
Temporal variability and health effects of air pollutants in epidemiological short-term studies

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The city of Munich, Germany



On a smog day...

The city of Munich, Germany

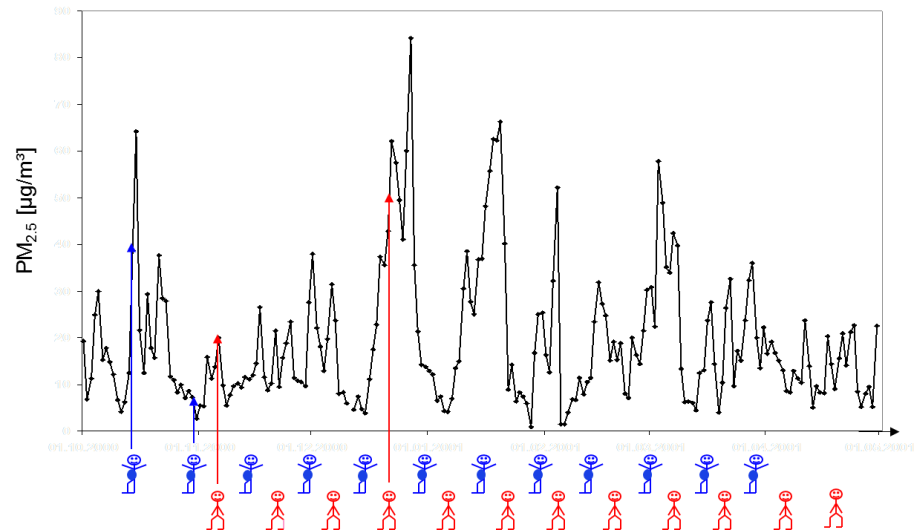


On a clear day...

Short-term vs. long-term effect studies

Short-term

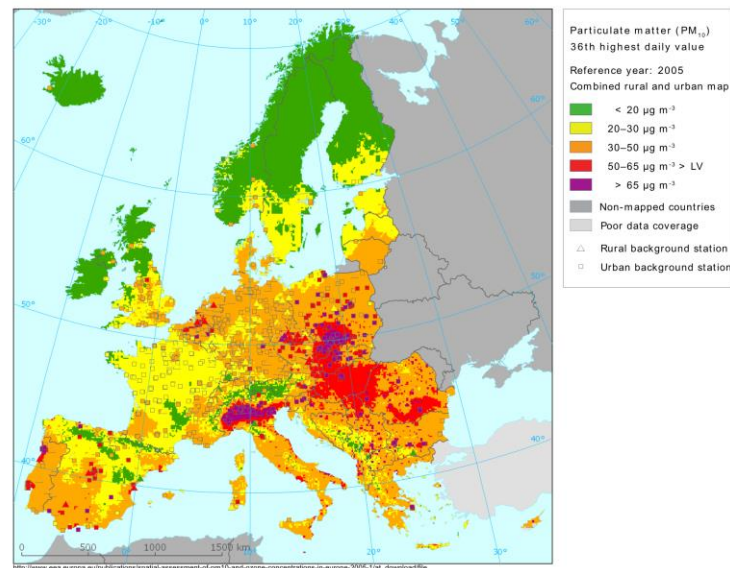
- Effects of **short-term** exposure to ambient air pollutants
- Exposure period: **hours, days, weeks**
- Assessment of **temporal variation**



Short-term vs. long-term effect studies

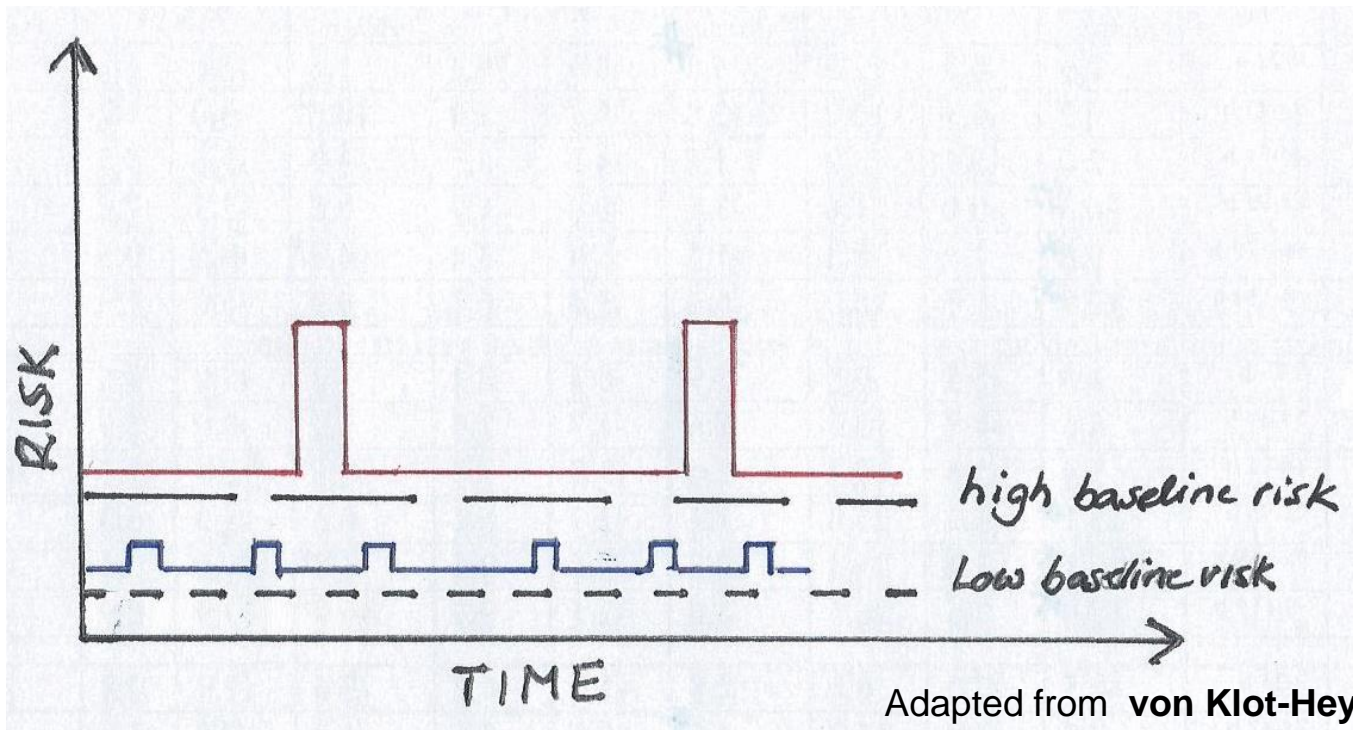
Long-term

- Effects of **long-term** exposure to ambient air pollutants
- Exposure period: **several years, at least one year**
- Assessment of **geographical variation** (between study areas or participants)



Why studies on short- and long-term effects?

There are **chronic** and **acute** health effects (of air pollutants) which are independent.



Why studies on short- and long-term effects?

Short-term studies assess:

- Effects of acute (transient) changes
- Potential physiological pathways

Long-term studies assess:

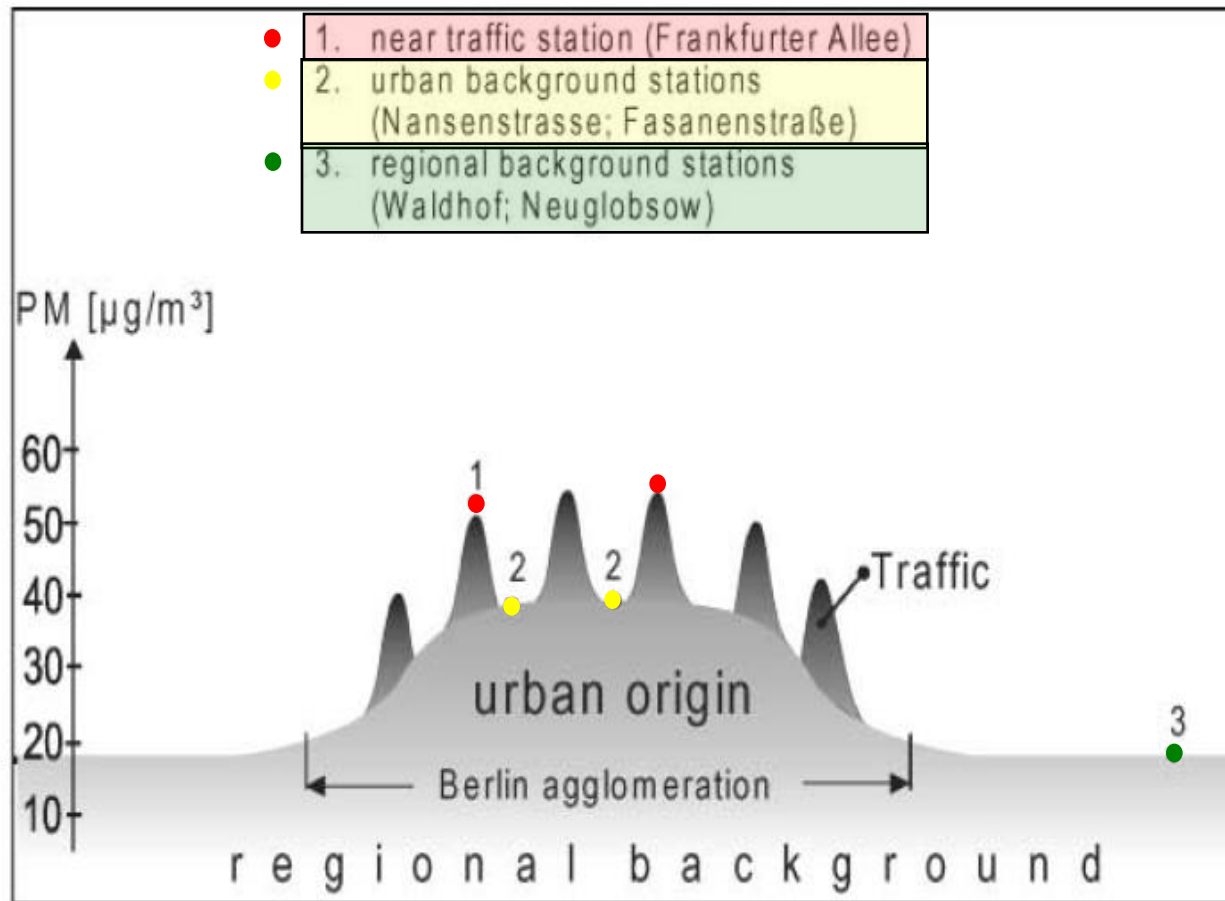
- Effects of moderate or high long-term (chronic) exposure and cumulative effects of repeated episodes of increased exposure
- Health benefits of clean air acts

Important for public-health!

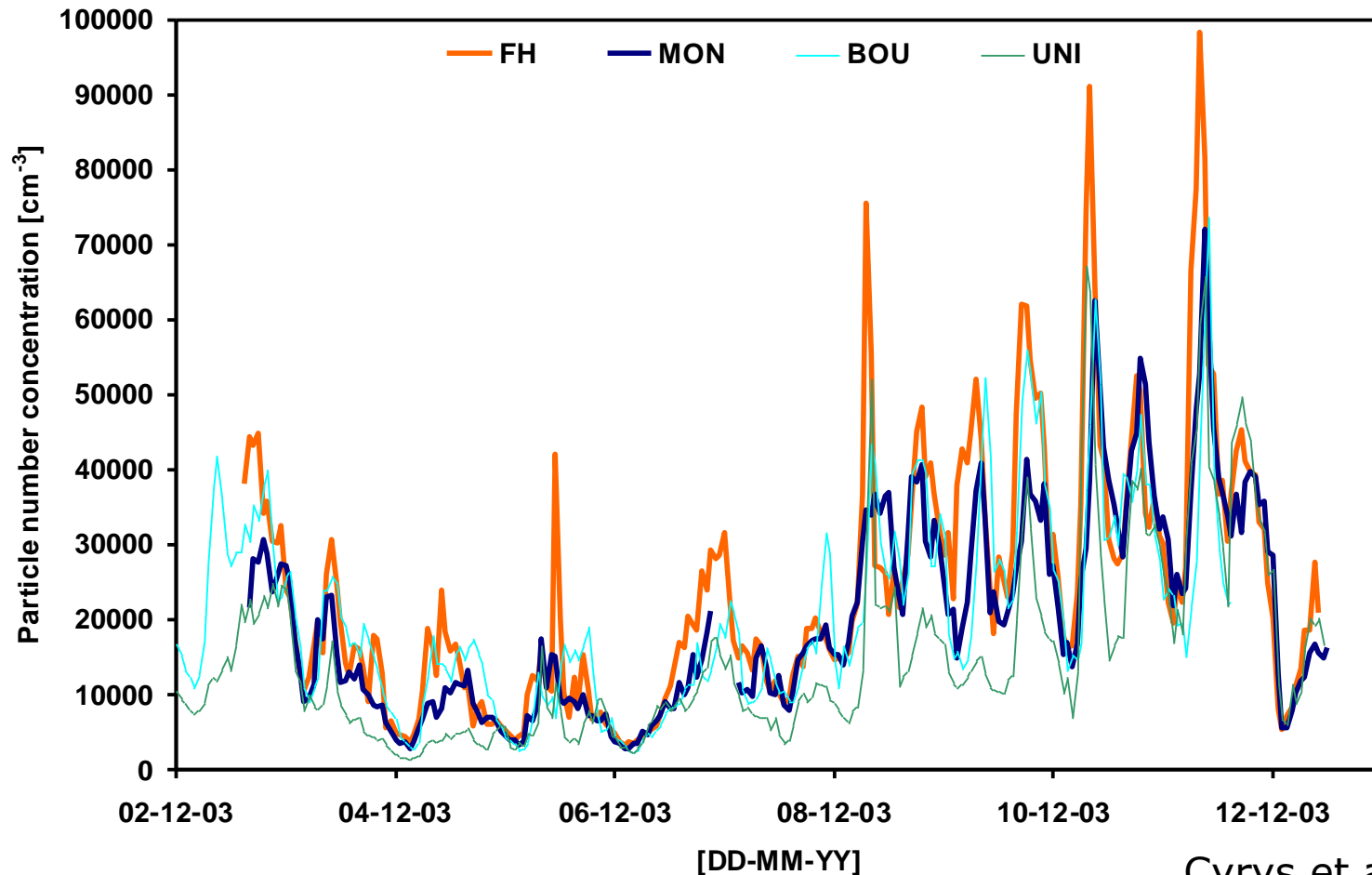
How/why do short-term studies work?

- PM measured at a central site reflects well **temporal variation** near homes across urban areas
- Correlations with the central site are usually similar for background and traffic locations
- Using a central site in **epidemiological time-series studies** is therefore justifiable

Schematic horizontal profile of ambient air pollution levels

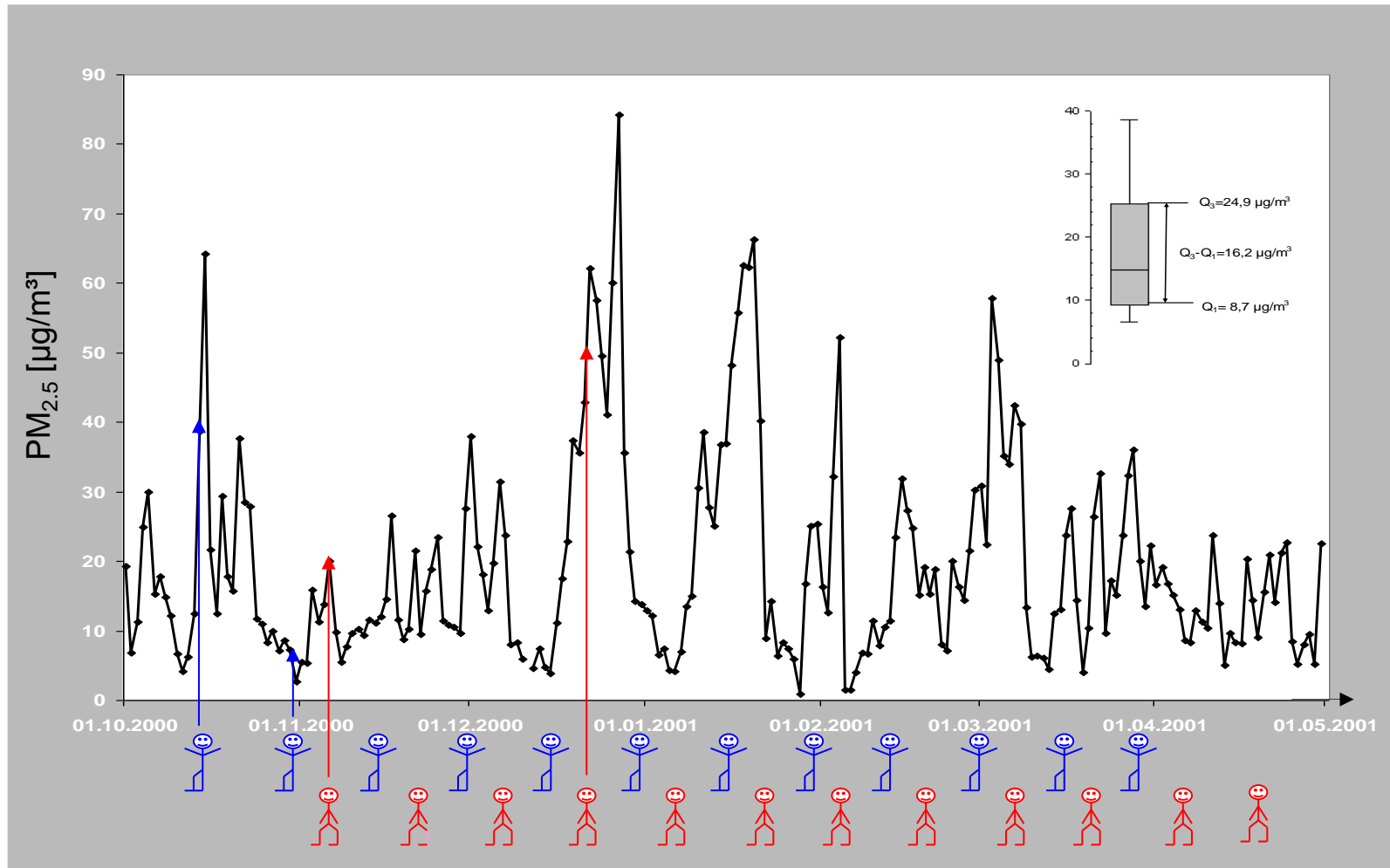


Temporal variation of PNC at different monitoring sites (Augsburg)



Cyrys et al., 2008

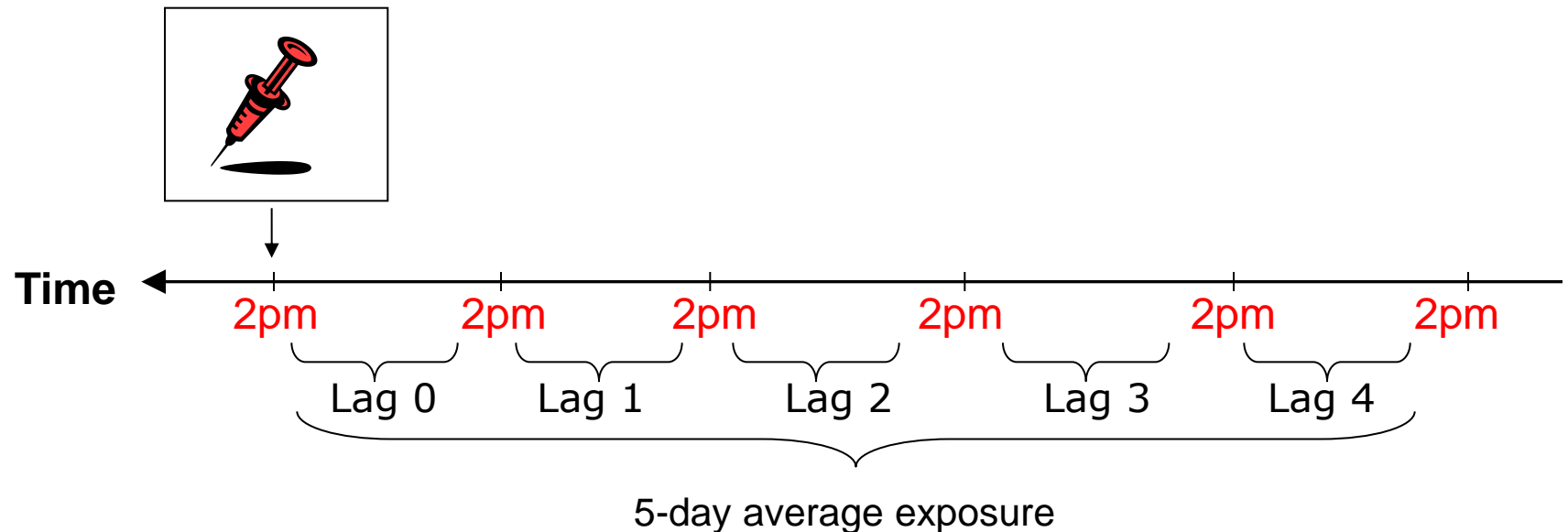
Study design of a panel study: Repeated measurements



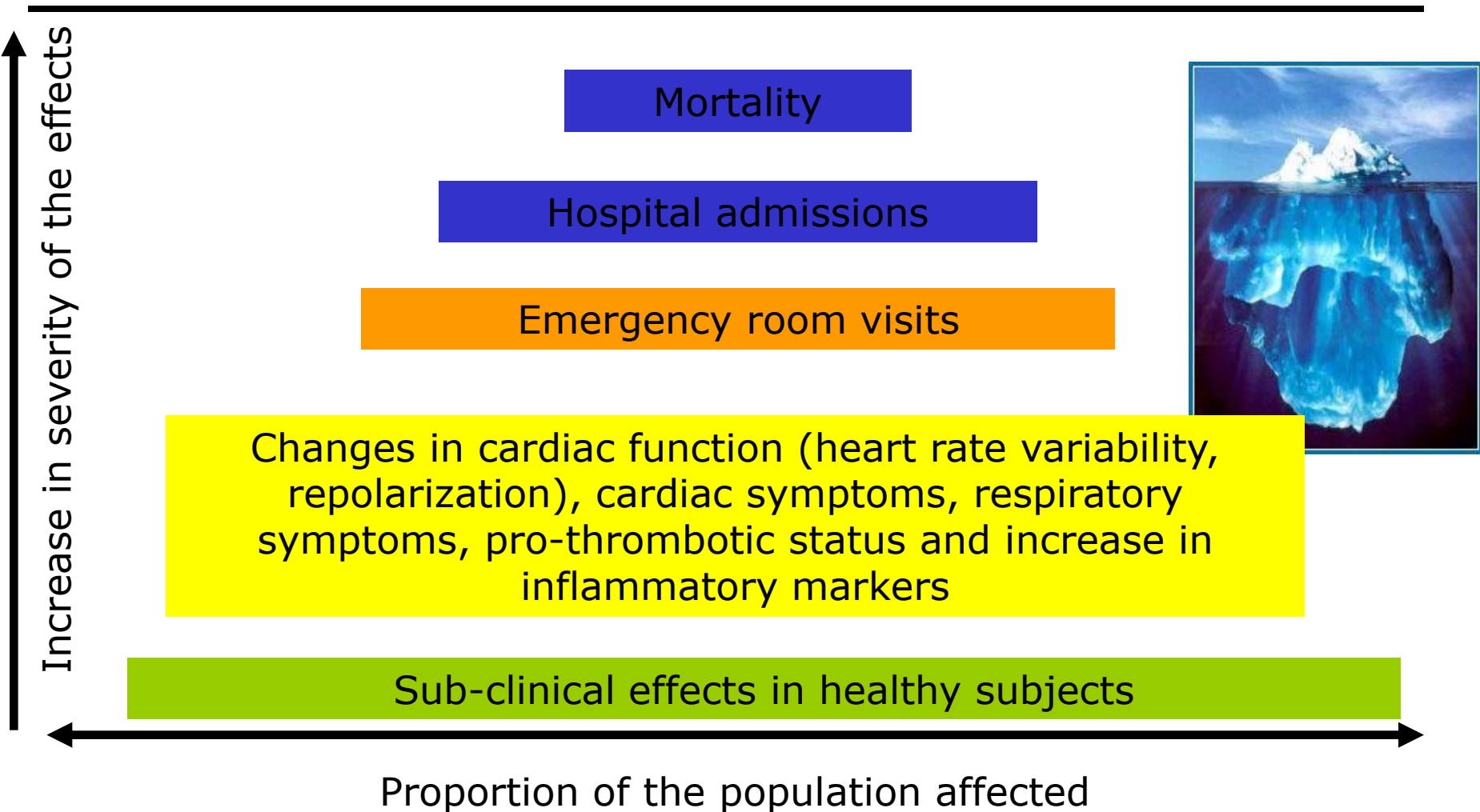
Calculation of individual exposure windows (example: individual 24-hour lags)

Important: Exposure data need to be on an hourly basis (minimum)

Principle of individual lag-times:



Health effects of particulate air pollution based on epidemiological studies



Parts of the body that can be affected by air pollution

- Respiratory mortality
- Respiratory symptoms
- Rhinitis/Pneumonia
- Airway inflammation
- Decreased lung function
- Decreased lung growth
- Lung cancer

Lungs

Brain

- Stroke
- Diseases of the central nervous system

Heart

- Cardiovascular mortality
- Cardiovascular hospital admission
- Changes in heart rate variability
- ST-segment depression
- Changes in repolarisation

- Changes in blood pressure
- Endothelial function
- Increased blood coagulation
- Systemic inflammation

Vascular system

- Premature birth
- Decreased birth weight
- Decreased foetal growth
- Intrauterine growth retardation
- Decreased sperm quality

Reproductive organs

Studies on health effects of soot (BS/BC/EC/OC) are still comparatively rare...

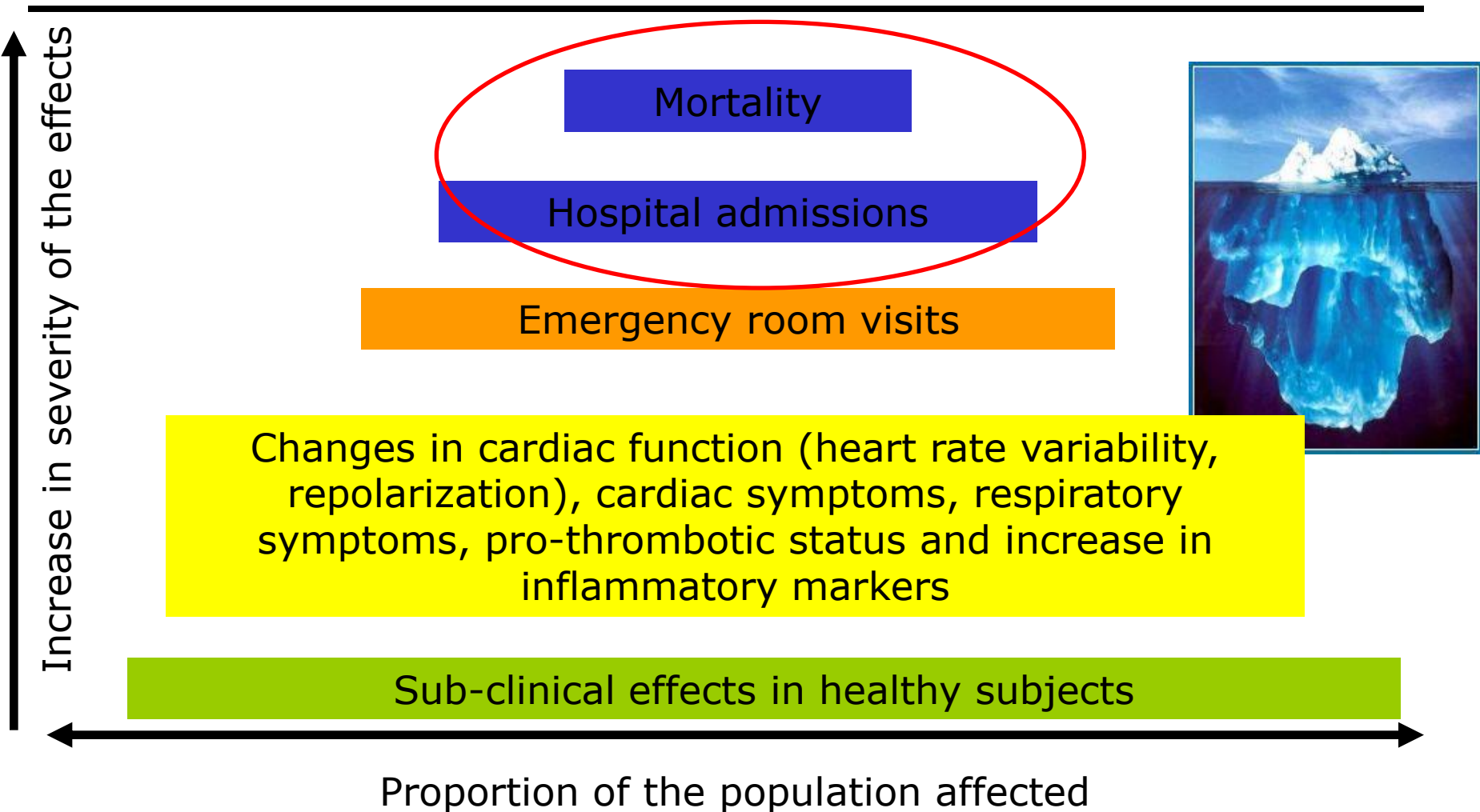
Table 1. Air pollutants and health outcomes.

Variables	Short-term studies						Long-term studies					
	PM ₁₀	PM _{2.5}	UFP	BS/BC	EC/OC	Other	PM ₁₀	PM _{2.5}	UFP	BS/BC	EC/OC	Other
Mortality												
All cause	xxx	xxx	x	x	x		xx	xx	x	xx	x	x
Cardiovascular	xxx	xxx	x	x	x		xx	xx	x	xx	x	x
Pulmonary	xxx	xxx	x	x	x		xx	xx	x	xx	x	x
Pulmonary effects												
Lung function, e.g., PEF	xxx	xxx	xx		x		xxx	xxx				
Lung function growth							xxx	xxx				
Asthma and COPD exacerbation						x						
Acute respiratory symptoms		xx	x			x	xxx	xxx				
Medication use			x									
Lung cancer												
Hospital admission							xx	xx	x			x
Cardiovascular effects												
Hospital admission	xxx	xxx					x	x				x
ECG-related endpoints												
Autonomic nervous system	xxx	xxx	xx	x								
Myocardial substrate and vulnerability		xx	x	x		x						
Vascular function												
Blood pressure	xx	xxx	x	x	x	x						
Endothelial function	x	xx	x	x		x						
Variables	PM ₁₀	PM _{2.5}	UFP	BS/BC	EC/OC	Other						
Blood markers												
Pro inflammatory mediators	xx	xx	xx	x	x	xx						
Coagulation blood markers	xx	xx	xx	x	x	x						
Endothelial function	x	x	xx	x	x	x						
Reproduction												
Premature birth	x	x				x						
Birth weight	xx	x				xx						
IUR/SGA	x	x				x						
Fetal growth						x						
Birth defects	x					x						
Infant mortality	xx	x				xx						
Sperm quality	x	x				x						
Neurotoxic effects												
Diseases of the central nervous system				x		xx						

x, few studies; xx, many studies; xxx, large number of studies.

Rückerl et al., 2011

Health effects of particulate air pollution based on epidemiological studies



Comparison between effects of black carbon particles and PM₁₀ on health – a review

34 included publications, mostly studies conducted in Europe

Health outcomes:

Daily mortality due to all causes, cardiovascular diseases, respiratory diseases

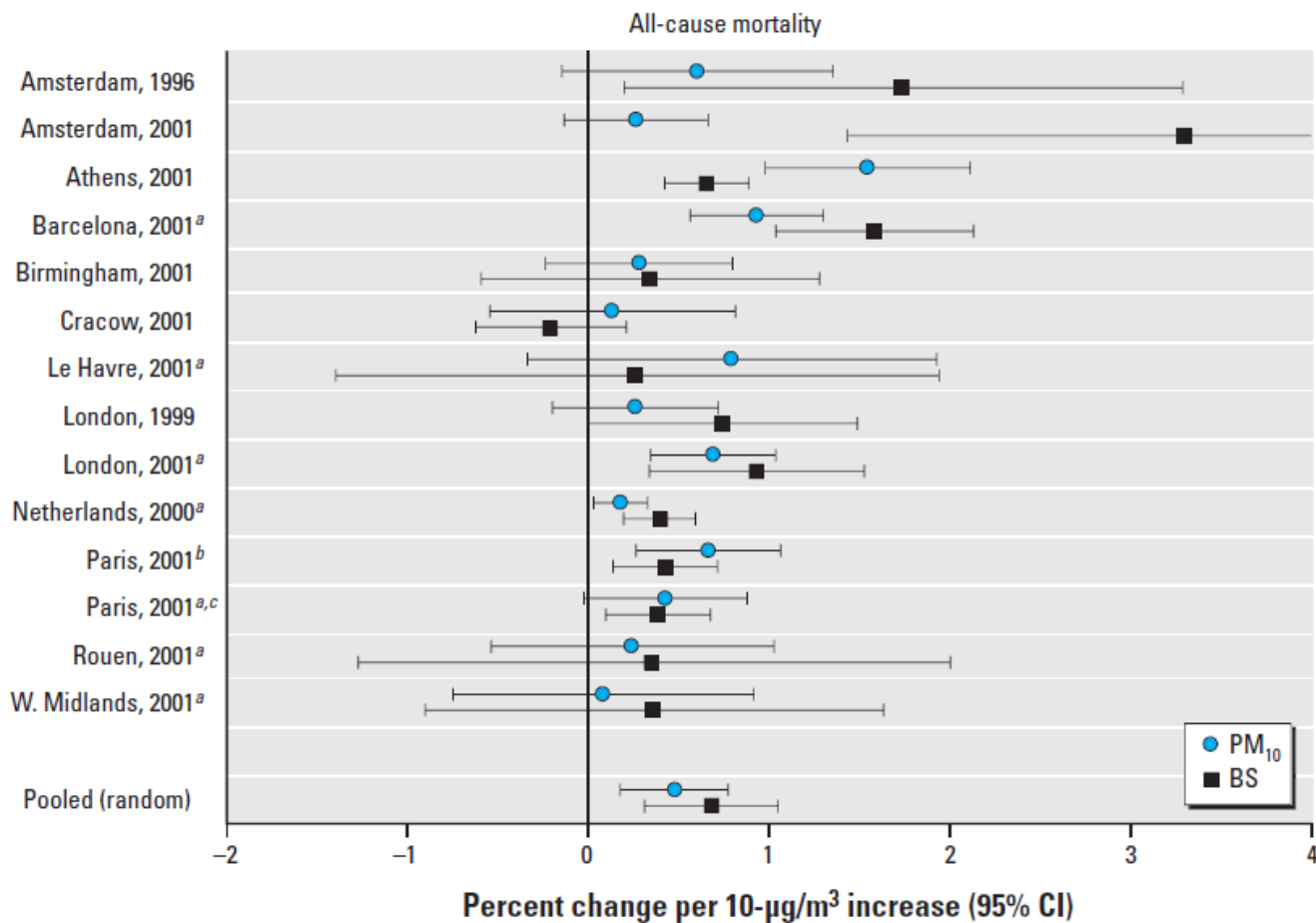
Hospital admissions due to respiratory diseases, asthma, cardiac diseases and ischemic heart diseases

Results:

- Most studies show an increase in health outcome with increased air pollution
- Effects per an 10µg/m³ increase are higher for BCP than for PM₁₀
- Results are similar when IQR is used

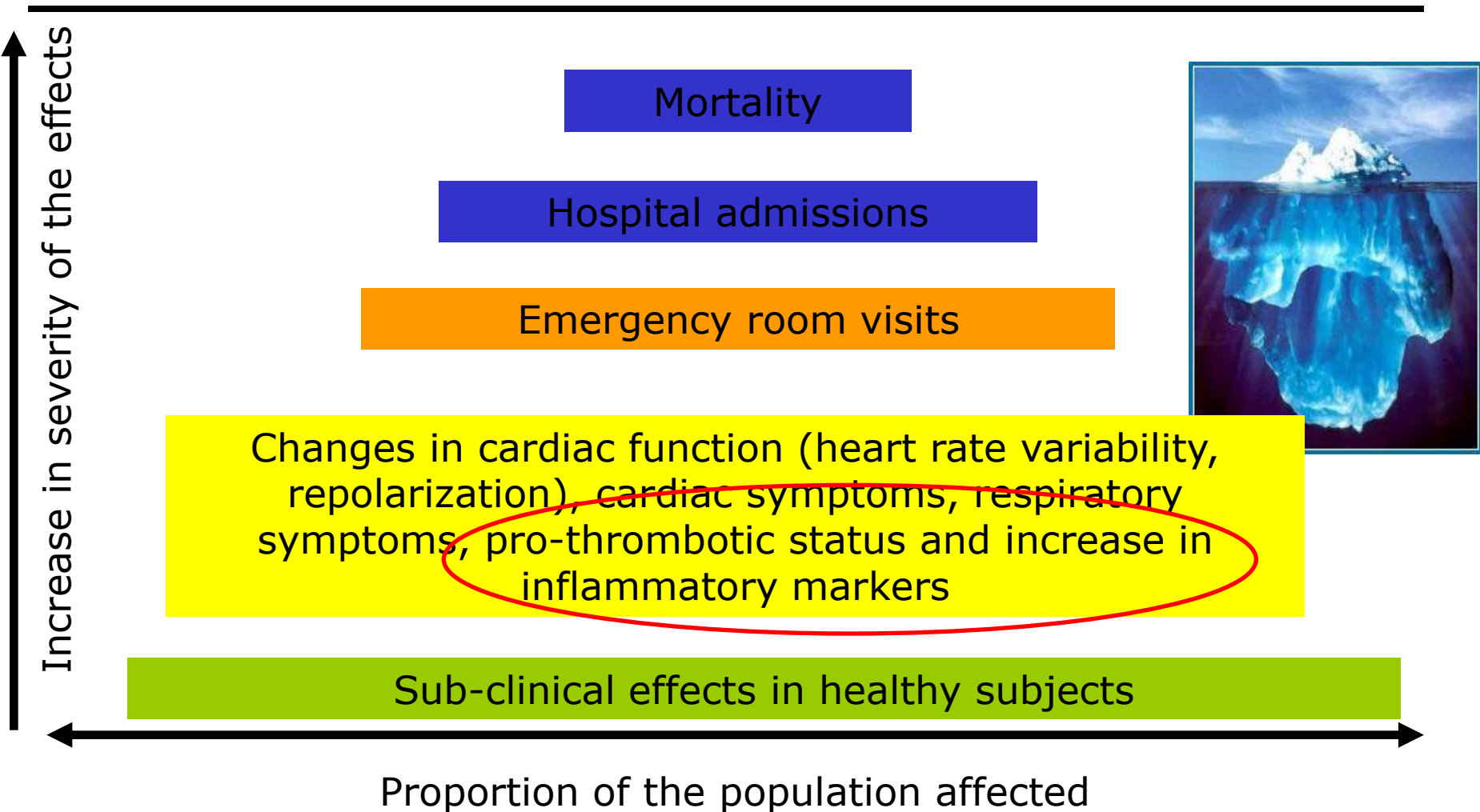
Janssen et al., 2011

PM₁₀ vs. BS/BC/EC/OC in studies on daily all-cause mortality



Janssen et al., 2011

Health effects of particulate air pollution based on epidemiological studies



Examples for short-term studies on BS/BC/EC/OC and inflammatory/ prothrombotic blood biomarkers

Reference	Air pollutants	CRP	MPO	Fibrinogen
Rückerl, 2006	EC/OC	o	n.m.	o
Delfino, 2008	EC/OC/BC/OC _{pri} /SOC	+	o	o
Hildebrandt, 2009	EC/OC	o	n.m.	+
Delfino, 2009	EC/OC/BC/OC _{pri} /SOC	+	n.m.	n.m.
Bind, 2012	BC	o	n.m.	+
Rückerl, 2014	BC	++	++	+
Li, 2016	BC	n.m.	+	n.m.

O no association; + positive association; - negative association; n.m. not measured

CRP: C-reactive protein – biomarker of systemic inflammation

MPO: Myeloperoxidase - pro-oxidant enzyme/indicator of neutrophil activation

Fibrinogen: important role in blood coagulation

OC_{pri}/SOC: estimated primary and secondary organic carbon

„Source-specific health effects of ultrafine and fine particles“ (Augsburger Umweltstudie)

Study objective:

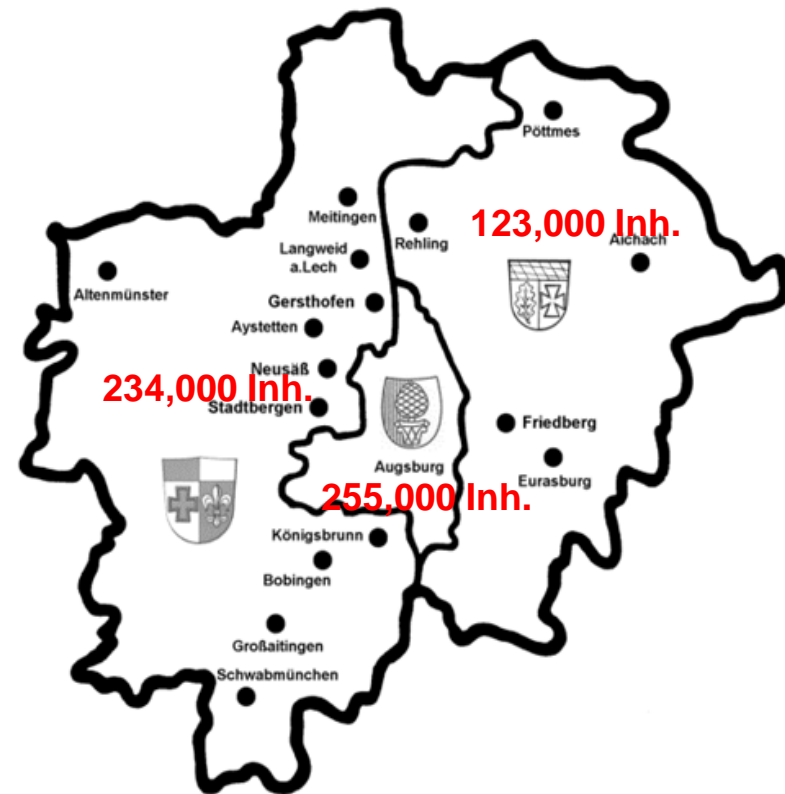
Description of health endpoint in **susceptible groups**

Study location: Area of Augsburg, Germany.

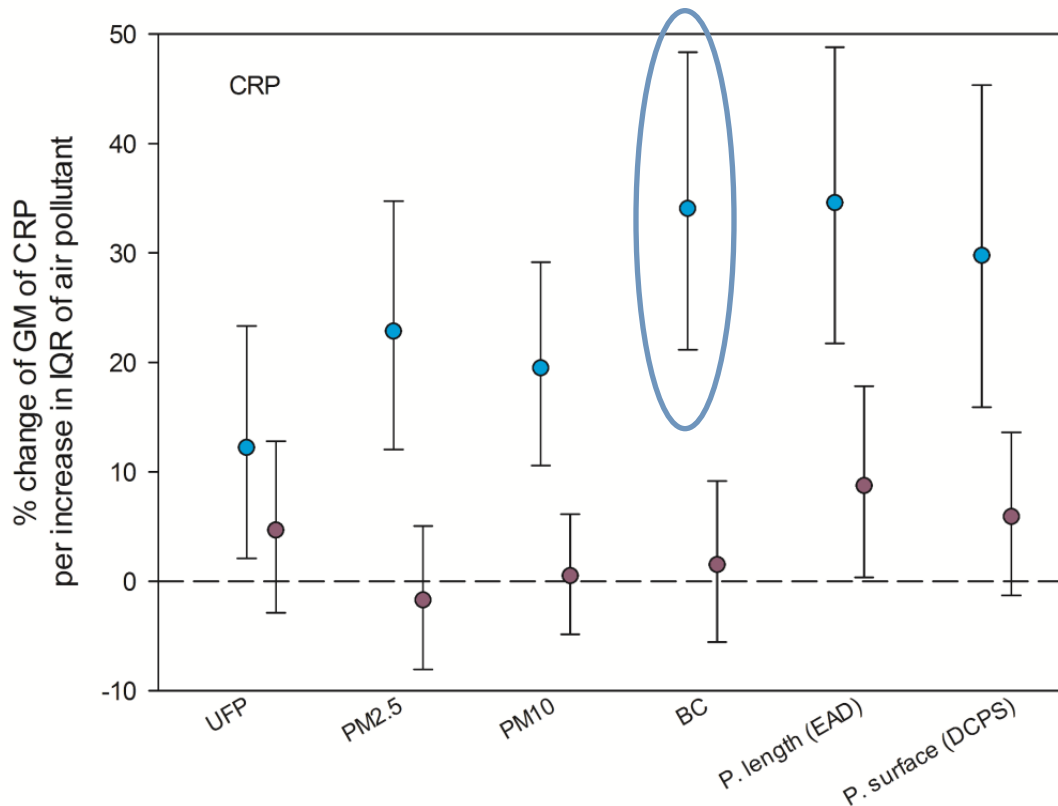
Study period: Mar 2007 - Dec 2008

Study design:

Panel study with **up to seven repeated measurements** every four to six weeks



Associations between 5-day average exposure of air pollutants and CRP

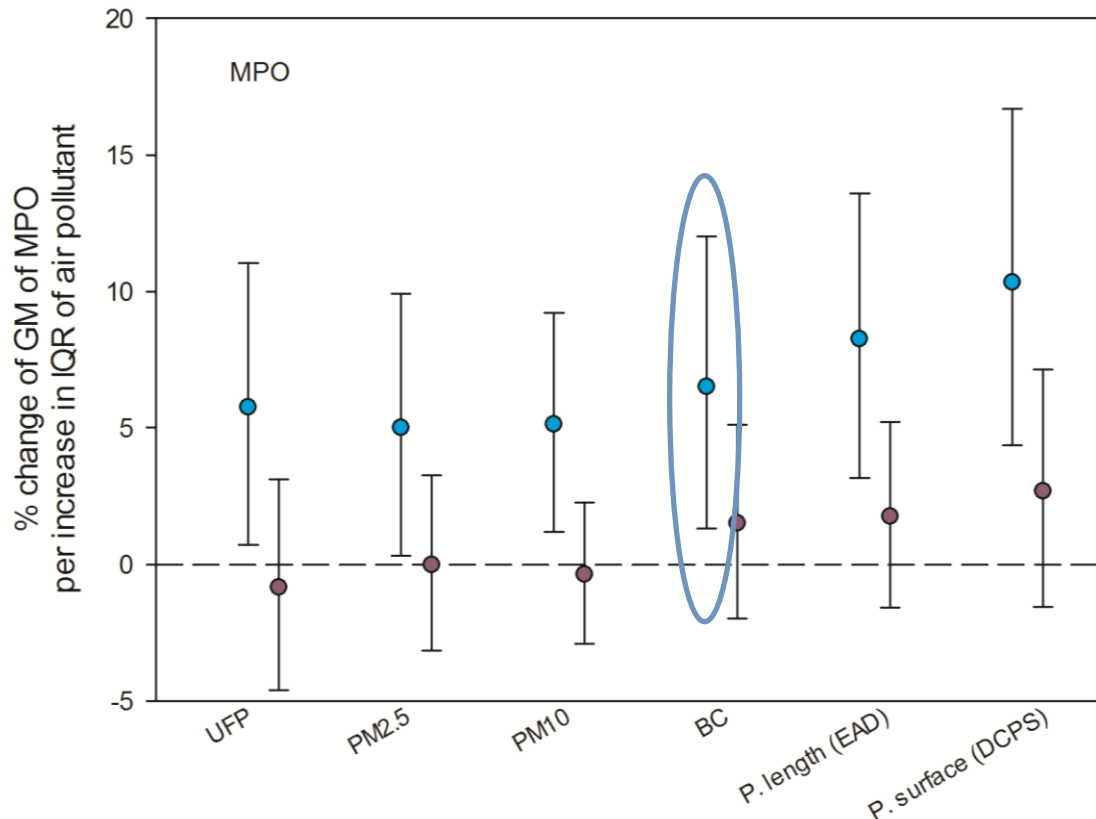


- Non-diabetic subjects with a potential genetic predisposition on the detoxifying pathway (GSTM-1 null), n=87
- Patients with Type II diabetes or impaired glucose tolerance, n=187

CRP: C-reactive protein – biomarker of systemic inflammation

Rückerl, 2014
Rückerl, 2016

Associations between 5-day average exposure of air pollutants and MPO

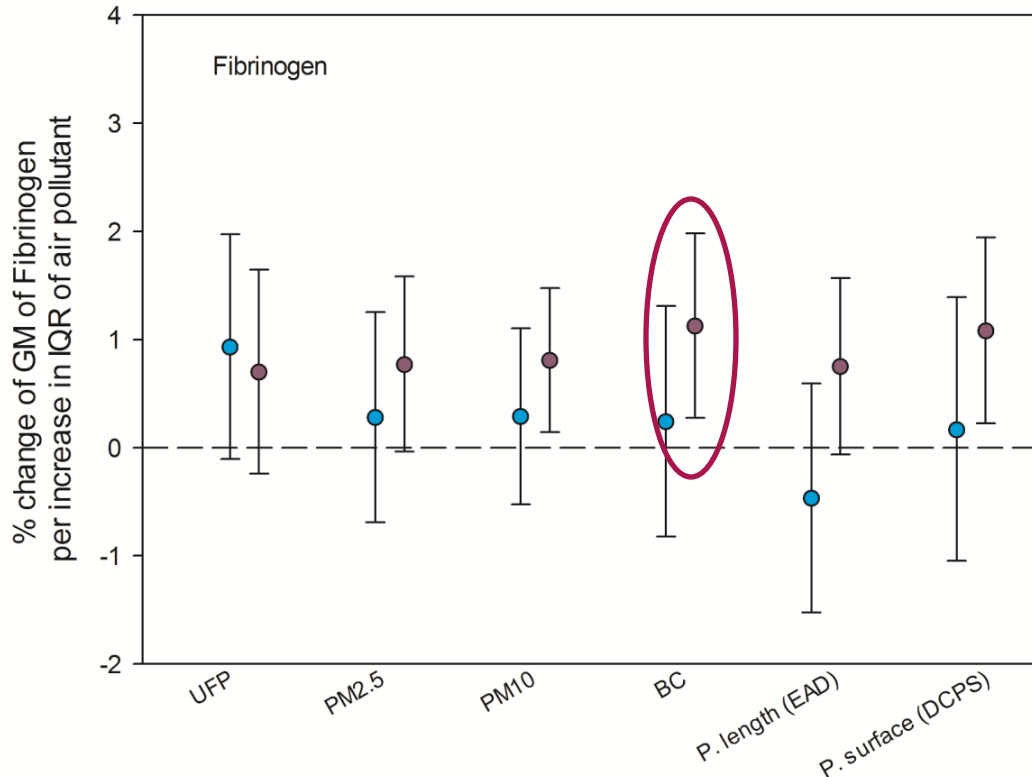


- Non-diabetic subjects with a potential genetic predisposition on the detoxifying pathway (GSTM-1 null), n=87
- Patients with Type II diabetes or impaired glucose tolerance, n=187

MPO: Myeloperoxidase - pro-oxidant enzyme/
indicator of neutrophil activation

Rückerl, 2014
Rückerl, 2016

Associations between 5-day average exposure of air pollutants and fibrinogen



- Non-diabetic subjects with a potential genetic predisposition on the detoxifying pathway (GSTM-1 null), n=87
- Patients with Type II diabetes or impaired glucose tolerance, n=187

Fibrinogen: important role in blood coagulation

Rückerl, 2014

Rückerl, 2016

Thank you for your attention!

