Controlled human exposure to fine and ultrafine particles from indoor sources – changes in lung function and blood pressure

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19. ETH-Conference on Combustion Generated Nanoparticles

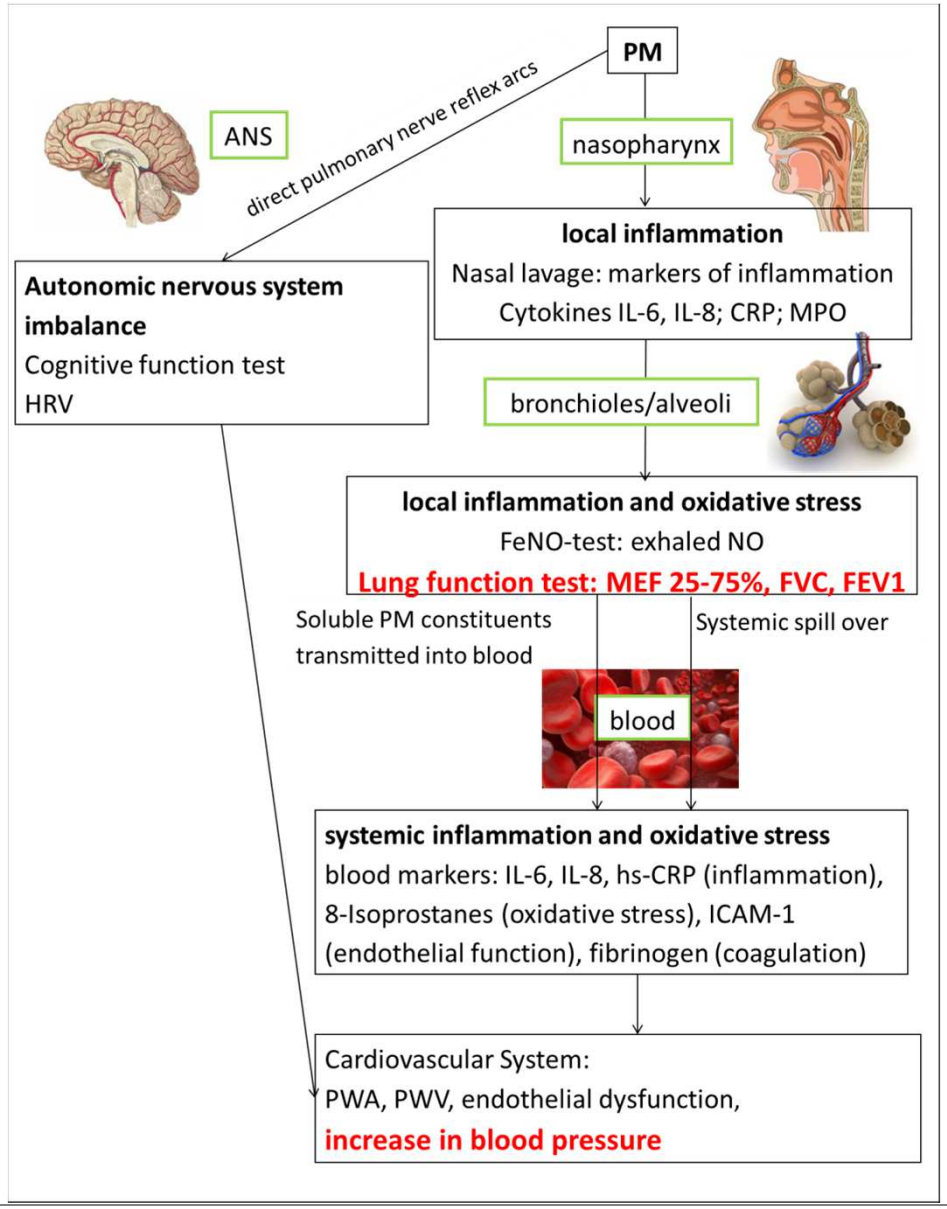
Mitglied der Leibniz-Gemeinschaft

EPIA: **E**ffects of **P**articles from **I**ndoor **A**ctivities

Background

- Fine particulate matter (PM) is linked to cardiovascular diseases, allergic & inflammatory conditions of the lung
- To date, most studies investigate **ambient** particles
- In the developed world, humans spend most of their time **indoors**
- Several indoor activities emit high amounts of fine and ultrafine particles

Hypothesized biological pathways of particulate matter



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Objective

- **To investigate whether exposure to particles from indoor activities leads to health-related changes in healthy volunteers**

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EPIA: Design

- Sham-controlled cross-over exposure study with 55 healthy volunteers
- Temperature-controlled expsoure chamber
- Two hour exposure
  - Candles (C)
  - Toasting bread (TB)
  - Frying sausages (FS)
  - Sham exposure: „Air refresher“ (Room Air)

- Exposure on the same day and time of the week at least 2 weeks apart

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Exposure Measurements

Continuous measurements during each exposure session

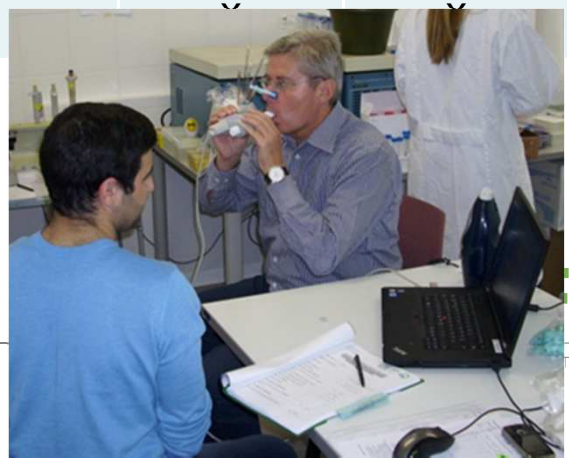
Calculation of personal 2h-exposure during session

- **Size-specific particle number** concentration PNC (FMPS and APS)
- **Particle mass** concentrations for PM_1, $PM_{2.5}$, PM_{10}, (FMPS and gravimetric)
- **Alveolar deposited surface area** concentration (NSAM)
- **Chemical composition** (AMS)
- **EC/OC** Analyser
- CO Monitor
- Particle collection for tox

Health Outcomes

	Pre-exposure (baseline)	During exposure	Directly after exposure	2 h after exposure	4 h after exposure	24 h after exposure
Diary	x	x	x	x	x	x
Nasal lavage	x			x		x
FeNO-Test	x			x		x
Blood draw	x			x		x
Blood pressure	**x**	**x**	**x**	**x**	**x**	**x**
Lung function	**x**				**x**	**x**
PWA	x		x	x	x	x
PWV and HRV	x		x			x
PEG-Board-Test	x					

Lung function: Spirometry (ndd Easy One)
Blood pressure: automatic ambulatory blood pressure monitor (M10-IT; Omron Healthcare GmbH)



Statistical Analysis

- Linear mixed regression analysis with random participant intercept
- Separate analysis for each exposure
- Independent variables: personal cumulative exposure to the particle metrics size-specific particle mass, particle number and surface area during the exposure sessions
- Dependent variable: intra-individual difference to *t*0
- Interaction term: exposure*time point
- Covariates: age, height, sex, temperature, humidity, travel time and means of transportation (full model).

Results – Study population (N=55)

Characteristic	Measure
Age, years (mean±SD)	33.0 (16.6)
Born in Germany, n (%)	35 (64.8)
Male, n (%)	28 (50.9)
Weight, kg (mean±SD)	72.6 (14.0)
Height, cm (mean±SD)	174.3 (9.2)
Economic activity, n (%)	
High School Graduation	42 (79.3)
Employed	25 (47.2)
Smoking status, n (%)	
Ex-smoker	3 (5.6)
Never-smoker	51 (94.4)
History of allergy, n (%)	
Allergy	17 (32.7)
Transport mode, n (%)	
Car	106 (40.3)
Public transportation	145 (55.1)
On foot	2 (0.8)

Exposure characterization

	Room Air			
PM_{10} [µg/m³]	6.2	56 - 84	87 - 126	100 – 279
$PM_{2.5}$ [µg/m³]	4.7	53 - 81	63 - 82	84 – 235
PM_{1} [µg/m³]	3.2	50 – 79	38 – 80	71 - 208
PNC UFP [10^3/ml]	3.0	1,610 – 2,670	900 – 1,560	310 - 610
PSC [µm²/cm³]	23	2,201 – 3,840	1,769 – 3,780	1,325 – 3,456

Chemical Composition

- Candle burning:
  - Gases: Acetaldehydes, aceton < 1 ppm

    CO < detection limit
  - Particles: Organic hydrocarbons, Nitrates

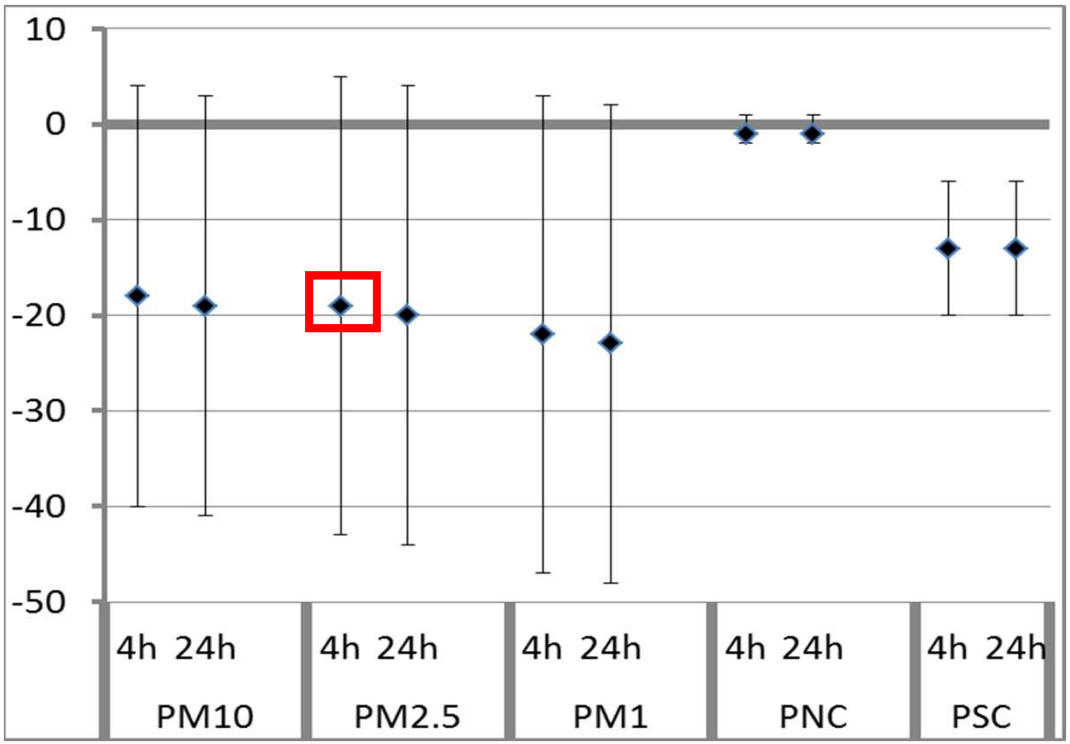
    OC >> EC (7%)
- Frying sausages:
  - Gases: Acetaldehydes, propanoic acid ~ 25 ppm
  - Particles: Organic hydrocarbons,

    OC
- Toasting bread:
  - Gases: Ethanol, Acetaldehydes << 1 ppm
  - Particles: Organic hydrocarbons

    OC (EC < 1%)

Lung function (FEV_1)

Candle burning *



- Mean effect estimates & 95% Confidence Interval (CI)
- Associated for changes (difference) with an increase in particulate metrics post 4 h and 24 h post exposure
- Associated for different exposure scenarios for PMC, PSC and PNC
- Changes refer to an increase of 10 µg/m³ (PMC), 100 µm²/cm³ (PSC) and 10,000 number/cm³ (PNC)

*Adjusted for source

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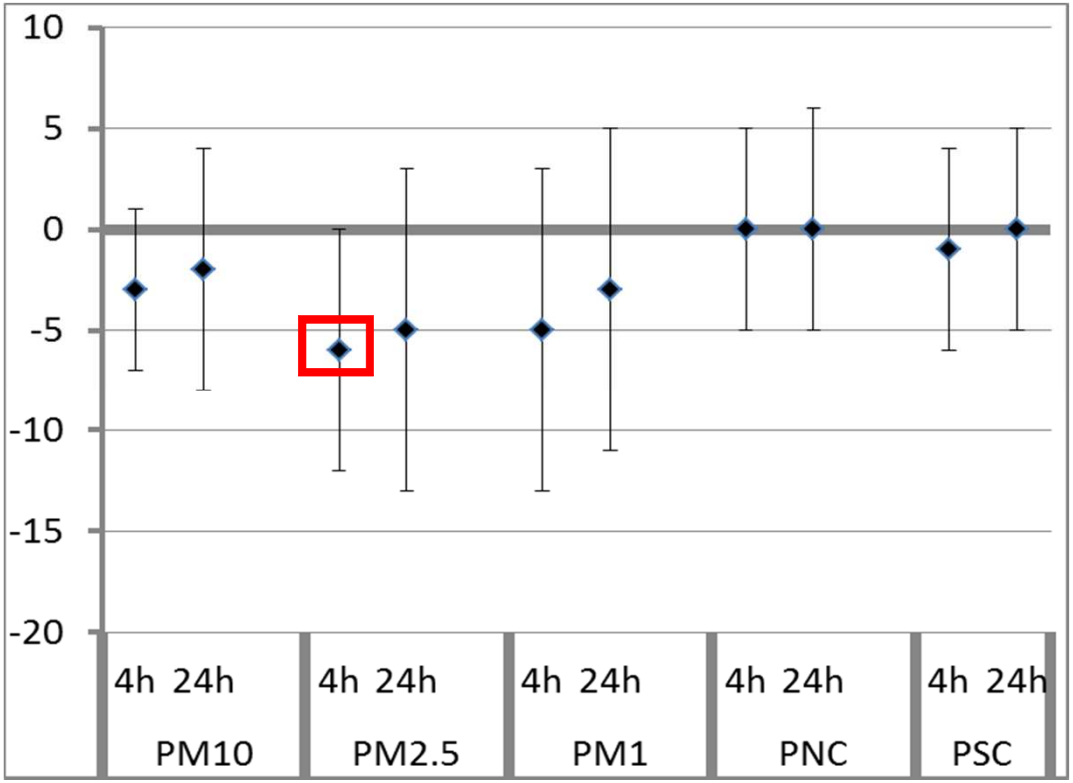
Lung function (FEV_1)

Frying sausages*



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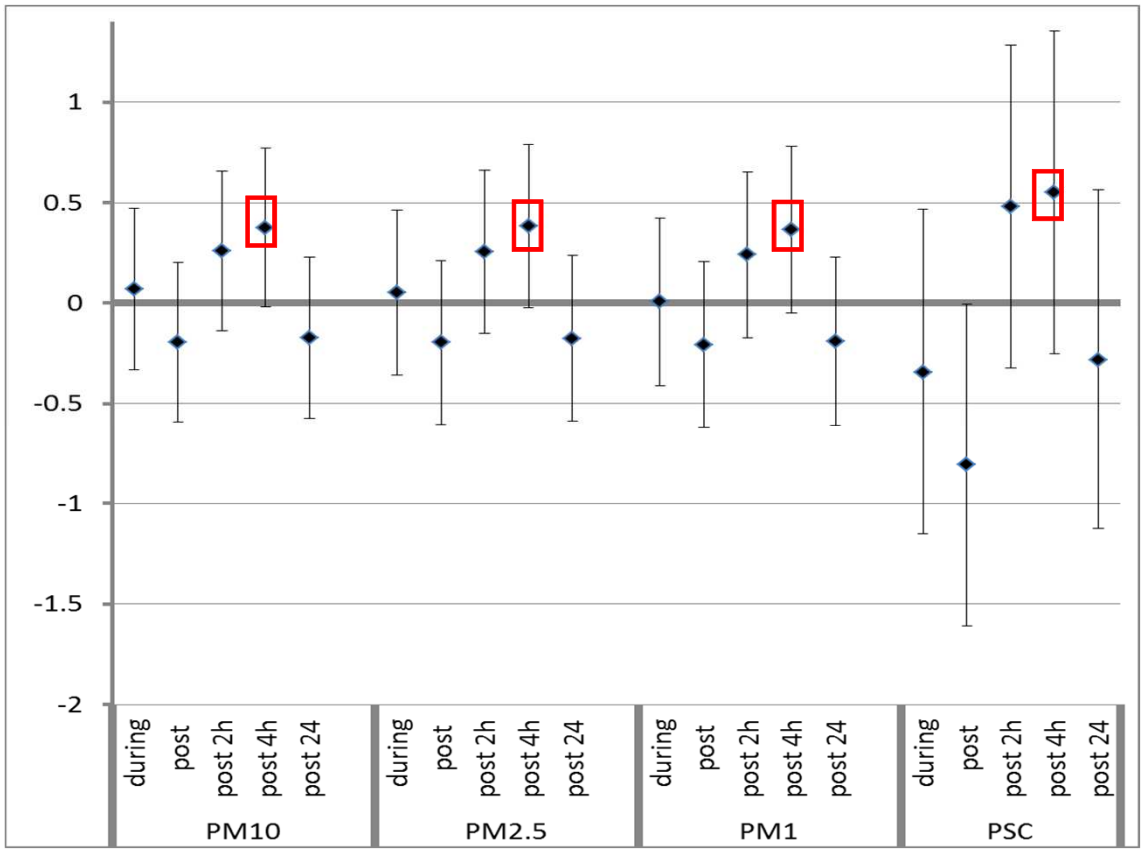
Blood pressure (systolic BP)

Candle burning



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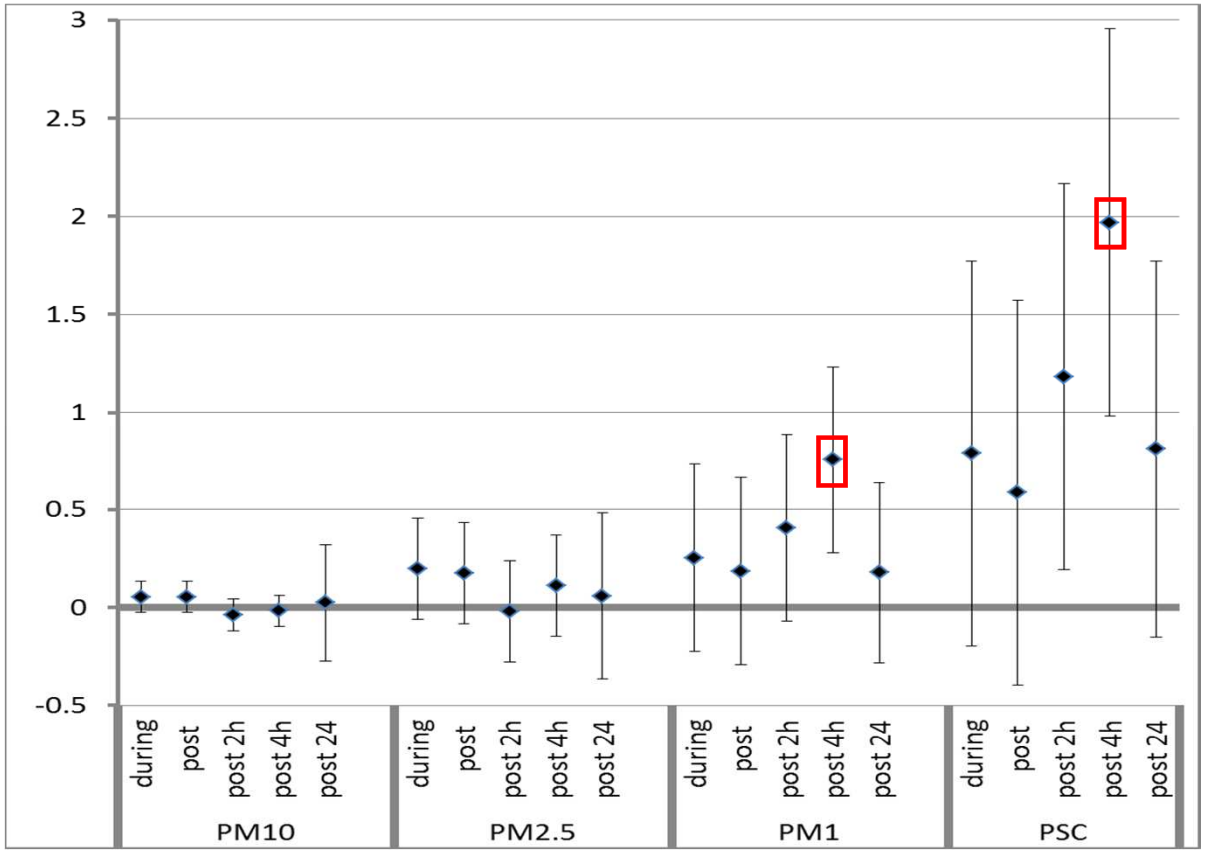
Blood pressure (systolic BP)

Toasting bread



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Summary and Discussion

- Use of novel metric „surface area“
- PSC was dominated by particles between 100-1000 nm in diameter
- Particles mostly organic hydrocarbons, little soot
- Effects differed across sources:
  - Candle burning & frying sausages showed clearest effects on lung function, associations strongest for particle mass concentration
  - After candle burning and toasting bread elevated blood pressure
    - Associations strongest for particle mass concentration and particle surface concentration, in particular 2 & 4 hours after exposure
    - Stronger effects for systolic blood pressure
    - No effects after frying sausages

Limitations

- Two-hour exposure short, but exposures comparatively high (higher than in real-life daily circumstances)
  - Nevertheless well below the concentrations that are typically present in controlled exposure studies of outdoor air pollutants (PMC: 200-300 g/m^3 PM2.5 (Cosselman et al 2012; Mills et al 2007) .
- Blinding not possible
- Participants healthy, no vulnerable populations included (i.e. asthmatics)

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Conclusions

- Examined sources showed large differences regarding their mass-, number- and surface-concentration *as well as their chemical composition*
- Two-hour exposures to high concentrations of fine particles from common indoor sources are variably associated with small decreases in lung function and increases in arterial blood pressure in healthy adults
- The effects of the examined sources varied, possibly due to the physical and chemical composition of the emitted particles > general transfer to sources of indoor particles is not possible
- The observed short-term effects are important because they point to the activation of similar biological mechanisms as short-term exposures to outdoor particles

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