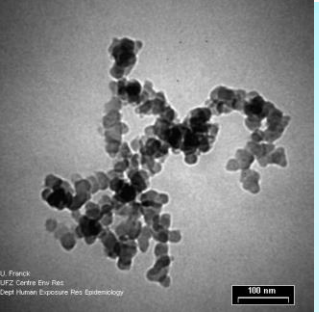

Beijing
Jun-26 – Jun-30

Ulrich Franck, Arne Leitte, Thomas Tuch, Annegret Kindler, Maria Manjarrez, Heinz-Josef Klimeczek, Stefan Röder, Alfred Wiedensohler, Olf Herbarth, Irina Lehmann

i. Airborne indoor particles.

…and an additional remark:

ii. Airborne exposure in urban environments is socio-spatially distributed: The example of Berlin

Dr. rer. nat. Dr. rer. med. Ulrich Franck
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HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Outline

- **Indoor particles**
  - i/o –concentration ratios
  - outdoor traffic and indoor smoking
  - indoor concentrations and respiratory health effects in young children

- **Airborne exposure in urban environments is socio-spatially distributed**
  - Spatial variations – maps
  - Social indicators and exposures
  - Variation of health effects of exposure to PM

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

INDOOR PARTICLES

- i/o concentration ratios
- Outdoor traffic – an indoor source
- Office (example - photocopiers)
- Measurements in children‘s rooms
- Indoor concentrations and respiratory health effects

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

State of Knowledge

- Most particulate matter health effects studies use outdoor (ambient) PM as a surrogate for personal exposure.
- More than half of the body's intake during a lifetime is air inhaled at home.
- Thus, most illnesses related to environmental exposures stem from indoor air.

- Indoor particle sources are:
  - ETS
  - heating, cooking
  - incense/candle burning
  - other sources (printers,…)
  - outdoor air (!)

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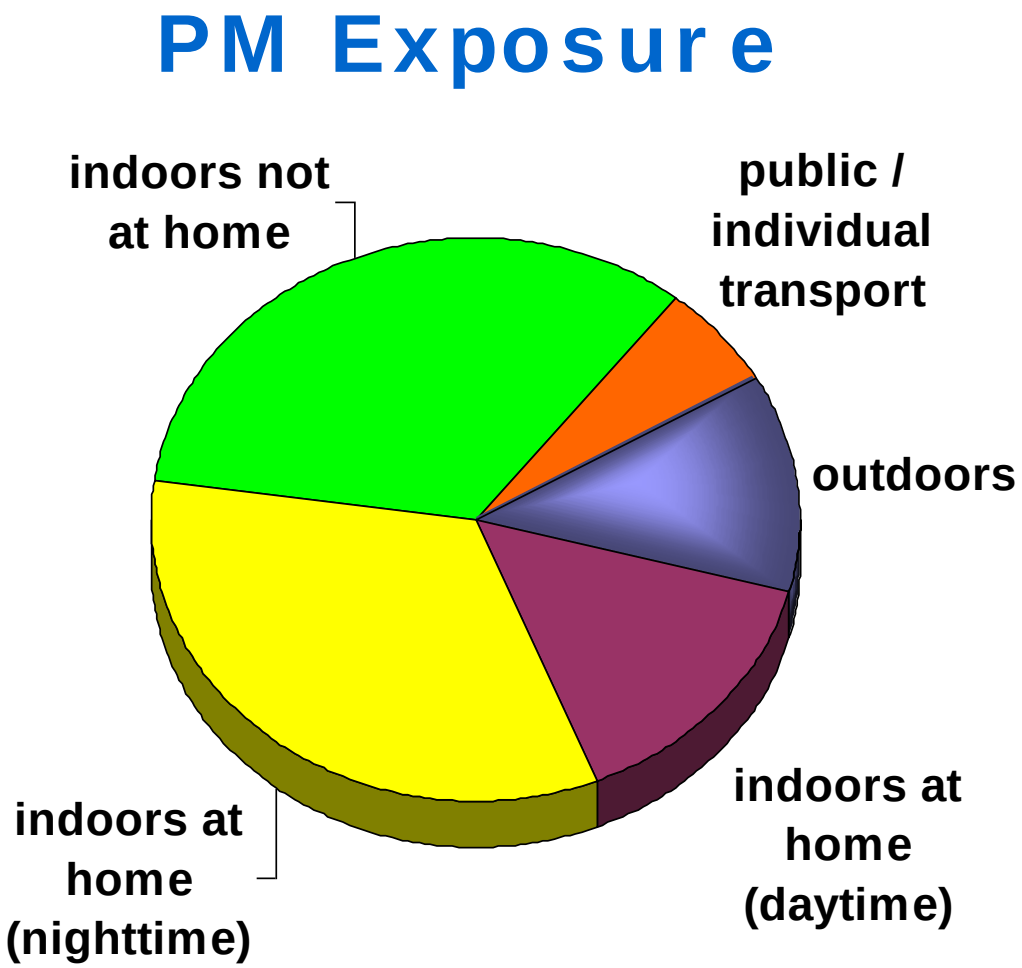
Time budgets



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i/o

- All seasons
- Night and day
- Unihabited rooms
- Absence of indoor sources
- Modern windows, closed
- SMPS

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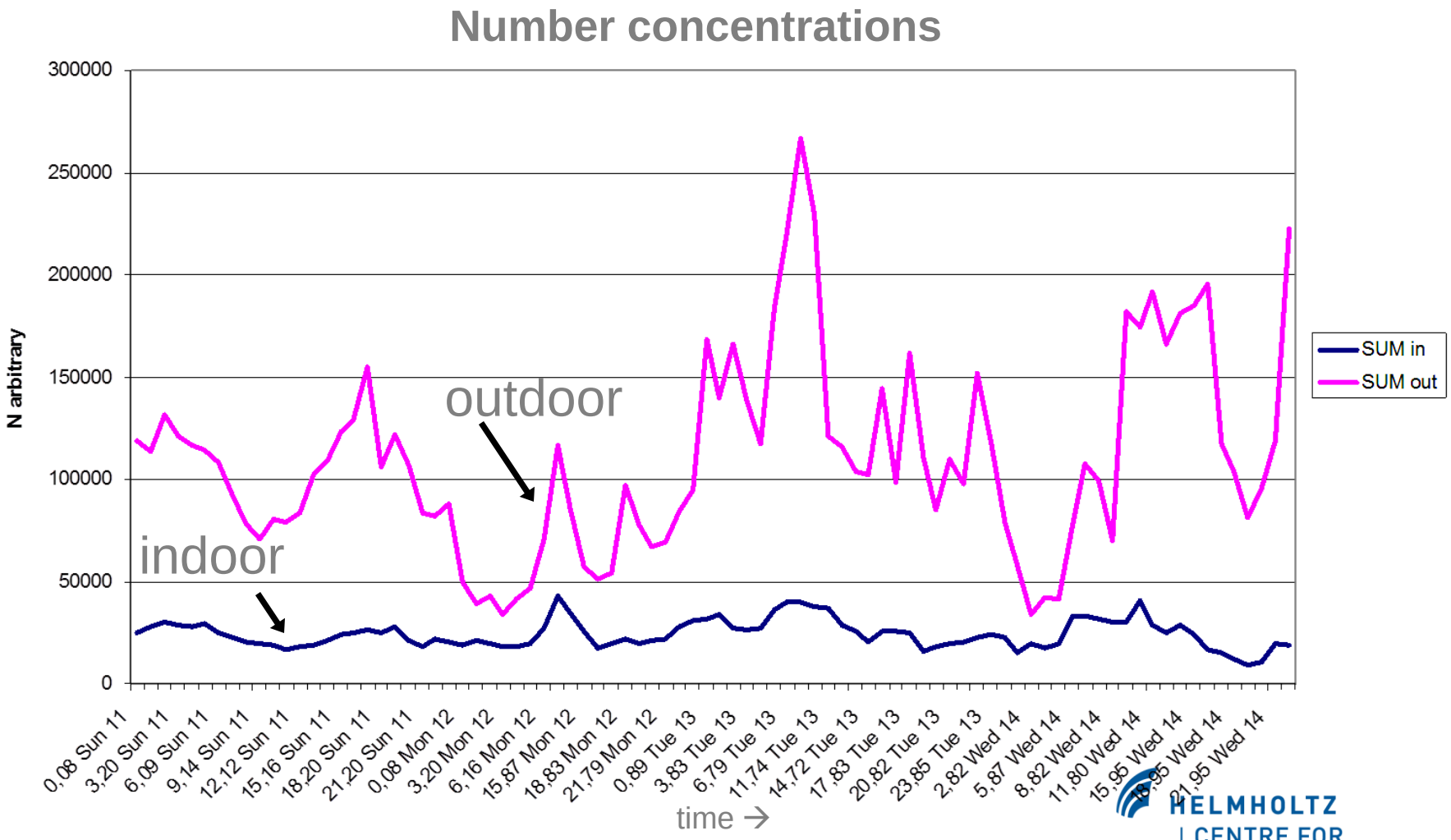
Course of time



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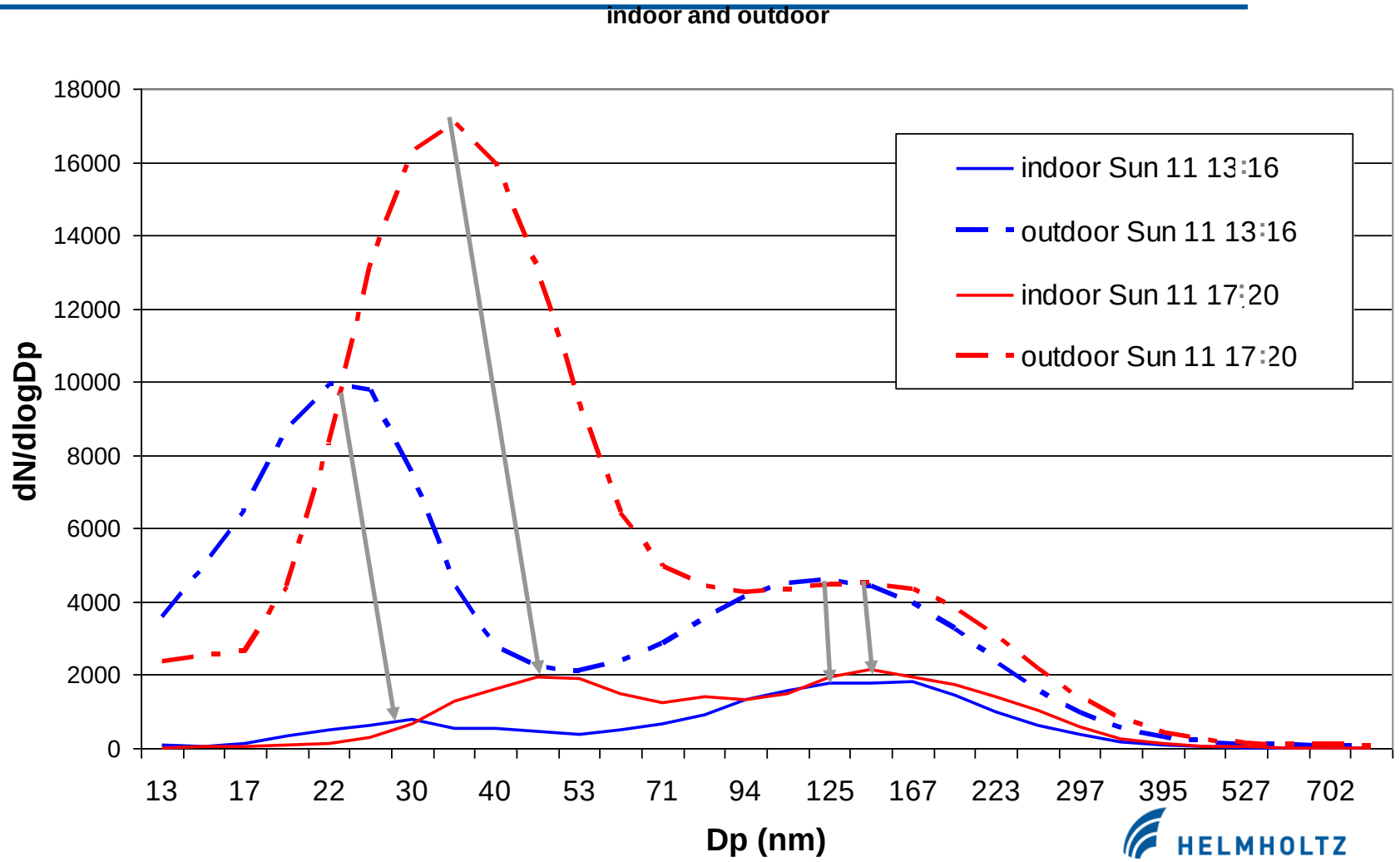
Size distributions - example



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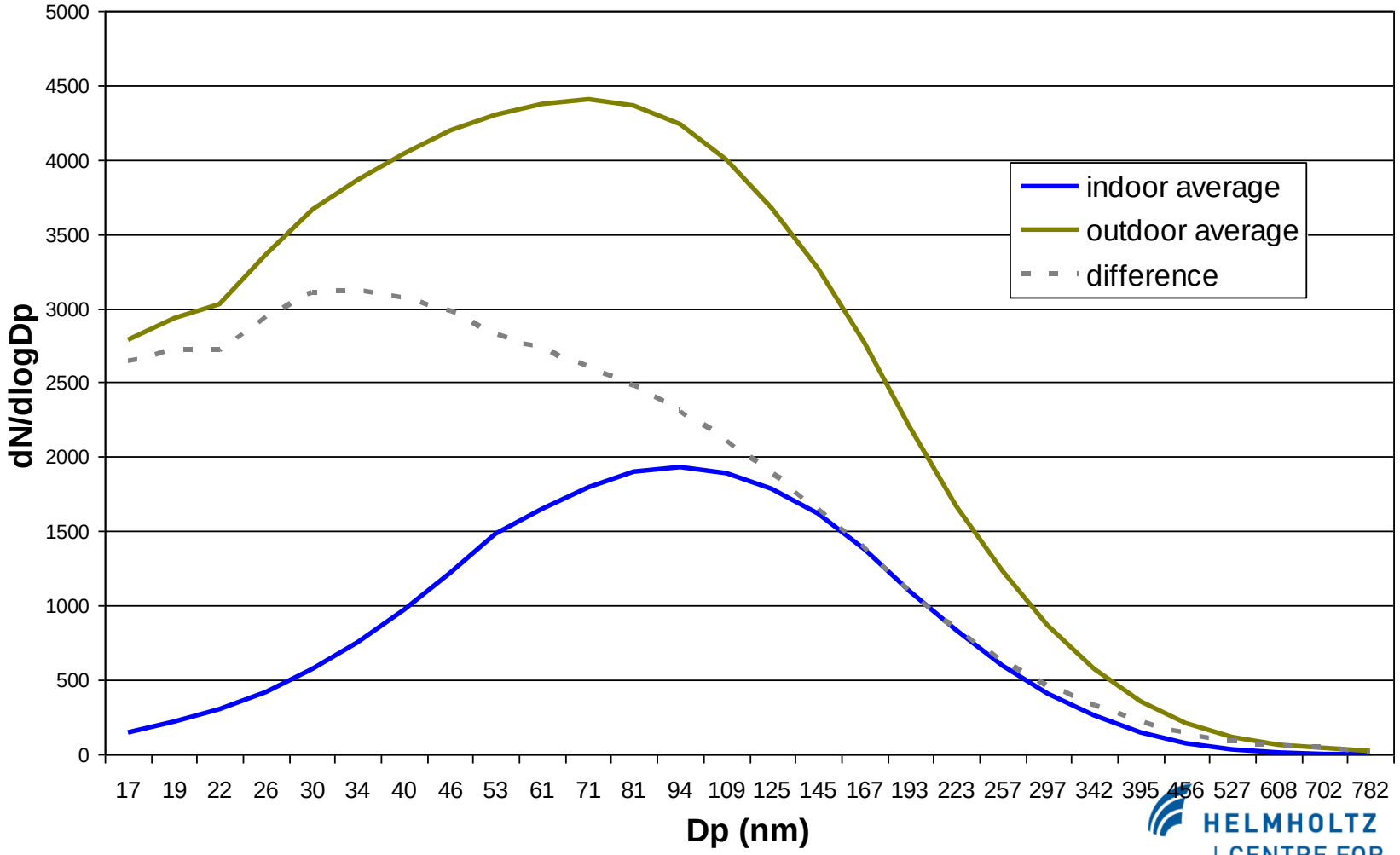
Size distributions - mean



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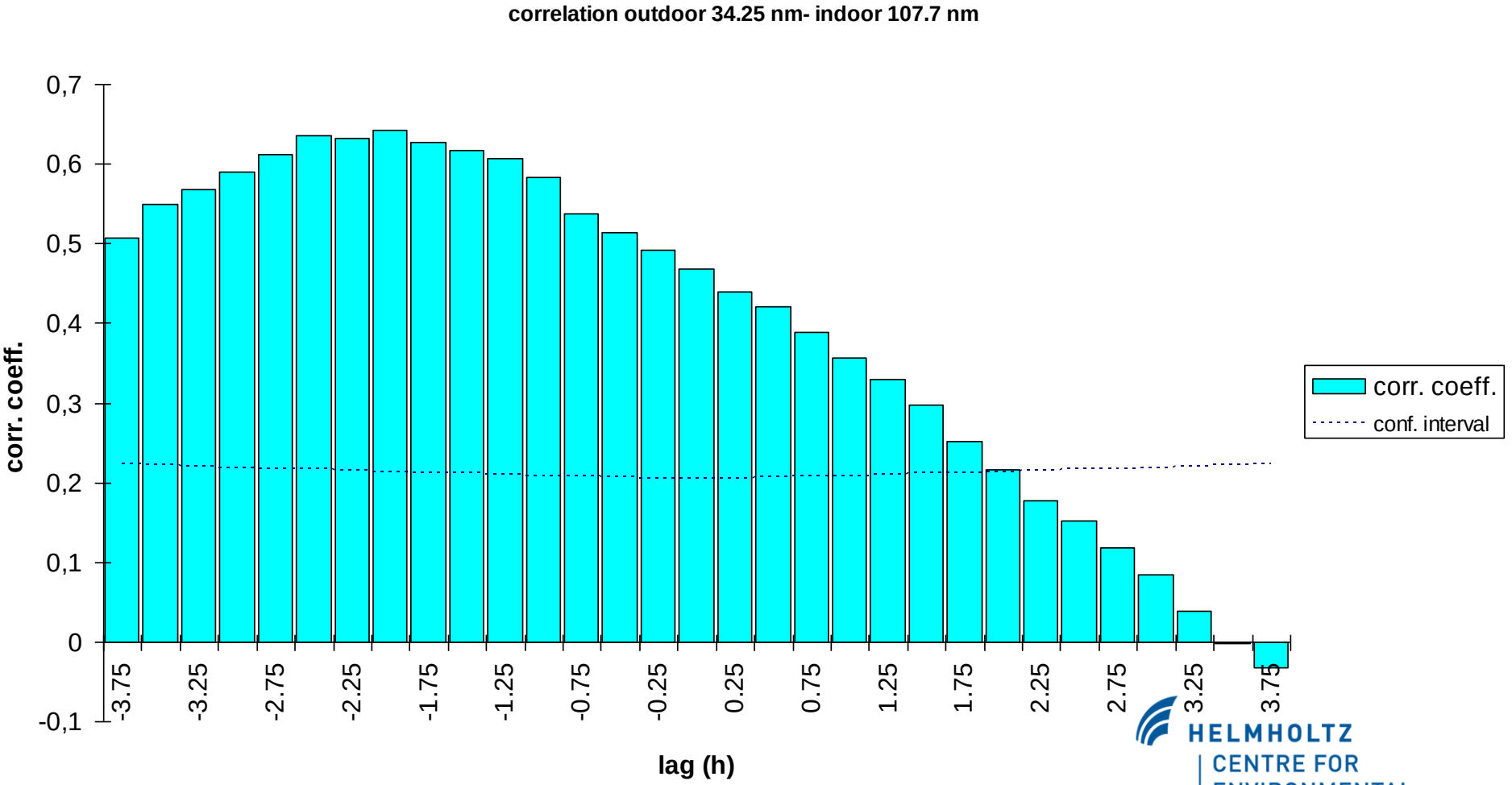
i/o - correlations



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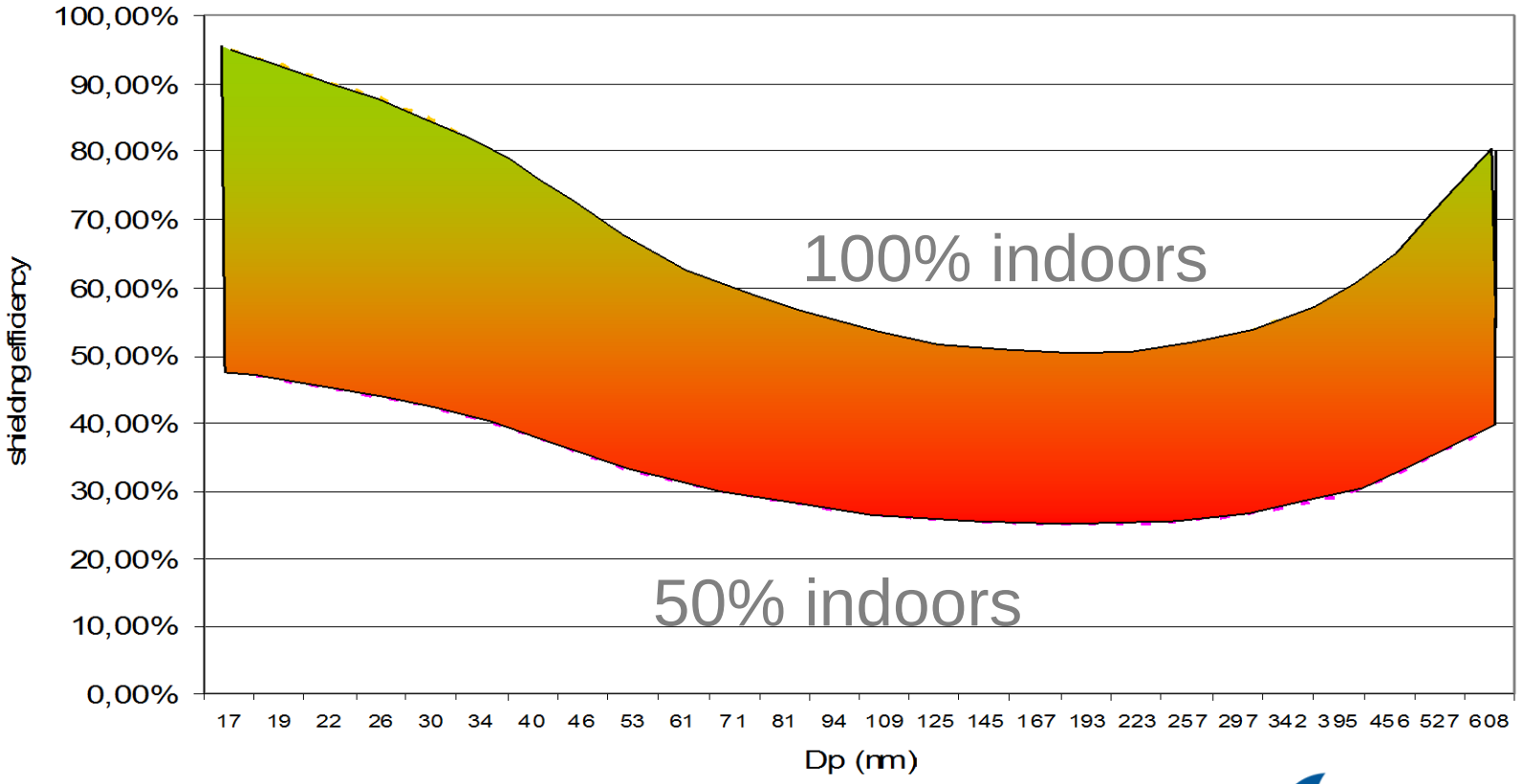
Shielding indoors



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i/o relationships

LESS:

indoor environment is generally shielded against outdoor particulates,

→ lower number concentrations indoors than outdoors,
(if no important indoor sources)

LARGER:

indoor size distributions of particles very different from outdoor one:

→ concentrations of very fine particles are decreased significantly

→ concentration maxima are shifted to larger diameters

LATER:

→ time lag between outdoor and indoor number concentrations

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i/o

- Measurements before and after reduction of street traffic
- Workdays and weekends, nighttime and daytime
- Unihabited rooms
- Absence of indoor sources
- Modern windows, closed
- SMPS

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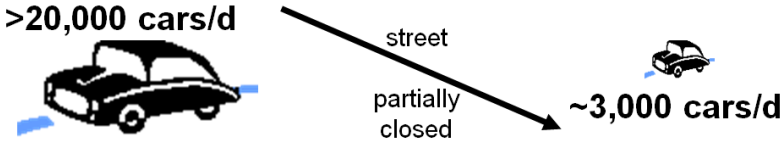
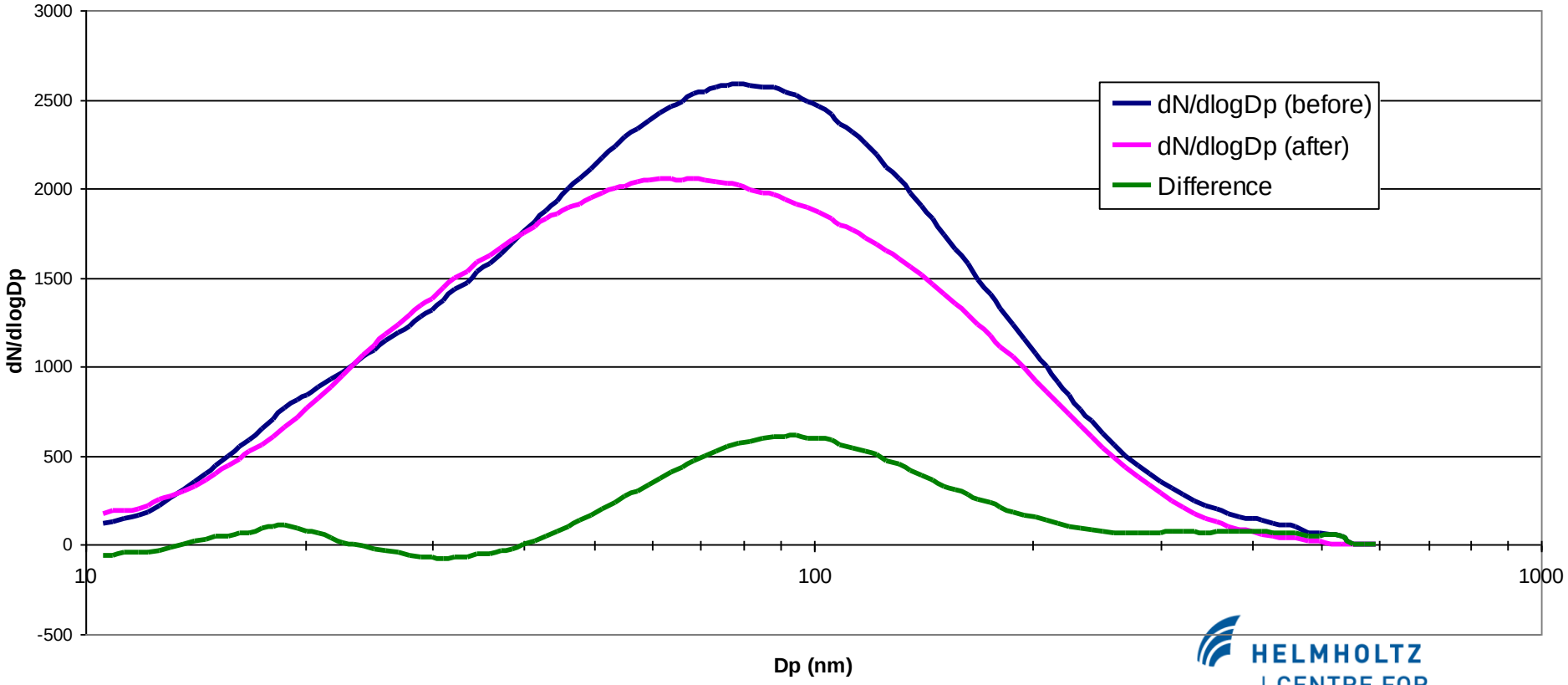
Traffic associated aerosols



Indoor exposure reduction - workdays



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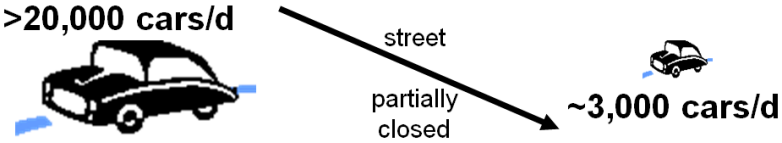
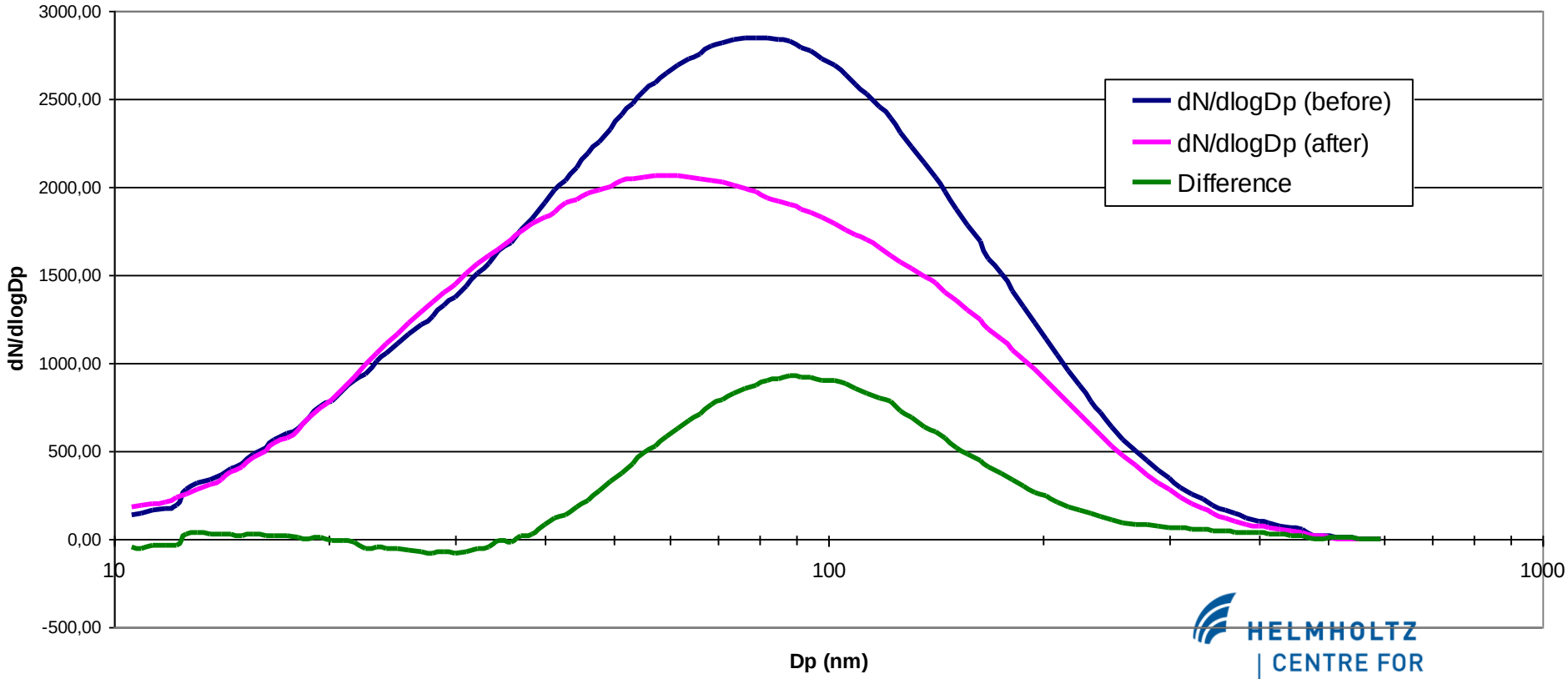
Traffic associated aerosols



Indoor exposure reduction – rush hours



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Indoor measurements and health effects

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Photocopiers

- Elango et al., Environmental Health 12 (2013) 78
- PM2.5, PM10
- 81 workers
- Spirometry
- Inflammation markers

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Photocopiers - lung function

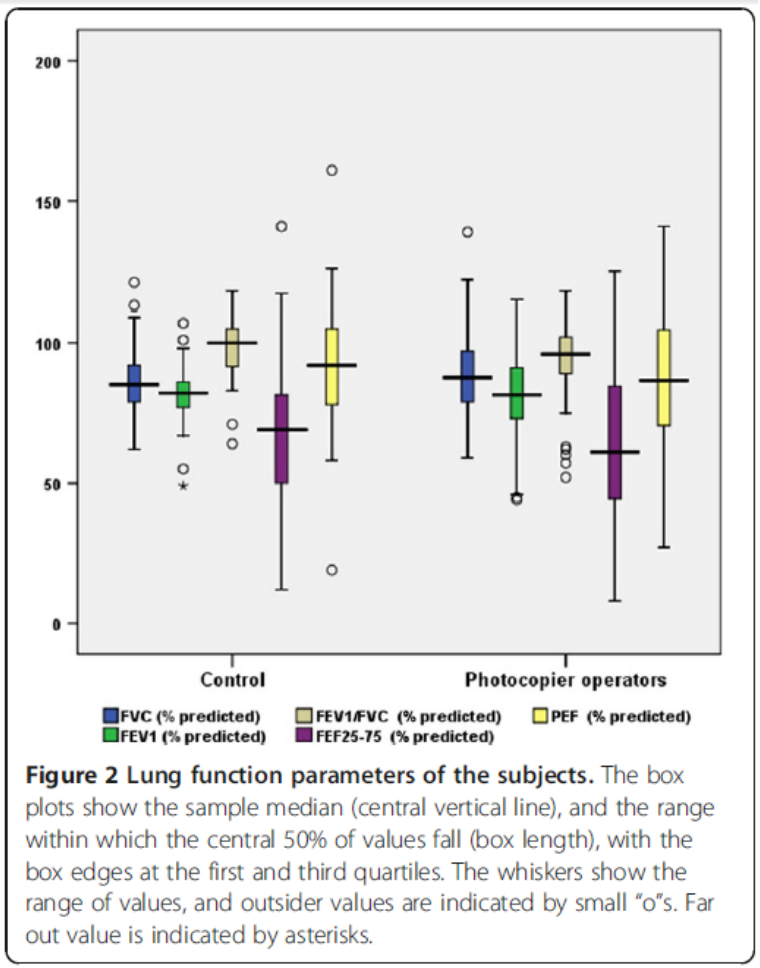

Figure 2 Lung function parameters of the subjects. The box plots show the sample median (central vertical line), and the range within which the central 50% of values fall (box length), with the box edges at the first and third quartiles. The whiskers show the range of values, and outsider values are indicated by small "o"s. Far out value is indicated by asterisks.

PHOTOCOPIER OPERATORS IN INDIA

Elango et al., Environmental Health 12 (2013) 78

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Photocopiers - oxidative stress and systematic inflammation

PHOTOCOPIER OPERATORS IN INDIA

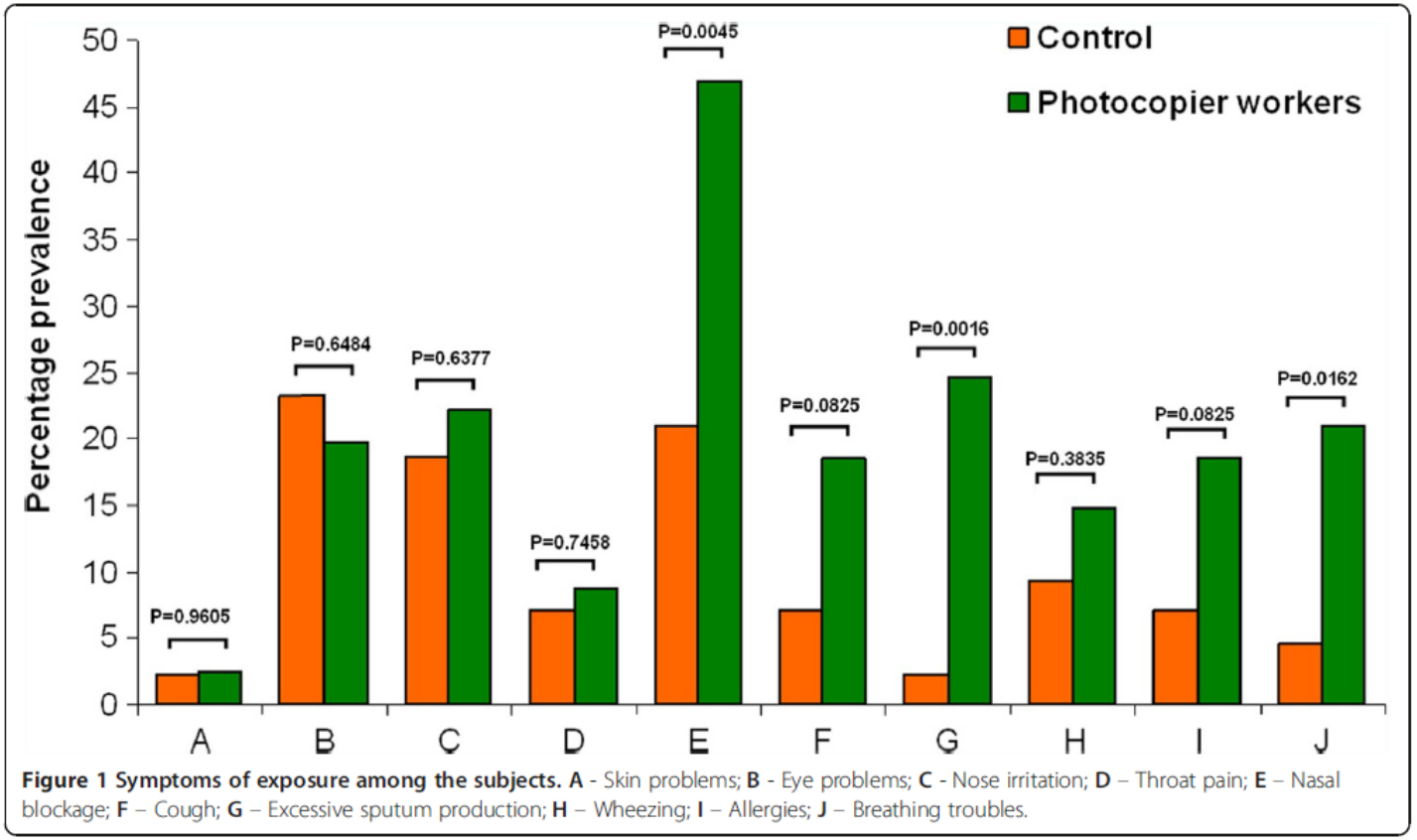

Figure 1 Symptoms of exposure among the subjects. A - Skin problems; **B** - Eye problems; **C** - Nose irritation; **D** – Throat pain; **E** – Nasal blockage; **F** – Cough; **G** – Excessive sputum production; **H** – Wheezing; **I** – Allergies; **J** – Breathing troubles.

Elango et al., Environmental Health 12 (2013) 78

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Photocopiers - oxidative stress and systematic inflammation

Table 8 Markers of oxidative-inflammatory status

Marker	Control n = 43	Photocopier operators n = 81	p value	Non smokers		
				Control n = 29	Photocopier operators n = 46	p value
Total protein (g/L)	68.9 (63.0 – 76.3)	72.4 (66.1 – 75.3)	0.167	68 (60.1 – 73.0)	72 (67.7 – 74.8)	0.048
Albumin (g/L)	39.6 (36.7 – 44.9)	37.1 (33.1 – 40.9)	0.011	38.8 (34.6 – 42.3)	36.5 (32.9 – 41.0)	0.228
Globulin (g/L)	27.1 (20.4 – 35.8)	34.0 (28.6 – 39.4)	0.015	27.9 (20.4 – 35.5)	34.0 (29.0 – 39.3)	0.042
FRAC (mM)	1.5 (0.8 – 1.9)	1.0 (0.8 – 1.4)	0.010	1.6 (0.8 – 2.0)	1.0 (0.7 – 1.4)	0.008
TBARS (μM)	1.4 (1.0 – 1.9)	2.7 (2.1 – 3.5)	<0.001	1.4 (0.8 – 1.7)	2.8 (2.1 – 3.4)	<0.001
8-Isoprostane (pg/mL)	41.7 (23.6 – 52.8)	46.4 (31.7 – 65.4)	0.146	35.4 (20.5 – 51.5)	45.5 (24.6 – 67.5)	0.159
CRP (μg/mL)	1.4 (0.6 – 2.6)	0.9 (0.4 – 1.8)	0.083	1.7 (1.0 – 2.8)	1.0 (0.4 – 2.0)	0.051
ICAM-1 (ng/mL)	113 (97 – 165)	187 (104 – 266)	0.015	113 (99 – 165)	135 (101 – 239)	0.356
LTB_4 (ng/mL)	13.0 (7.6 – 40.1)	81.9 (22.3 – 159.1)	<0.001	9.2 (6.5 – 15.9)	78 (12 – 169)	<0.001
CC-16 (ng/mL)	7.3 (2.7 – 28.3)	7.8 (3.3 – 33.8)	0.705	7.8 (2.7 – 36.1)	7.1 (2.9 – 32.3)	0.908
ECP (ng/mL)	135 (80 – 207)	213 (118 – 307)	0.009	128 (80 – 207)	215 (147 – 327)	0.015
IL-8 (pg/mL)	17.4 (10.6 – 18.6)	18.1 (17.1 – 20.7)	0.001	16.4 (8.6 – 17.8)	18.2 (16.7- 21.1)	0.002

FRAC Ferric Reducing Antioxidant Capacity, *TBARS* Thiobarbituric acid reactive substances, *CRP* C-reactive protein, *ICAM-1* Intercellular Adhesion Molecule 1, Leukotriene B_4 – Leukotriene B4, *CC-16*, Clara cell protein, *ECP* Eosinophilic Cationic Protein, *IL-8* Interleukin 8, *pg* Picogram, *μg* Microgram, *ng* Nanograms, *mM* Millimoles, *μM* Micromoles, p values for Mann Whitney test.

Elango et al., Environmental Health 12 (2013) 78

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Indoor concentrations and health effects

- 129 homes
- Mass and number concentrations
- Questionnaires
- Medical examination

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Indoor air: children‘s time budgets

- German toddlers spend more than 87% of their time indoors.
- Among the total time budget, German girls younger than seven years are 75 % and German boys 73% of their day at parental home.

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Introduction

Gapes of knowledge

- Measurements of size resolved indoor particle concentrations in apartments
- Associations between (non-occupational) indoor particle concentrations and health effects

Aim of the study

- Verification of associations between concentrations of indoor particles and respiratory health effects

- Identify typical sources of indoor particle exposure

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Material and Methods

Study area / Measuring site

- City of Leipzig (Central Germany, ~ 530,000 inhabitants)
- 129 apartments of participants of the *LISA* (Leipzig) study

Measurements

- Measurements 10-20 min in calm air without people in the room
- - total number concentration
  - number concentrations of particles > 0.3; 0.5; 1.0; 5.0 µm
  - mass concentrations (PM1; PM2.5; PM10)

Questionnaires

- heating, cooking, traffic, smoking, …
- age, month of birth, gender, siblings, pets, …

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RESULTS: Indoor Particle Concentrations

	median	mean	percentile			
			10th	25th	75th	90th
total number concentration (1/cm³)*	9,075	15,960	4,057	6,023	16,057	30,348
number concentration of particles (1/l)						
> 0.3 µm	82,318	103,768	39,410	51,468	134,118	195,051
> 0.5 µm	8,755	15,660	4,026	5,313	21,840	36,044
> 1.0 µm	3,259	5,277	1,071	1,781	6,873	10,738
> 5.0 µm	59.3	80.2	25.3	37.0	92.7	130.3
mass concentration of particles (µg/m³)						
PM1	31.0	63.4	9.0	16.0	64.0	124.0
PM2.5	32.0	65.6	10.0	20.0	66.0	115.0
PM10	76.0	121.2	33.0	46.0	119.0	229.0

* Total number of measurements of total number concentration which were carried out in 59 apartments of the subcohort, only. (Not included into health analysis)

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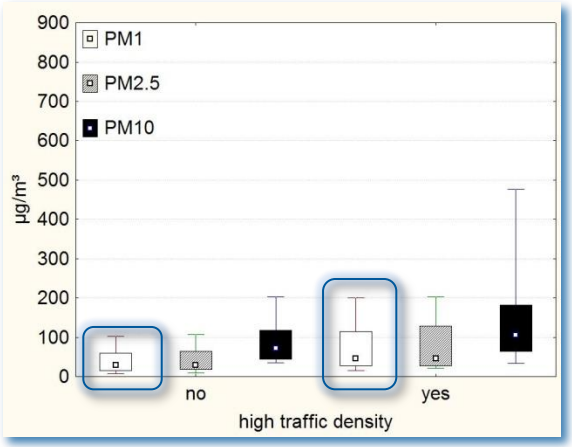
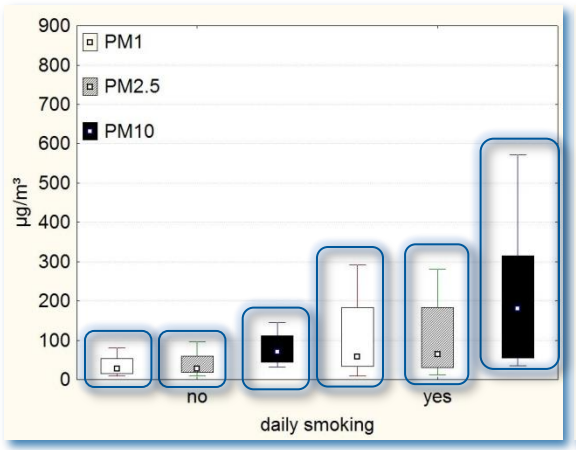
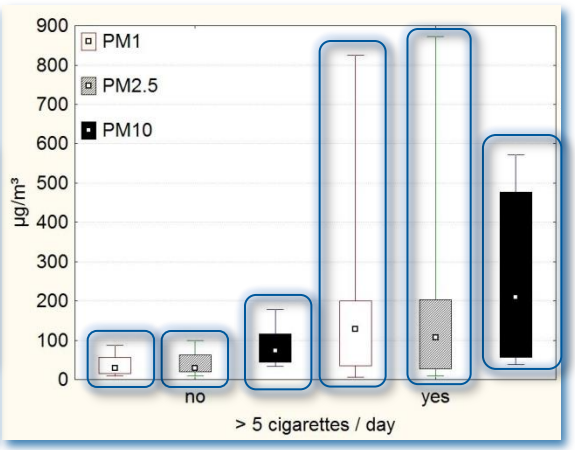
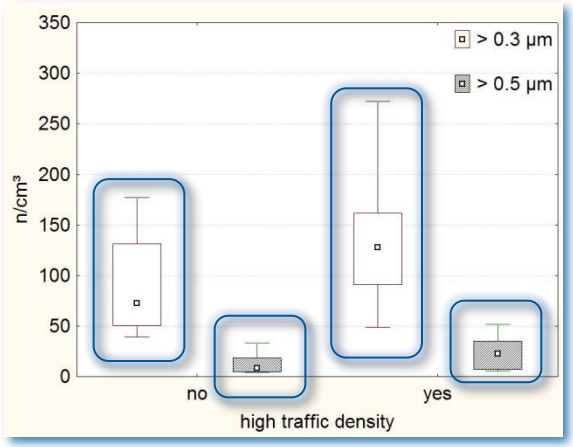
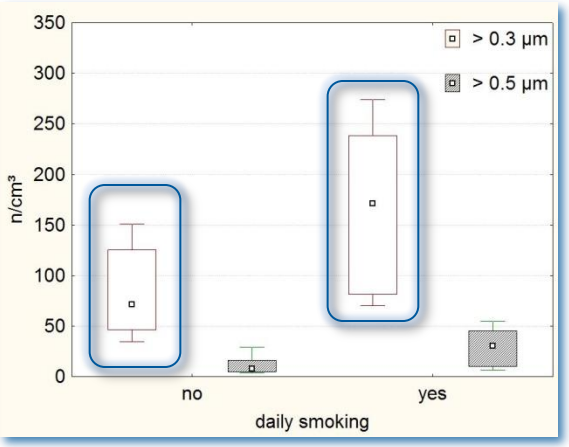
RESULTS: Indoor Particle Concentrations

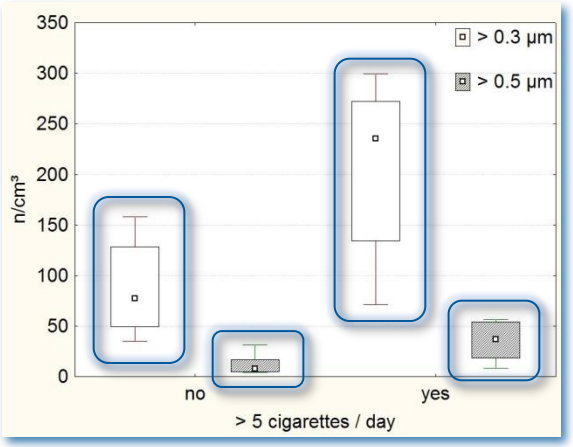












$p < 0.05$

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Material and Methods

Characteristics of the subcohort - *incidences*

	Analyzed Subcohort n (%) N=129	Total LISA cohort of Leipzig n (%) N=579
Incidences of respiratory diseases		
Physician diagnosed		
Bronchitis with fever	37 (28.7 %)	171 (29.5 %)
Obstructive bronchitis with fever	17 (13.2 %)	78 (13.5 %)
Obstructive bronchitis with or without fever	22 (17.1 %)	104 (18.0 %)
Asthma	4 (3.1 %)	20 (3.4 %)
Symptoms		
Wheezing with fever	7 (5.4 %)	58 (10.0 %)
Wheezing without fever	4 (3.1 %)	9 (1.6 %)

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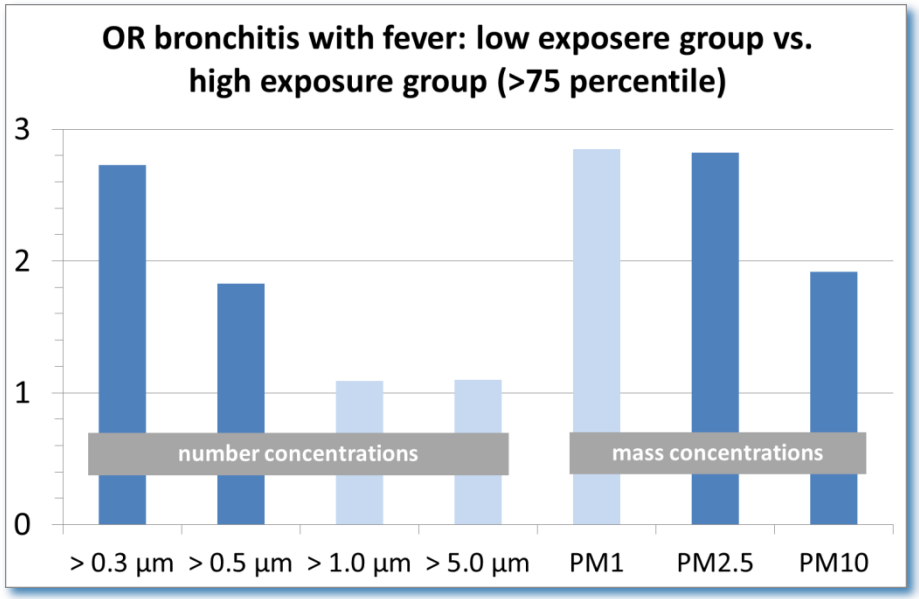
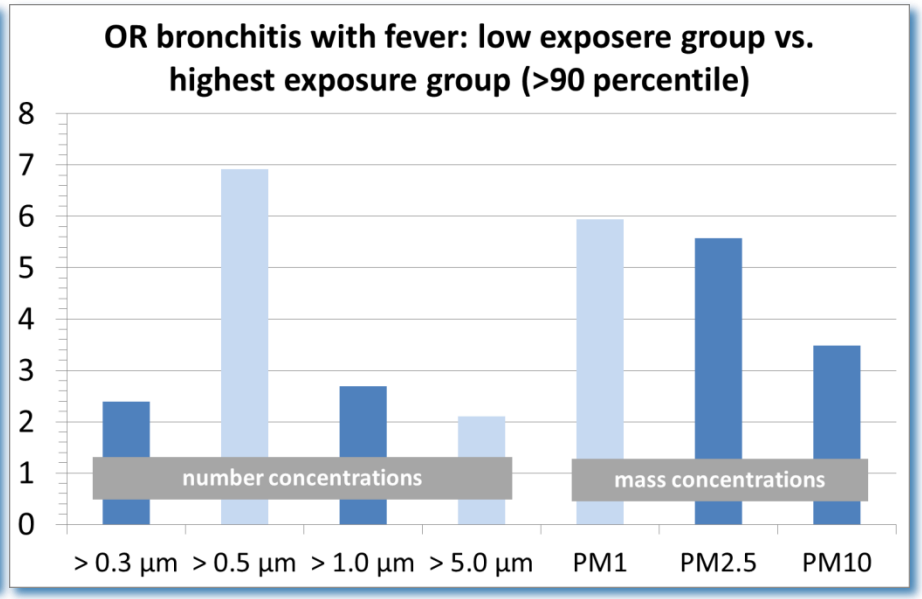
RESULTS: Bronchitis with fever





(dark blue: $p < 0.05$)

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SUMMARY – *exposure and health effects*

- particle exposure due to smoking outside children‘s room
- particle exposure due to traffic in front of children‘s room
- strongest impacts on bronchitis for particles < 1 µm

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Remark:

Environmental justice

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Outline

- Introduction
- Material and methods
- Inner-urban exposure
  - Spatial variations
  - Correlation between pollutant concentrations
- Social indicators and exposures
  - Exposure variations
  - Exposure risks
- Summary, Conclusions, Remarks

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Health Risks of Particulate Matter

- PM2.5
- Cardiovascular and respiratory effects especially in vulnerable people
- Long-term effects including cancer
- Increasing morbidity and number of premature death
- No threshold value for adverse effects of particulate matter!

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Health Risks of NO_2

- Part of air pollution
- Also at lower concentrations, NO_2 is the main source of nitrate aerosols, which form an important fraction of $PM_{2.5}$ and, in combination with sun light, of ozone.
- The major sources of anthropogenic emissions of NO_2 are combustion processes (engines in vehicles and ships, heating, power generation).

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Introduction: Objectives

Human exposure significantly varies within urban agglomerations.

Is there a correlation between social indices of population and the airborne exposure to PM2.5 and NO_2?

- Calculation of PM2.5 and NO_2 exposures including traffic contributions per planning area in Berlin
- Affected population
- Correlation of exposures and social status of population

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Material and Methods: Study area and population

- Administrative structure of Berlin:
  - 12 districts
  - 447 PLA - planning areas *(each with around 7,500 inhabitants!)*
  - 891 km²
  - 3.36 million inhabitants
- Low emission zone (since 1.1.2008):

  87 km²; about one million inhabitants
- Streets ranked by traffic densities (main roads)
- Socio-demographic data:

  Social status/dynamic index and development index in the planning areas in 2008

  Population per planning area in 2008

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Material and Methods: Social indicators

The **social indicators** include information about:

unemployment

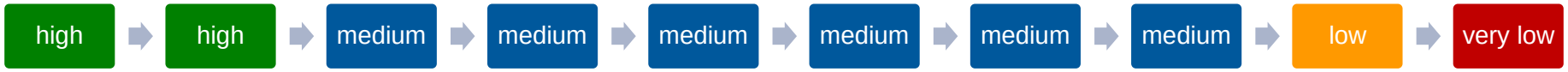
- percentages of unemployed
- unemployed in the age 15-24
- people unemployed longer than 1 year
- beneficiaries of welfare aid/unemployment pay (so-called Hartz IV compensation)

The **status-dynamic indicator** also includes *changes of parameters and migration balances* of different groups.

H.B. Jörn Welsch, Heidrun Nagel, Data sources of the Berlin pilot project: the Berlin Environmental Atlas and Social Urban Development Monitoring, in: K.G. Christiane Bunge (Ed.) Environmental Justice, Federal Office for Radiation Protection (BfS), Federal Institute for Risk Assessment (BfR), Robert Koch Institute (RKI), Federal Environment Agency (UBA), 2011, pp. 20 - 24.
A.W. Hartmut Häussermann, Daniel Förste, Patrick Hausmann, Social Urban Development Monitoring 2010 in, Senate Department for Urban Development, 2010, pp. 19.

Material and Methods: Social indicators

Deciles:



Indices of social indicators:

status index	1 → 4
dynamic index	1 → 3
development index	1 ← 4
additive index	1 → 6 (status + dynamic)
multiplicative index	1 → 8 (status x dynamic)
weighted index	1 → 9 (2 x status + 1 x dynamic)

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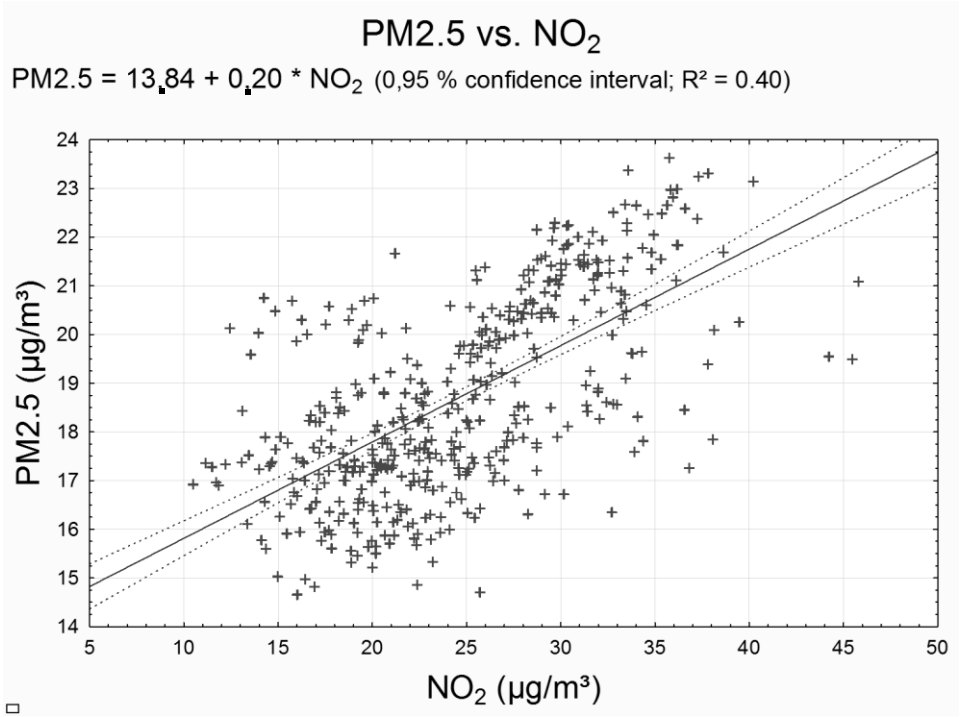
Results: Air pollutants



PEARSON correlation coefficients	mean (µg/m³)	stand. deviation	PM2.5	NO2
PM2.5	18.70	2.01	1.00	0.63*
NO2	24.58	6.45	0.63*	1.00

*p<0.005

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Results: Spatial socio-economic segregation

Status index:
Social situation

- unemployment rate
- share of persons with financial aid/transfer payments
- share of kids and juveniles with migration background

4 levels

- very low - medium - low - high

Dynamic index:
Changes of social situation

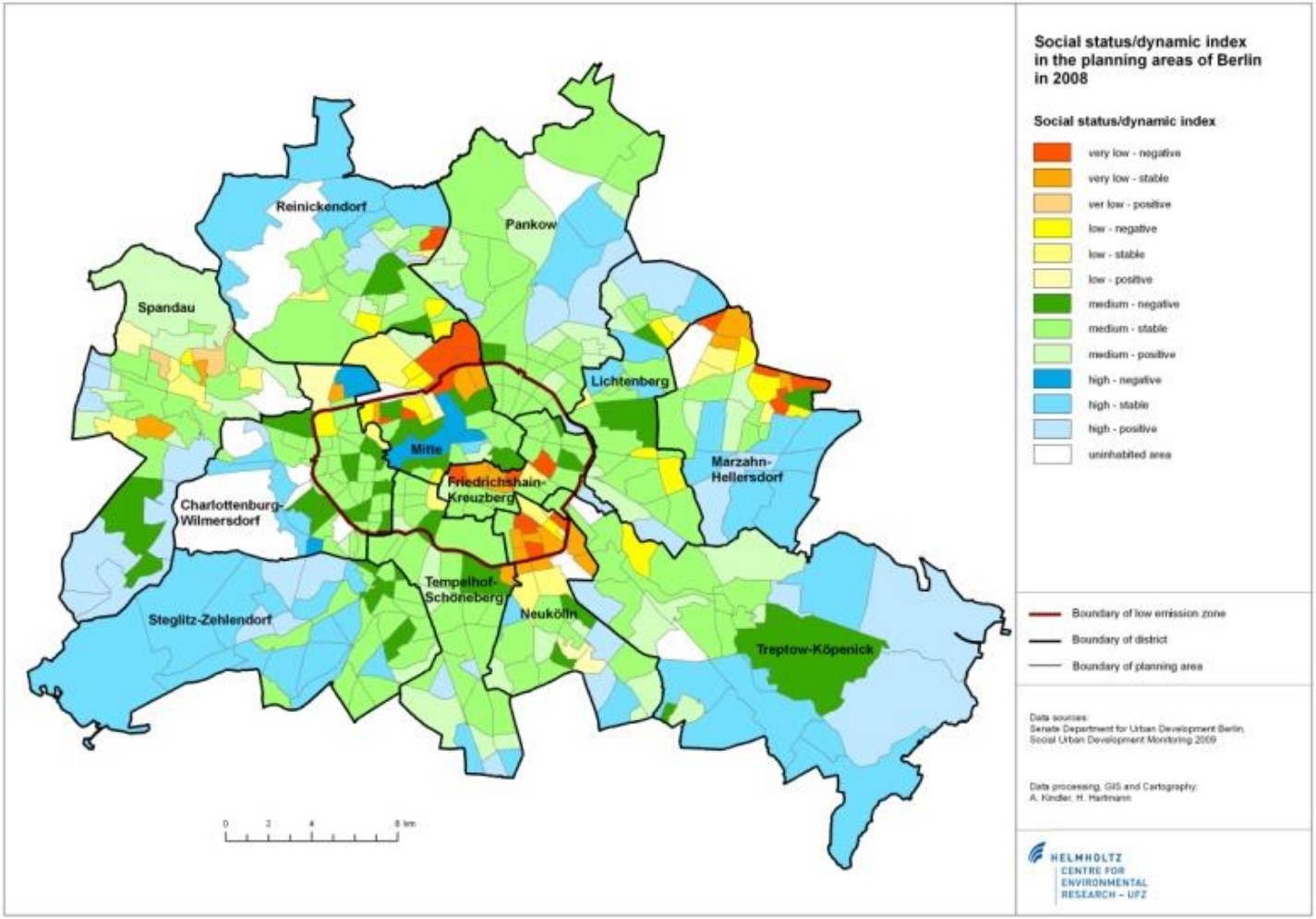
- migration
- alterations of status indicators

3 directions

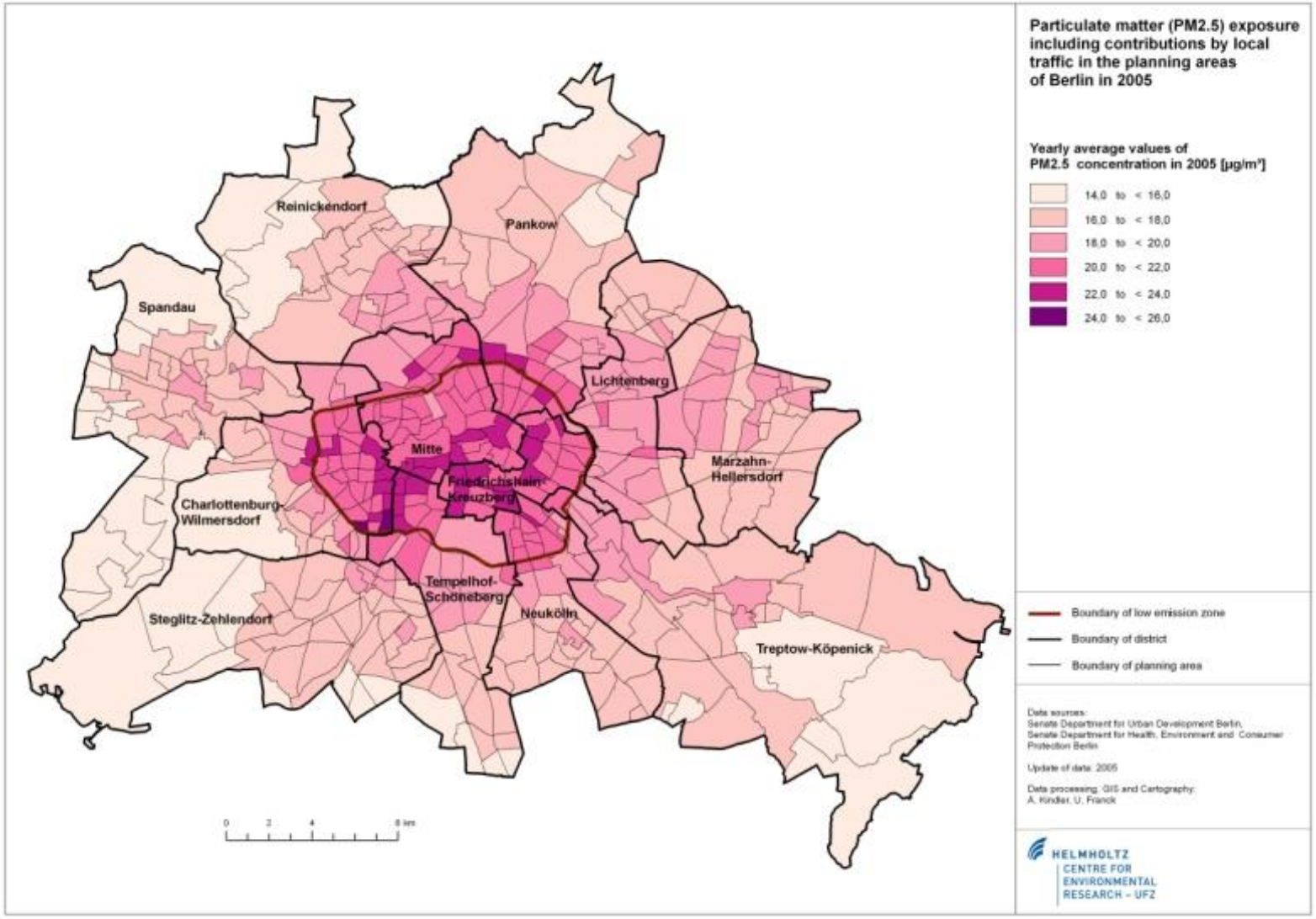
- negative
- stable
- positive

Development index:
Sum of status index and dynamic index (3:2)

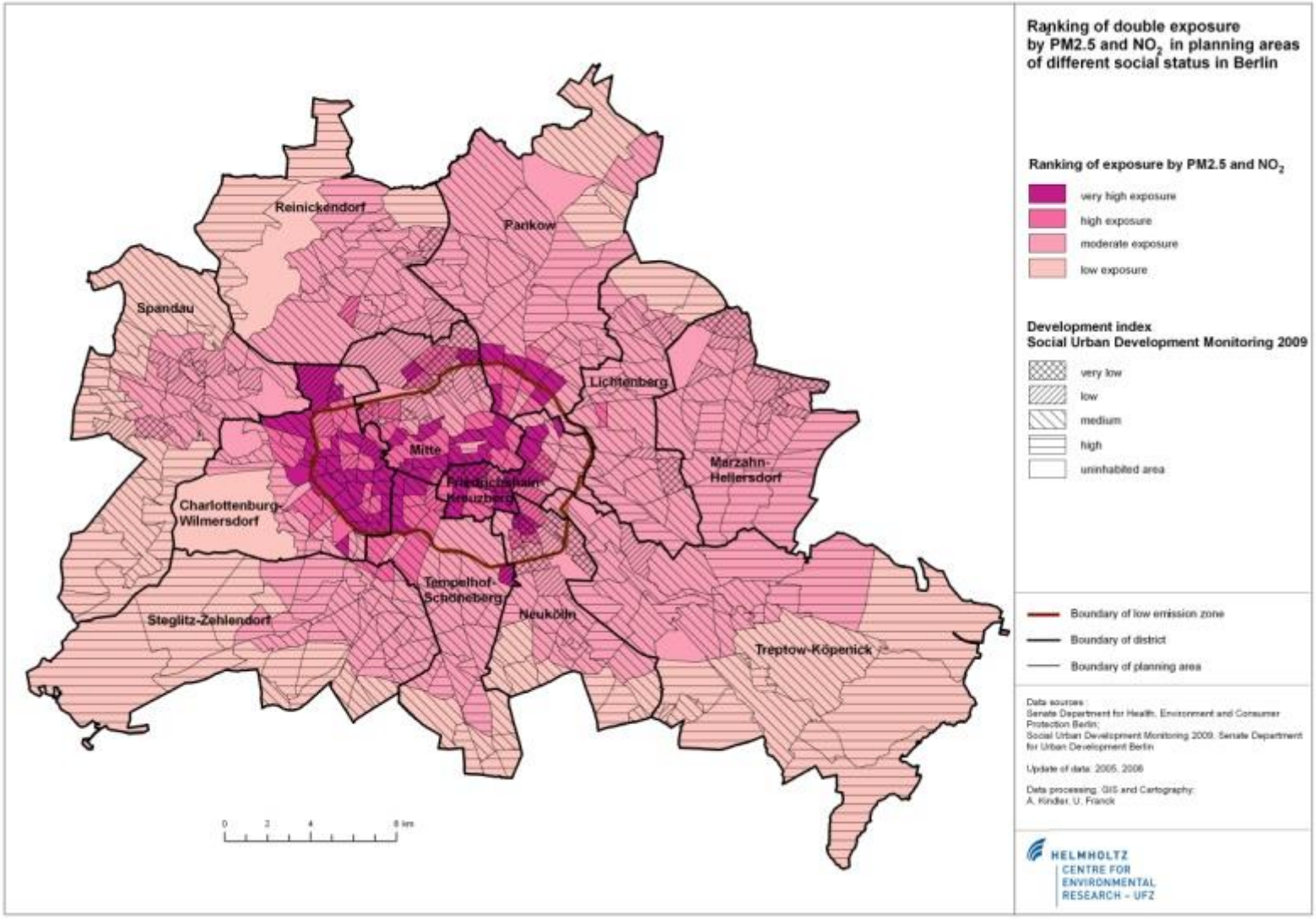
- very low - medium - low - high



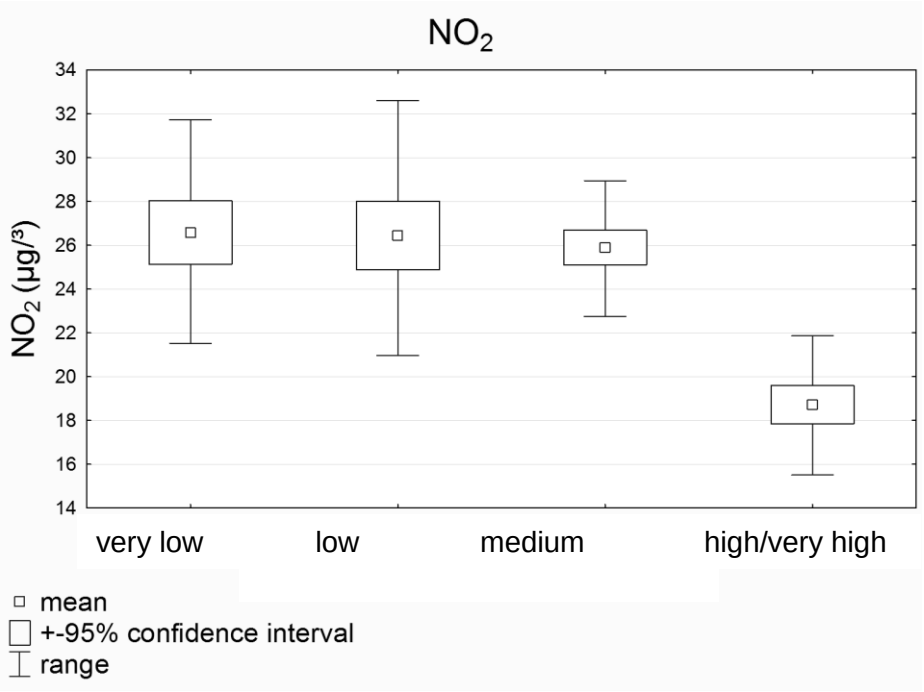
Results: Spatial distribution of PM2.5

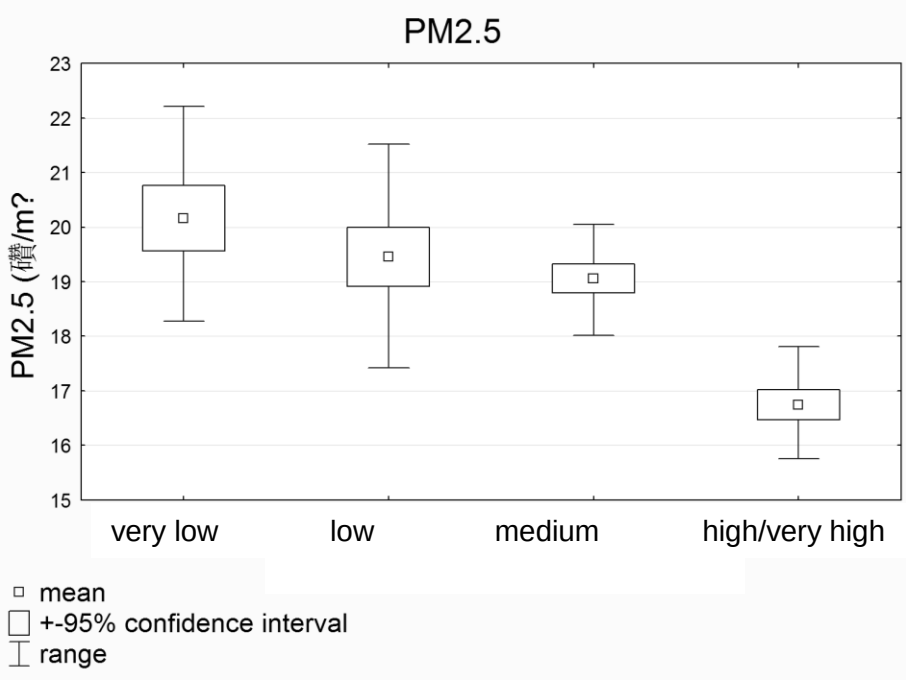


Results: Double discrimination



Results: Development index vs. air pollution





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Material and Methods: Exposure levels

$PM_{2.5}$ or NO_2 in the planning area	Rating of exposure to either PM2.5 or NO_2
1st - 2nd decile	low
3rd – 8th decile	medium
9th decile	high
10th decile	very high

µg/m³	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th decile
PM2.5	15.99	16.74	17.29	17.66	18.27	19.09	20.14	21.11	21.83	
NO_2	16.67	18.89	20.47	22.25	24.19	26.02	28.10	30.30	33.40	

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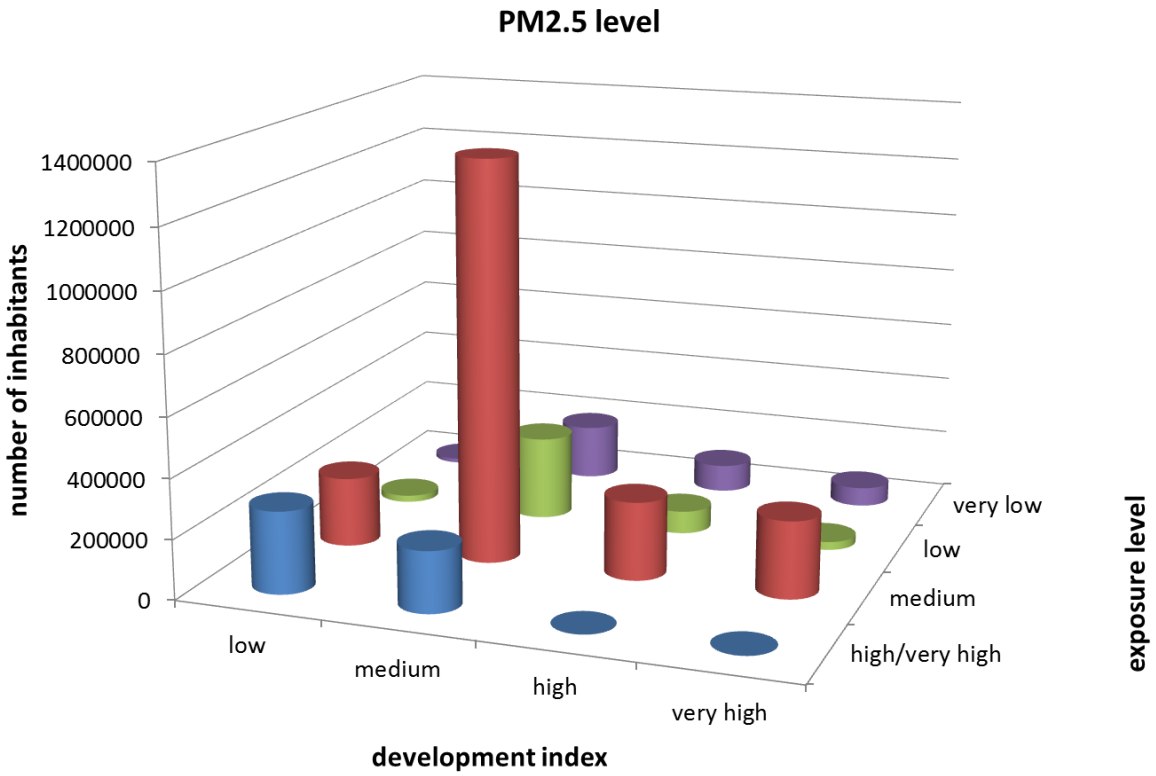
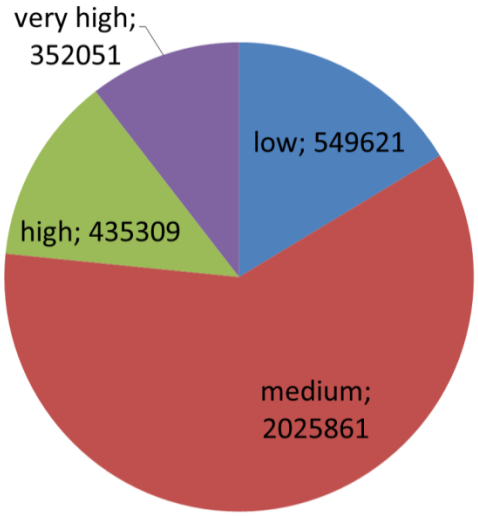
Results: Affected population - PM2.5 level





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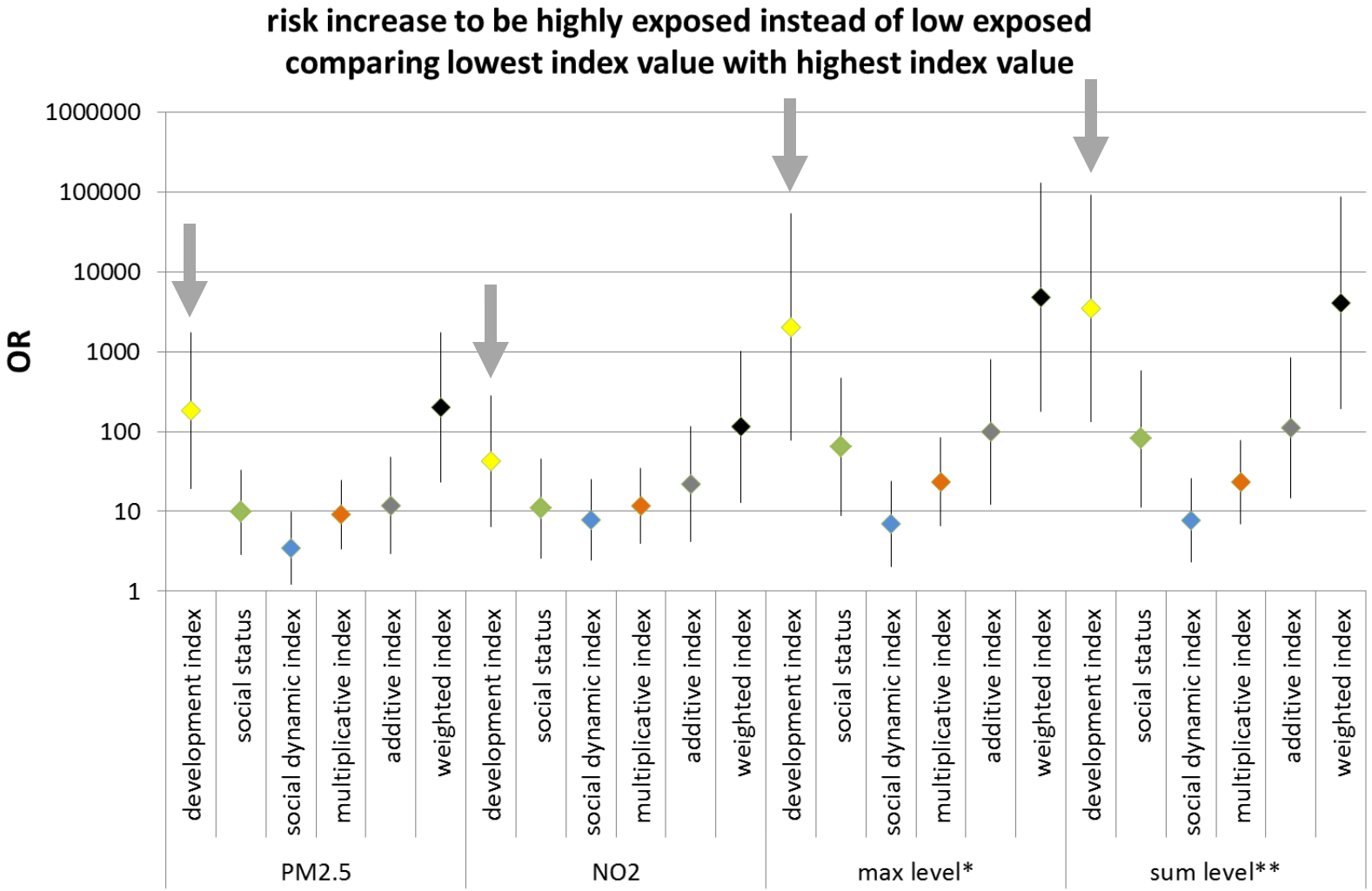
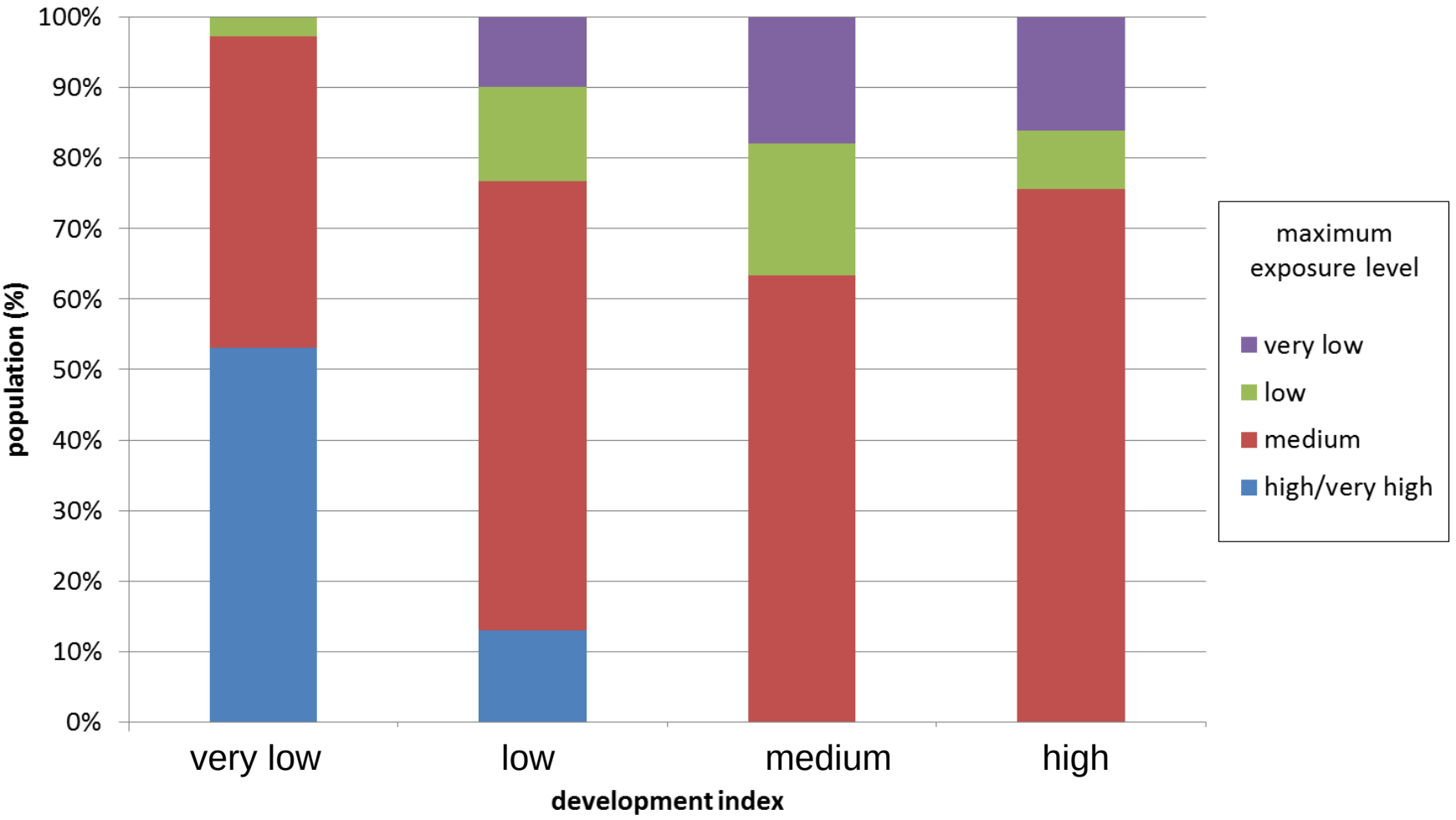
Results: Exposure risks vs. social indices



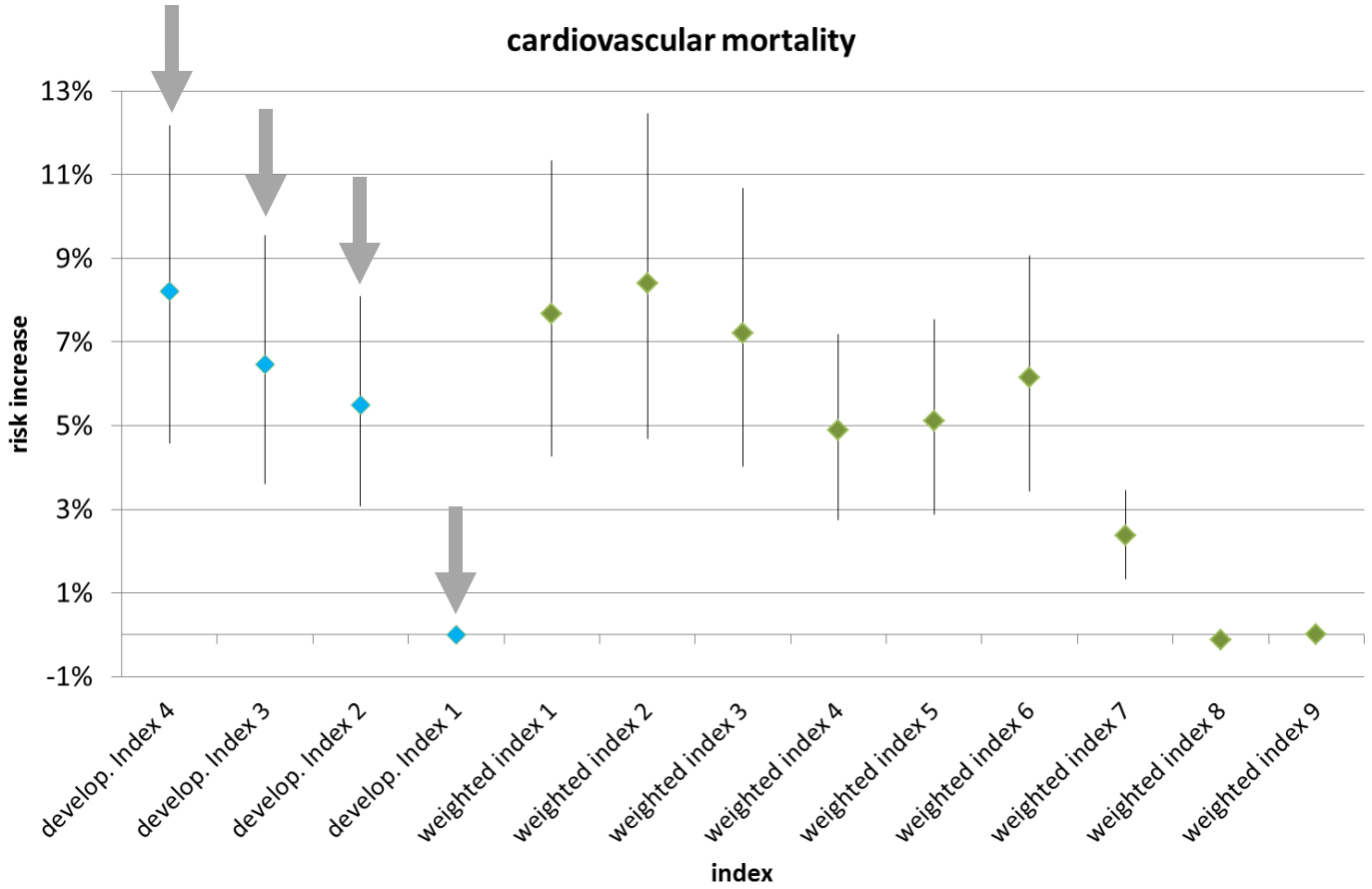
* highest of the two exposure levels

** high if at least one level is highest or both levels are medium; medium if at least one level is medium or both levels are low; low if at least one level is low; very low if both levels are very low

Results: Affected population – total exposure



Results: Human health risks due to PM2.5



(Risk increases assessed basing on data of Lepeule et al., EHP 2012)

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Conclusions from the Study

- Air pollutions by PM and NO_2 show considerable spatial variations within the urban area.
- The socio-spatial segregation is associated to varying exposures against airborne pollutants.
- Areas with lower social status are exposed to higher concentrations of airborne pollutants.
- The population but especially people living in areas which are discriminated twice (socially and by air pollution) would benefit from a reduction of air pollution especially related to urban traffic.

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Thank you for your attention!

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Methods

Calculation of NO2 concentration for PLA

$$NO_2 = \frac{A * NOx}{(B + NOx)} + C * NO_X$$

A,B,C = *constants depending on the type of measurement station (rural, urban, traffic) for the type„urban“:*

A = 67.70
B = 84.77 µg/m³
C = 0.0698

Calculation of local traffic contribution to NO_2 for PLA

$$NO_{2V} = xa * NO_2AV$$

NO_{2V} = *Local traffic contribution of NO_2*
x_a = *Share of traffic areas (streets) in the PLA*
NO_{2AV} = *Mean additional contribution by traffic (25 µg/m³ : Difference between long-term measurements of traffic stations (52 µg/m³) and mean value of urban background stations (27µg/m³)*

Calculation of the total NO_2 concentration for PLA

$$NO_{2SUM} = NO_{2b} + NO_{2V}$$