Austrian project on health effects of particles: First results on lung function changes in children

Manfred NEUBERGER***, Friedrich HORAK Jun.***, Thomas FRISCHER***, Michael KUNDI**, Hans PUXBAUM***, Michael STUDNICKA****, Helga HAUCK***, Otto PREINING*


Introduction

In Vienna, the capital of Austria, winter smog episodes during the 70s were related to increased daily mortality from all, cardiovascular and respiratory disease at age >70 years. These increases related to SO₂ were found independent of increases related to influenza and/or low temperature [1]. During the 80s SO₂ was reduced in Austria and relations to excess mortality disappeared, however, respiratory symptoms in children were still found increased by outdoor air pollution in Vienna, independent of increases by indoor air pollution [2]. Small airway dysfunction showed closer relations to outdoor urban NO₂ than to SO₂ and TSP [3]. In urban districts where only SO₂ but not NO₂ decreased, no improvement of lung function growth could be proven [4]. Recent epidemiological results showed health effects of fine particles [5] which have not been used for routine monitoring up to now. In order to find better health related indicators for surveillance of urban air quality, the Clean Air Commission of the Austrian Academy of Science set up the interdisciplinary Austrian Project on Health Effects of Particulates (AUPHEP), which combines epidemiological studies on mortality, morbidity, child health and lung function with research on aerosols and gaseous pollutants in the three largest Austrian towns (Vienna, Graz, Linz) and a rural control area in Lower Austria. The following first results focus on child health and lung function monitored in 1999/2000 together with air quality in Vienna.

Methods and persons

In addition to routine ambient air monitoring for TSP, SO₂, NO, NO₂, O₃, CO and meteorological parameters (wind speed and direction, temperature, relative humidity, precipitation) a special surveillance started, after intercalibration exercises, on June 1st, 1999 at an urban station in Vienna and a rural station in Lower Austria. Mass concentrations were measured continuously by TEOM (R&P) and β-gauge (Eberline) for PM₁₀, PM₂.₅ and PM₁₀. Gravimetric monitoring of PM₂.₅ and PM₁₀ was also performed by high volume sampling (Digitel) on quartz filters analyzed daily for ions (Na, NH₄, K, Ca, Mg, Cl, NO₃, NO₂, SO₄, oxalate), total carbon (TC), elemental carbon (EC) and organic carbon (OC); 32 different organic compounds and the heavy metals As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, V and Zn were analyzed from monthly filter extracts. Samples for the analysis of 20 PAHs were taken on a randomized basis. Monthly benzene and 2-weekly NH₃ was collected by passive samplers. Particle numbers were counted continuously by condensation particle counters (CPC-TSI). Over a winter and a summer month period cascade impactor campaigns were conducted on a daily basis for closer investigation of the size distributions of particles and their chemical composition.

Time series studies are performed on daily mortality (death certificates) and daily morbidity (hospital diagnoses) of the general population; on respiratory symptoms and signs of >1000 elementary school children living in the vicinity of the air monitoring stations; on lung functions of 232 elementary school children and of 61 kindergarten children living in the close vicinity of the air monitoring station. The following
Results and discussion

The following means (± SD) were found in continuous monitoring over 366 days for particle numbers/cm³; PM₁₀; PM₂.₅; PM₁₀; SO₂ (µg/cm³); NO₂ and O₃ (ppb) in Vienna: 26217 ± 9686; 14.8 ± 7.7; 18.5 ± 10.7; 26.4 ± 13.3; 2.5 ± 1.6; 16.9 ± 6.5 and 24.7 ± 11.6.

In the rural control area the corresponding figures were: 10320 ± 4358; 12.8 ± 6.7; 14.6 ± 8.5; 20.7 ± 10.7; 4.0 ± 3.0; 5.1 ± 3.5 and 26.7 ± 10.6. Particle number concentrations showed different patterns than particle mass and correlated with NO₂ (r = 0.6) significantly in all four seasons. In the rural control area this correlation was found in winter only.

For Vienna, Figure 1 shows daily means of PM₁₀; PM₂.₅ and PM₁₀ which peaked on December 25th with 75, 96 and 105 µg/m³. Even more pronounced was the increase of particle numbers (CPC) in winter which peaked on January 18th with 62835/cm³. No seasonal pattern was observed in the rural control area (data not shown). Also the carbon content of the PM₂.₅ fraction was higher in Vienna (32.1%) than in the rural area (25.6%) and the TC and OC in the PM₂.₅ fraction reached highest values in Vienna in winter and peaked on December 10th with 23.7 and 19.5 µg/m³ (Figure 1).

Examined children from Viennese kindergartens were 3.0-5.9 years of age (mean 4.8), and 55.6% boys; 54 children had at least 3 examinations (mean 12.9 examinations). Parents reported on respiratory symptoms of their children in 43% and of allergic symptoms in 13%; 44% of parents had higher education; 56% used single-story heating systems, 83% gas for energy supply and 53% used a gas stove; 66% of children lived at least one smoker and were exposed to environmental tobacco smoke of 0-40 (mean 8.8) cigarettes/day in the household. Cotinine ranged from 0.01 to 34.2 (mean 10.6) ng/mg hair. In 62% of children a level of 2 ng cotinine/mg was exceeded. In 80% children also attended a kindergarten with smoking personnel, but the 56% used single-story heating systems, 83% used a gas stove; 66% of children lived with at least one smoker and were exposed to environmental tobacco smoke of 0-40 (mean 8.8) cigarettes/day in the household. Cotinine ranged from 0.01 to 34.2 (mean 10.6) ng/mg hair. In 62% of children a level of 2 ng cotinine/mg was exceeded. In 80% children also attended a kindergarten with smoking personnel, but the
Figure 1.
Mass (PM$_{1.0}$, PM$_{2.5}$, PM$_{10}$) and number (CPC) concentrations of particles and total carbon (TC).

Masa (PM$_{1.0}$, PM$_{2.5}$, PM$_{10}$) y número (CPC) concentraciones de partículas y carbono total (TC).
Table 2.
Effects of an increase in number (CPC)/mass of particles/carbon on tPTEF/τE (~).

<table>
<thead>
<tr>
<th>24 h</th>
<th>CPC</th>
<th>PM₁₀</th>
<th>PM₁₂</th>
<th>PM₁₀</th>
<th>TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>-0.07</td>
<td>-0.1</td>
<td>-0.07</td>
<td>-0.03</td>
<td>-0.21</td>
</tr>
<tr>
<td>P</td>
<td>0.160</td>
<td>0.060</td>
<td>0.091</td>
<td>0.241</td>
<td>0.03</td>
</tr>
</tbody>
</table>

P: Level of significance.

Table 3.
Effects of an increase in number (CPC)/mass of particles averaged over 7 days.

<table>
<thead>
<tr>
<th>7d</th>
<th>CPC</th>
<th>PM₁₀</th>
<th>PM₁₂</th>
<th>PM₃₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>-0.13</td>
<td>-0.08</td>
<td>-0.001</td>
<td>-0.009</td>
</tr>
<tr>
<td>P</td>
<td>0.098</td>
<td>0.415</td>
<td>0.979</td>
<td>0.840</td>
</tr>
</tbody>
</table>

P: Level of significance.

The only air pollution indicator which showed a larger negative effect after averaging concentrations over 7 days was particle number concentration (CPC). This can be seen as a trend (p<0.1), but did not reach significance in our small sample of children. No other air pollutant monitored (SO₂, NO₂, O₃, NH₃, SO₄, Ca, etc.) showed a trend of correlation with airway obstruction, neither for 24 hour nor for 7 day averages.

Studies on health effects of particles have been criticized because of their conclusions on groups of very heterogeneous particles [8]. The results of this study suggest to look more closely into the carbon fraction of fine particles when analyzing acute respiratory effects on children and to include surveillance of particle numbers in monitoring of air quality.

Conclusion

In time series studies on Austrian children we attempt to detect early health effects of PM and to find better indicators for surveillance of urban air quality. Kindergarten children (aged 3.0-5.9 years) living near an air monitoring station in Vienna were examined by questionnaires, interviews, diary, 13 lung function tests (calibrated respiratory inducance plethysmography), hair analyses for cotinine and nasal swabs for virus infection. After adjustments for confounders an influence of particulate carbon on lung function was found significant. There was also a trend for total particle mass to impair lung function, more pronounced for particles <1 μm than for particles <2.5 μm. These impairments were detected when mass particles was averaged over 24 hours before lung function testing. The only air pollution indicator which showed a trend for negative effect after averaging concentrations over 7 days was particle number.

Acknowledgements

The study was supported by the Austrian Ministries for Environment and Science, the Austrian Academy of Science, the Austrian Provincial Governments, the Federal Environmental Agency and several companies. We are indebted to T. Popow-Kraupp for the virological tests, to C. Gartner for the statistics, and to S. Stopper and B. Gomiscek for collection and analysis of air quality data.

References