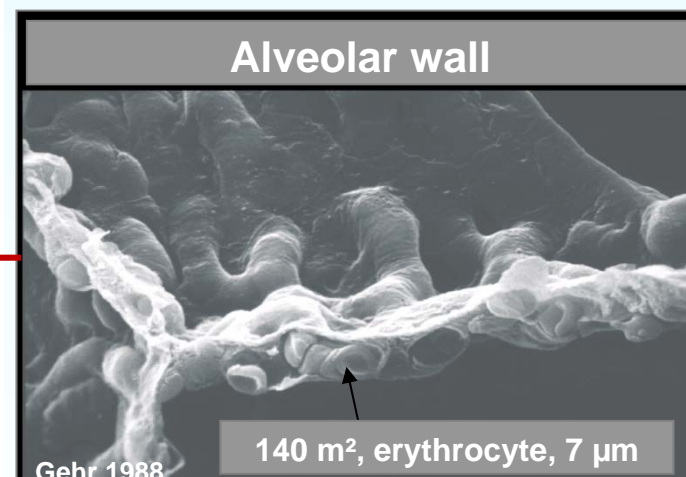
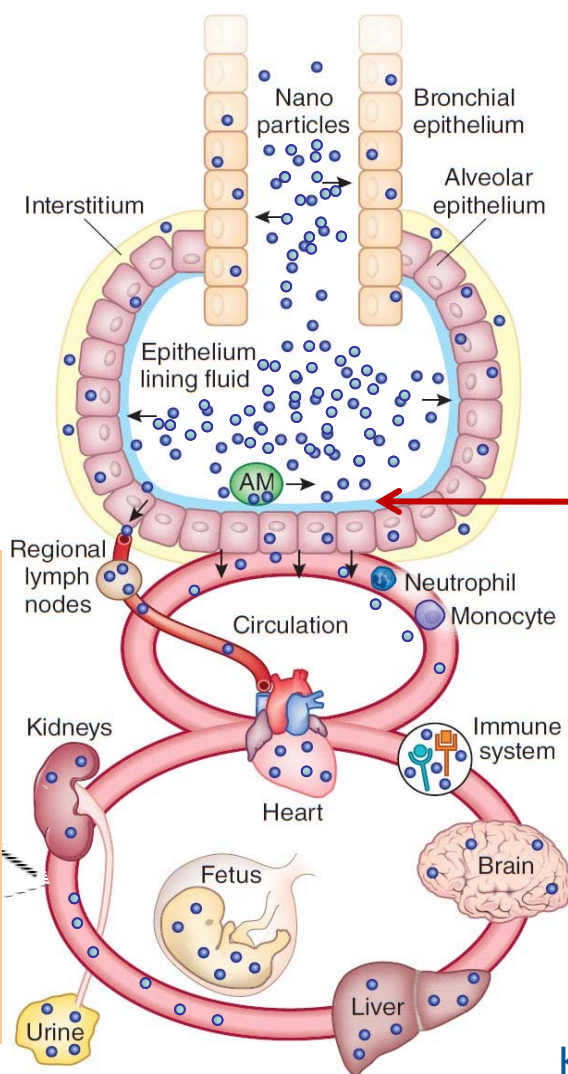
- PM Composition
  - Black carbonaceous particles
  - Secondary organic aerosols
  - Secondary inorganic aerosols
- Coarse particles
- Ultrafine particles



# Nanoparticle Incorporation and Translocation



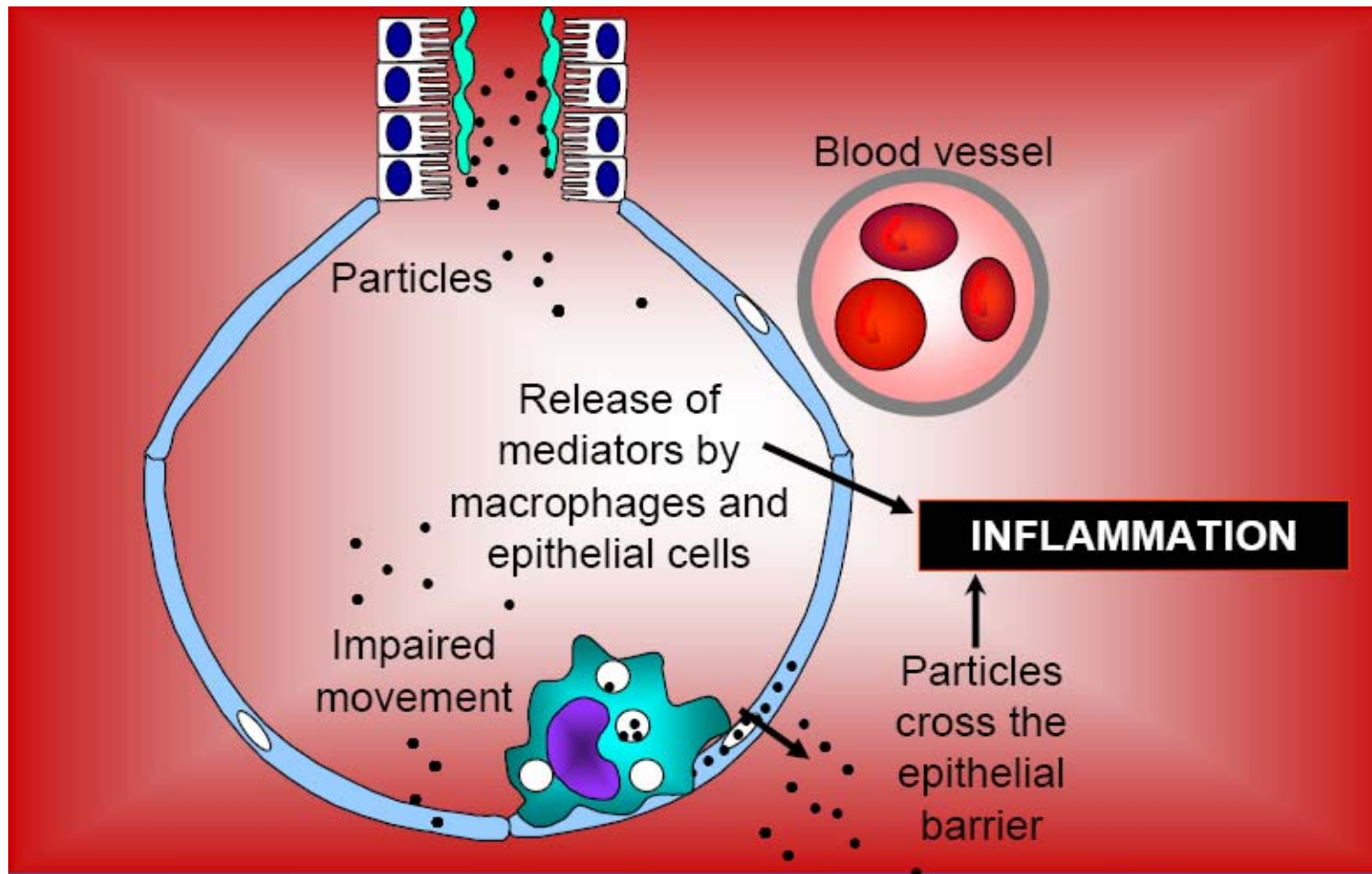
**Biokinetics** provides the dose estimate for both the primary and secondary organs and tissues and therefore it is the rationale for subsequent toxicological studies assessing potential health risks



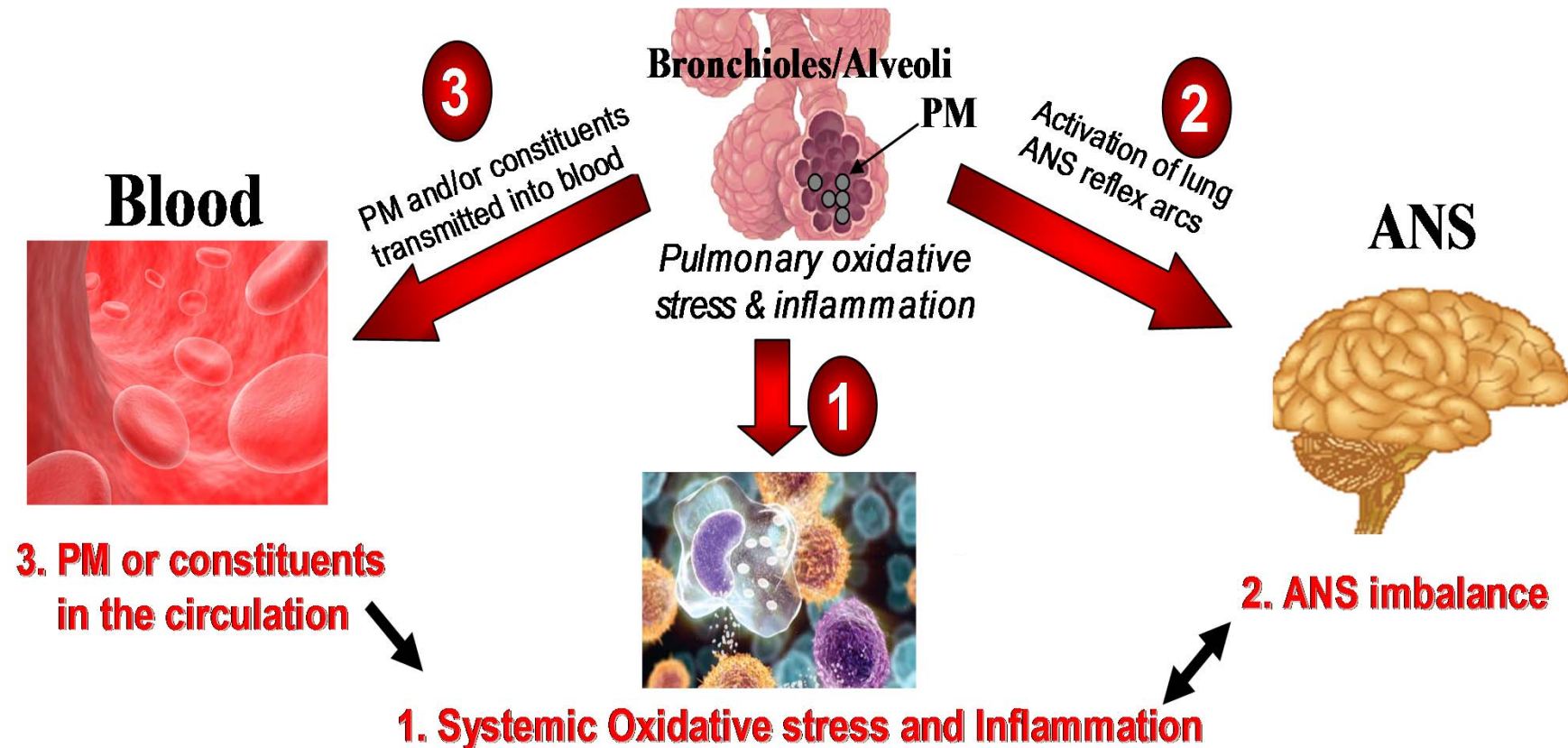
Kreyling et al., Nat Biotech, 2010



# Particles Impact the Lung and their Effects Go Beyond

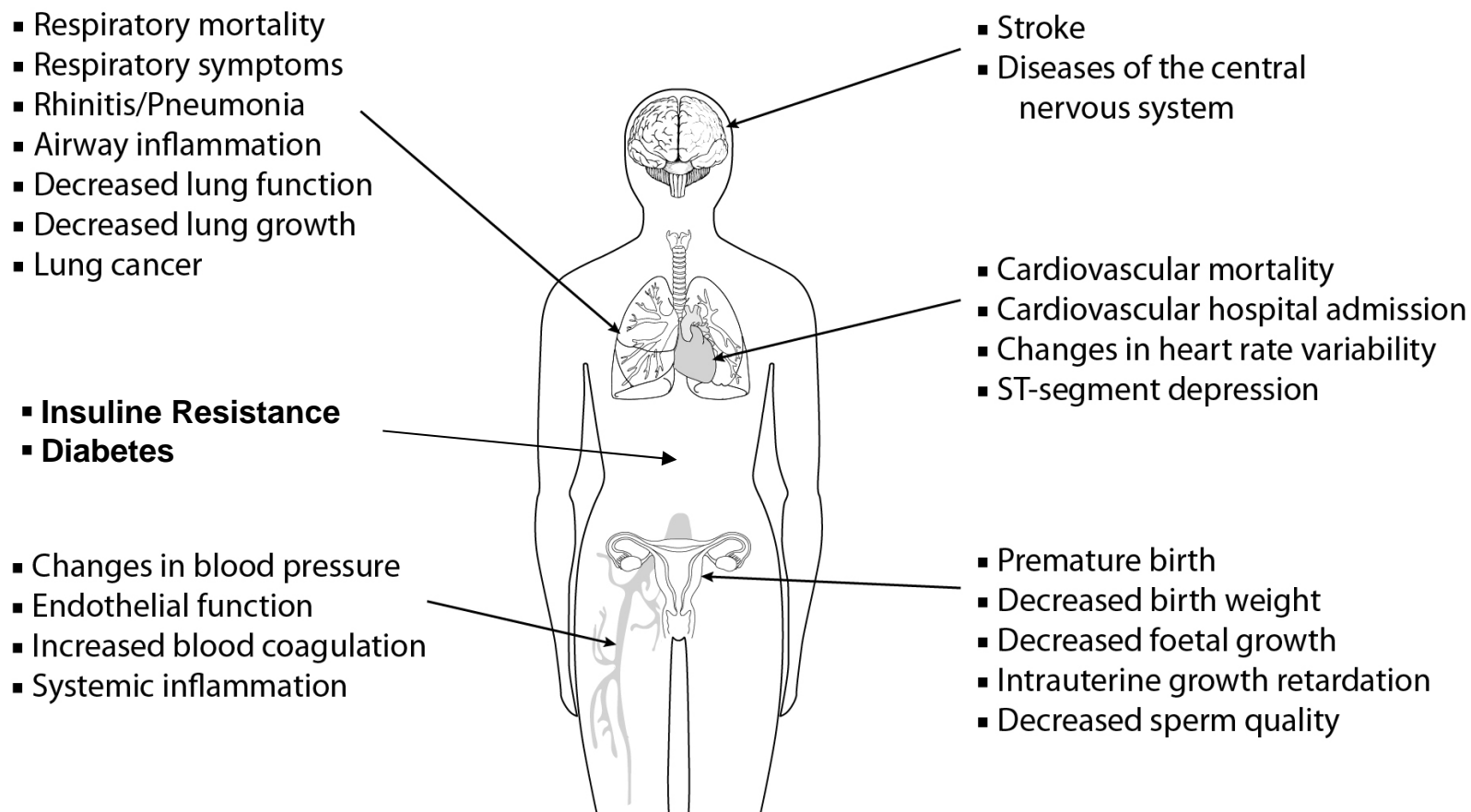


# Cardiovascular disease due to traffic exposures and fine particles





# Organs of the human body affected by particulate air pollution



# Health Effects of Ambient Ultrafine Particles

---

**Particle sizes determine their location of deposition and their fate within the body**



**Particle chemistry determines their mode of action**



# Health Effects of Ambient Ultrafine Particles

---

- Health Effects of Fine Particles
- Modes of Action of Particles Depend on their Size
- Health Effects of Ultrafine Particles
- Research Needs



# Research gaps for ultrafine particles

---

## HEI Perspectives 3

January 2013

*Insights from HEI's research*



### Understanding the Health Effects of Ambient Ultrafine Particles

HEI Review Panel on Ultrafine Particles

<http://www.healtheffects.org/Workshops/Brussels2013/Presentations/Shaiikh.pdf>

# Key Findings: Observational Epidemiologic Studies

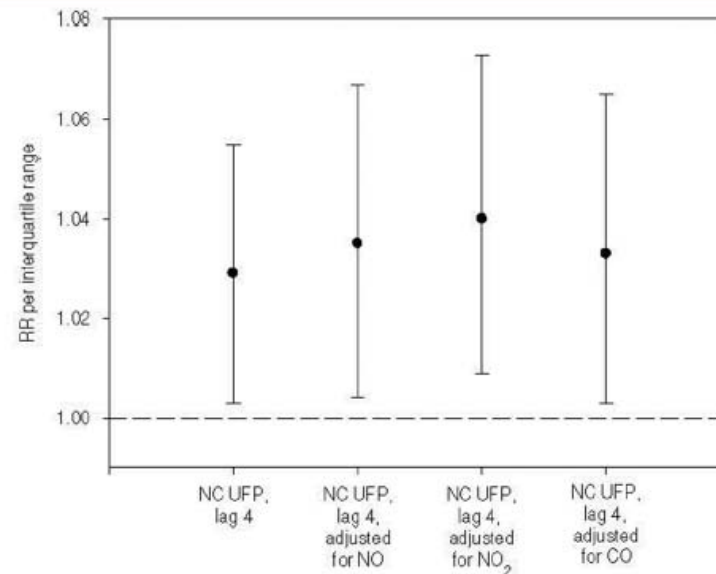
- Short-term studies only
  - Time-series, panel studies
  - Variable study designs
  - Single studies
- No studies of long term exposures





# Key Findings: Observational Epidemiologic Studies

- Some studies have found clear, independent associations of ultrafines with adverse effects on health
- For Example: Studies in Erfurt ('95 – '01)
  - Increased mortality
  - Total number concentration
  - Adjusted for co-pollutants
  - Generally, only for lag 4 days post-exposure

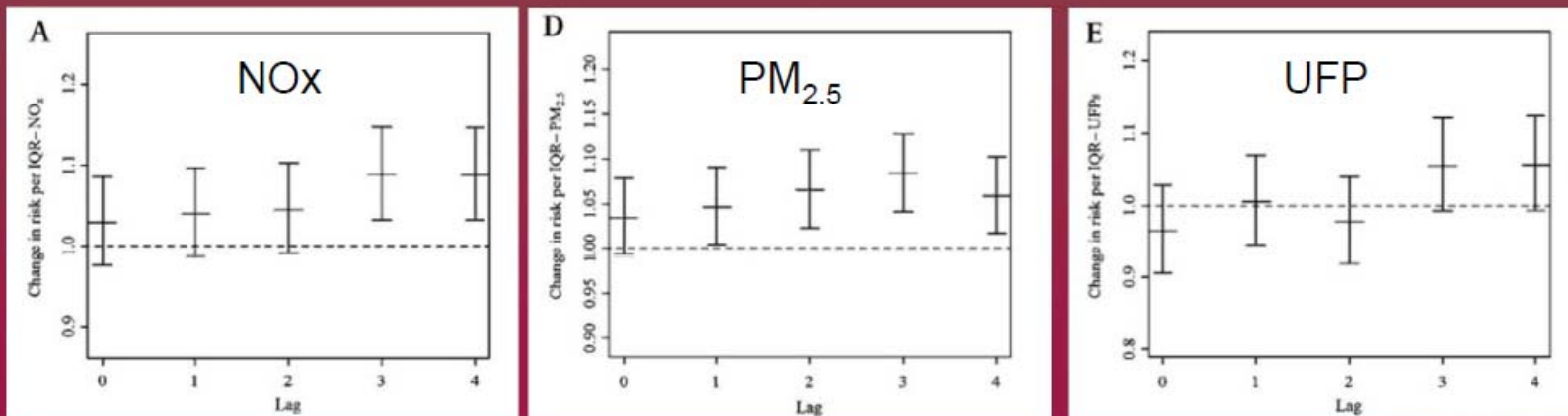


**Figure 3.** Relative risk estimates for UFP NC, adjusted for gaseous pollutants in two-pollutant models. Erfurt, Germany, September 1995 to August 2001.

Stölzel et al. (2007)

# Key Findings: Observational Epidemiologic Studies

- Other studies have not...
  - Associations observed with NO<sub>x</sub>, NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, but not as strongly with total UFP
  - Weaker in two-pollutant models



Associations with pediatric asthma hospitalizations in Copenhagen

(Iskandar et al., 2012)





# Overall Conclusions

- Motor vehicles, especially diesel, have been important sources of emissions and exposures to ambient UFPs but emissions set to change substantially in the years ahead.
- UFPs differ from larger particles in their deposition, clearance and potential for translocation.
- Experimental and epidemiologic studies provide suggestive, but not consistent, evidence of adverse effects of short-term exposures to ambient UFP.
- The lack of support for a substantial, independent effect “does not mean that such effects, as one part of the broader effects attributable to PM<sub>2.5</sub> can be entirely ruled out.”

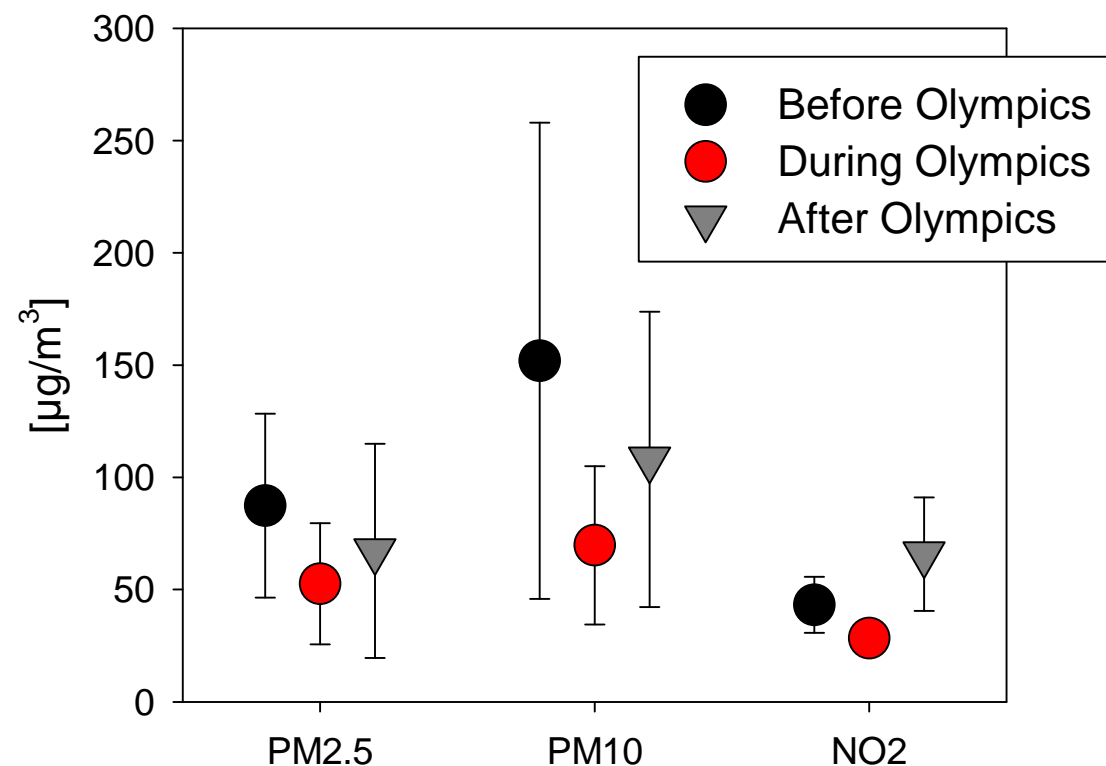
And, therefore,

- “The current evidence does not support a conclusion that “exposure to UFPs alone can account in substantial ways for the adverse effects ... of PM<sub>2.5</sub>”

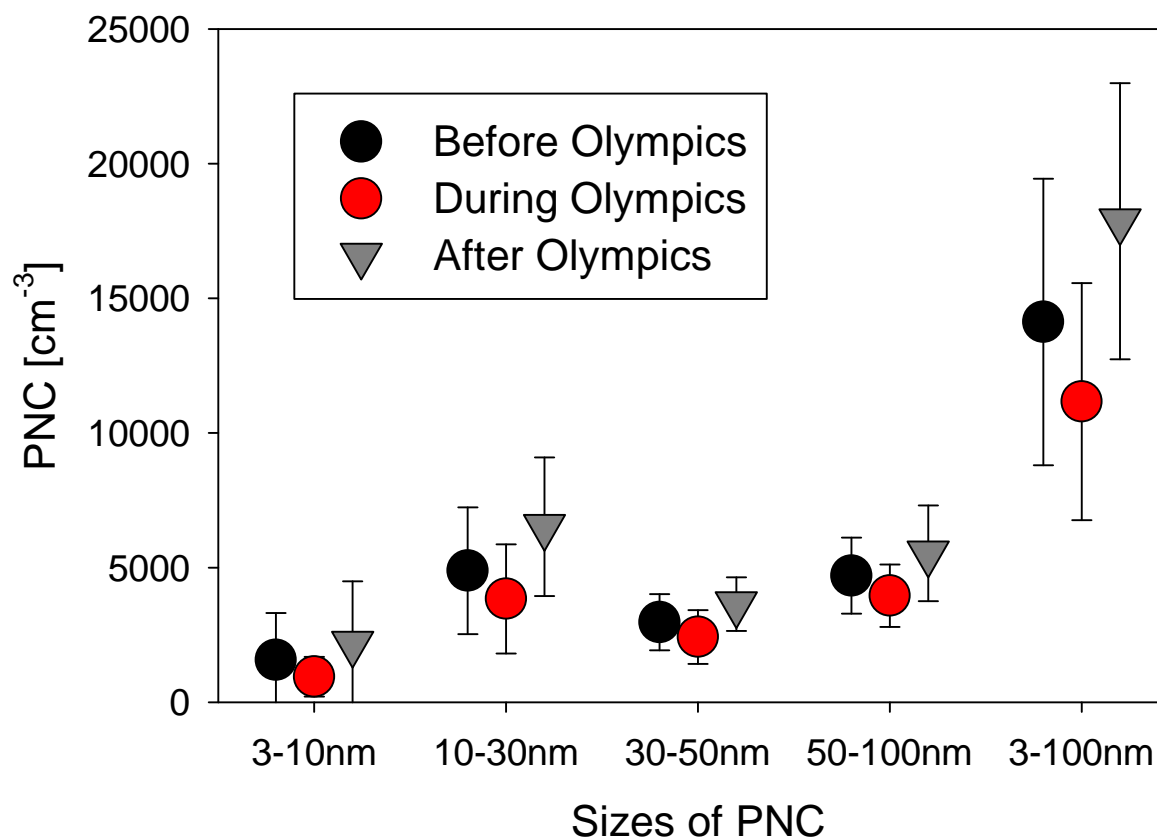
# Novel Evidence: The 2008 Beijing Olympics



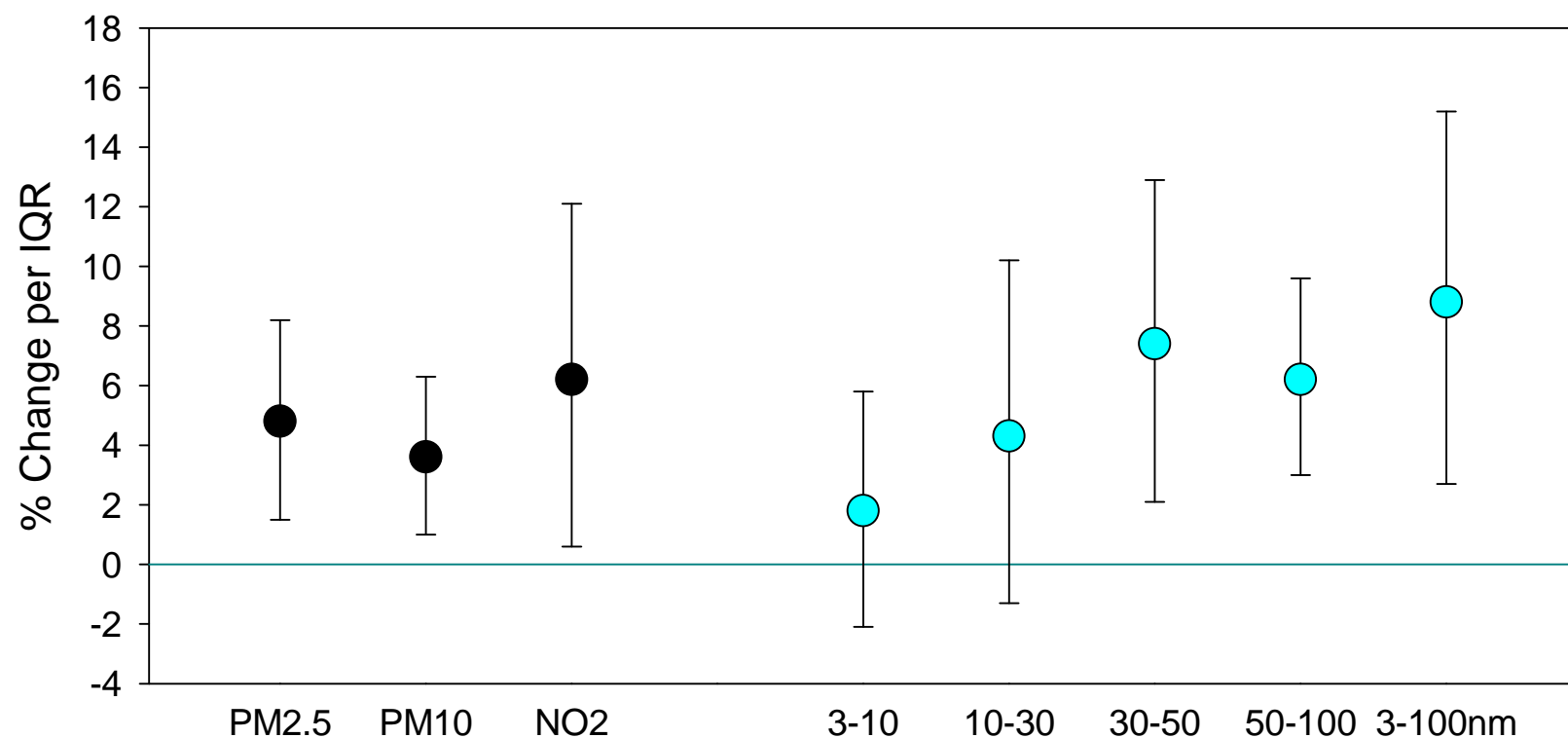
- Monitoring of  $\text{PM}_{10}$  and  $\text{NO}_2$  at 8 official monitoring sites
- Monitoring of  $\text{PM}_{2.5}$  and particle size distribution at Peking University
- Cardiovascular disease mortality for the Beijing urban area



# Novel Evidence: The 2008 Beijing Olympics



# Novel Evidence: The 2008 Beijing Olympics Cardiovascular Disease Mortality



# Health Effects of Ambient Ultrafine Particles

---

**Health effects of  
ultrafine particles are shown  
for short-term exposures**

**Capture important properties  
of ambient aerosols in  
addition to fine particles**

**Need to be controlled at the  
source to reduce health  
effects in urban areas**



# Health Effects of Ambient Ultrafine Particles

---

- Health Effects of Fine Particles
- Modes of Action of Particles Depend on their Size
- Health Effects of Ultrafine Particles
- Research Needs





# Critical data Gaps for Ultrafine Particles to Promote an Ambient Standard

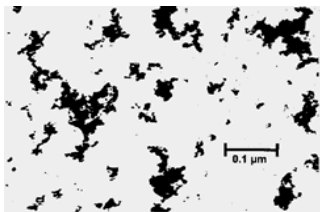
---

- Studies on long-term health effect studies based on prospective cohort studies
- Studies on short-term health effects based on multicenter time-series studies including meta-analyses
- Studies on personal short-term exposures and health effects in panel studies
- Studies assessing all criteria pollutants and black carbon jointly with ultrafine particles

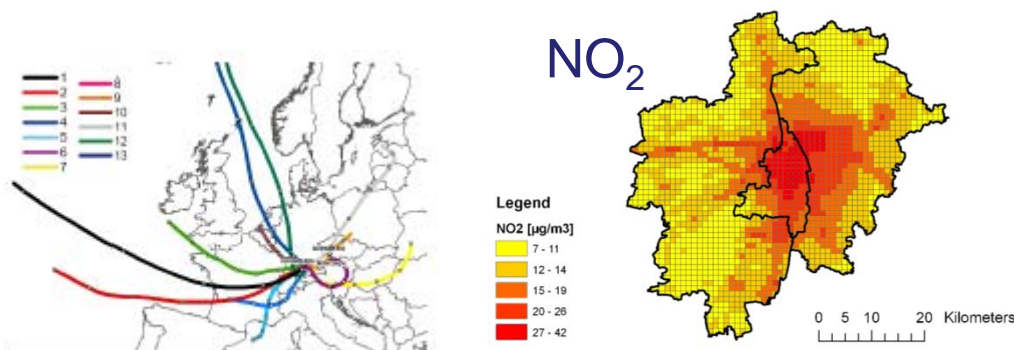




# ULTRA III: Closing Gaps in Research on Ambient Ultrafine Particles



- Measurements of ultrafine particles
- Chemical composition of ultrafine particles
- Microclimate data
- Modeling of residential exposures
- Links to ongoing epidemiological re-examinations in KORA including preclinical phenotypes determined by imaging



**HICE • Aerosols and Health**  
Helmholtz Virtual Institute of Complex  
Molecular Systems in Environmental Health

# Thank you very much for your attention!

---

