Health risk due to nanoparticles - epidemiological knowledge

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Content

- Ambient concentrations
- Respiratory effects
- Cardiovascular effects
- Summary
Abbreviations:

PM$_{10}$  fine and coarse particles (mass)  $<$ 10 $\mu$m
FP    fine particles      (mass)  $<$ 2.5 $\mu$m
UP    ultrafine particles (number)  $<$ 0.1 $\mu$m

UP = nanoparticles
Particle distribution in Erfurt

number density \( [10^4 \text{ cm}^{-3}] \)

- Diameter [\( \mu \text{m} \)]
  - 0.01
  - 0.1
  - 1

- Year:
  - 1991/92
  - 1995/96
  - 1996/97
  - 1997/98
  - 1998/99
  - 1999/2000
  - 2000/01
Relative particle number, BC, CO concentrations versus distance from the 710 freeway

Day of week pattern of UP

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>% Deviation from mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>-35</td>
</tr>
<tr>
<td>Tue</td>
<td>-30</td>
</tr>
<tr>
<td>Wed</td>
<td>-25</td>
</tr>
<tr>
<td>Thu</td>
<td>-20</td>
</tr>
<tr>
<td>Fri</td>
<td>-15</td>
</tr>
<tr>
<td>Sat</td>
<td>-10</td>
</tr>
<tr>
<td>Sun</td>
<td>-5</td>
</tr>
<tr>
<td>Mon</td>
<td>0</td>
</tr>
<tr>
<td>Tue</td>
<td>5</td>
</tr>
<tr>
<td>Wed</td>
<td>10</td>
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<td>Thu</td>
<td>15</td>
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</tr>
<tr>
<td>Mon</td>
<td>35</td>
</tr>
<tr>
<td>Tue</td>
<td>40</td>
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</tbody>
</table>

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Ultrafine Particles at conventional workplaces

- Fumes from hot processes (e.g. smelting and refining metals; welding)
- Fumes from combustion processes (e.g. diesel motor emissions, carbon black manufacture)
- Bioaerosols (e.g. agriculture, biotechnology)
Who is susceptible and why?

Inhalation of ambient particles

Local effects
- Inflammation

Systemic effects
- Acute phase proteins
- Cytokines

- Asthma Attacks
- Acute Bronchitis

- Ischemia
- Arrhythmia
Particulate matter was associated with mortality

WHO, 1997
Role of ultrafine particles

- Ultrafine particles are deposited in the alveolar region with high efficiency.
- The large surface of ultrafine particles can increase toxicity.
- Decreased phagocytosis allows enhanced interaction between ultrafine particles and the epithelium.
- Ultrafine particles are dislocated from the alveolar space and might therefore elicit systemic effects.
Mortality Study on ultrafine particles

- Daily mortality counts were collected in Erfurt between summer 1995 and the end of 1998.
- Particle size distributions were measured with an aerosol spectrometer between 10 nm and 2.5 µm.
- Ultrafine particles were only moderately correlated with PM$_{2.5}$.

Wichmann et al. *HEI Report* 2000
Particle and Daily Mortality, 1995 to 1998, Erfurt

Single Fractions

<table>
<thead>
<tr>
<th>Particle Fraction [nm]</th>
<th>Relative Risk</th>
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</thead>
<tbody>
<tr>
<td>30</td>
<td>1.00</td>
</tr>
<tr>
<td>50</td>
<td>1.05</td>
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<tr>
<td>100</td>
<td>1.10</td>
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<tr>
<td>500</td>
<td>1.15</td>
</tr>
<tr>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>2500</td>
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</table>

Cumulative Effects

<table>
<thead>
<tr>
<th>Particle Fraction [nm]</th>
<th>Relative Risk</th>
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<tbody>
<tr>
<td>30</td>
<td></td>
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<tr>
<td>50</td>
<td></td>
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<tr>
<td>100</td>
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<td>500</td>
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<tr>
<td>1000</td>
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<tr>
<td>2500</td>
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</table>

Wichmann et al. (2000)
Regression results by cause of death

<table>
<thead>
<tr>
<th>UP</th>
<th>&quot;PM2.5&quot;</th>
</tr>
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<tbody>
<tr>
<td>RR per interquartile range</td>
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</tr>
<tr>
<td>0.90</td>
<td>1.00</td>
</tr>
<tr>
<td>0.95</td>
<td>1.05</td>
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<tr>
<td>1.00</td>
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<tr>
<td>1.05</td>
<td>1.16</td>
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<tr>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>1.16</td>
<td>1.28</td>
</tr>
</tbody>
</table>

- UP: 4 4 1 1
- "PM2.5": 0 5 0 0

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Lung function reduction in asthmatic adults

![Graph showing correlation between change in PEF (l/min) and correlation coefficient with NCP\textsubscript{0.01-0.1} for fine particles and ultrafine particles.](Diagram)

Peters et al., 1997
Medication use increased in adult asthmatics (Erfurt)

52 subjects followed for 5 months during winter 96/97

Change in prevalence [% per IQR]

Beta-agonists

Corticosteriods

UP     FP    PM$_{10}$

UP     FP    PM$_{10}$

von Klot et al. (2000)
Potential mechanism leading to cardiovascular effects

- Increased sympathetic activation and/or withdrawal of parasympathetic tone
- Imbalance of sympathetic and parasympathetic control
- Decreased heart rate variability
- Increased risk for cardiac events (alteration of myocardial substrate, increased myocardial vulnerability)
Particles and Myocardial Infarction in Augsburg

<table>
<thead>
<tr>
<th>Change [%]</th>
<th>Primary MI</th>
<th>Secondary MI</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particle number (estimated)</td>
<td></td>
<td></td>
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</tbody>
</table>
Traffic and Onset of Myocardial Infarction in Augsburg

- 691 MI survivors of the KORA MI Registry Augsburg
- Activities were recorded 4 days before the event
- Using a car, public transport or a bicycle might be a risk factor for MI

Peters et al. NEJM in press
Rochester Particle Center Study in Erfurt, Germany

- Panel Study in 56 patients with coronary artery disease (winter 2000/01)
- Panel Study in 37 patients with chronic obstructive pulmonary disease (winter 2001/02)
- Blood biomarkers and EKG recordings at 12 clinic visits
- Central monitoring of ultrafine and accumulation mode particles, \( \text{PM}_{2.5} \)
Particle effects on normalized HF in Erfurt
spontaneous breathing, 5 min recordings

Exposure to average concentrations of ambient air particles concurrent and prior to the 24 hr recording
Ultrafine Particle number, PM$_{2.5}$ and Temperature (CAD panel, Erfurt, winter 2000/2001)
Particle effects on T wave amplitude in Erfurt
spontaneous breathing, 5 min recordings

Am

Ambient pollutant exposure: 6 hours and 24 hours average before the recording
Particle effects on T wave complexity in Erfurt
spontaneous breathing, 5 min recordings

% change of average T wave complexity per increase in IQR pollutant

Ambient pollutant exposure: 6 hours and 24 hours average before the recording

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Summary

- Main ambient source of UP is automobile traffic
- Health effects of UP on respiratory and cardiovascular endpoints shown, but open questions
- Epidemiology on technically produced nanoparticles missing (work place and environment)
- Epidemiology on UP from combustion may serve as model for nanoparticles