

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

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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 PM_{1.0}, PM_{2.5} and PM₁₀. Gravimetric monitoring of PM_{2.5} 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

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results on the children from 5 kindergartens around the air monitoring station in Vienna have been observed between September 1999 and April 2000. The lung function test used in these children was time to peak tidal expiratory flow/expiration time (tPTEF/tE) measured by induction plethysmography (Respirace) which has been proven to be an early indicator for airway obstruction in young children [6, 7]. Personal exposures from indoor sources were assessed by standardized questionnaires and analyses of cotinine in hair.

Starting with the half hour mean outdoor concentrations of air pollutants 24 hours/7 days before each individual child's lung function testings person-related exposures were calculated. The resulting daily/weekly means were used for a time series study assuming autoregressive correlation of repeated measurements of tPTEF/tE.

Results and discussion

The following means ($\pm$ SD) were found in continuous monitoring over 366 days for particle numbers/cm³; PM_{1.0}; PM_{2.5}; PM₁₀; SO₂ (μ g/cm³); NO₂ and O₃ (ppb) in Vienna: 26217 $\pm$ 9686; 14.8 $\pm$ 7.7; 18.5 $\pm$ 10.7; 26.4 $\pm$ 13.3; 2.5 $\pm$ 1.6; 16.9 $\pm$ 6.5 and 24.7 $\pm$ 11.6.

In the rural control area the corresponding figures were: 10320 $\pm$ 4358; 12.8 $\pm$ 6.7; 14.6 $\pm$ 8.5; 20.7 $\pm$ 10.7; 4.0 $\pm$ 3.0; 5.1 $\pm$ 3.5 and 26.1 $\pm$ 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 PM_{1.0}; PM_{2.5} and PM₁₀ which peaked on December 25th with 75, 96 and 105 μ g/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 PM_{2.5} fraction was higher in Vienna (32.1%) than in the rural area (25.6%) and the TC and OC in the PM_{2.5} fraction reached highest values in Vienna in winter and peaked on December 10th with 23.7 and 19.5 μ g/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; 68% 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

numbers of cigarettes smoked there (0-40, mean 22) did not show a positive correlation with children's hair cotinine so that no important ETS contribution from this source (separate rooms for smokers in kindergartens) can be assumed.

Diaries kept by kindergarten personnel showed a mean absence rate of 17% (20 of 117 registered days) which was highest for children whose parents had reported to live at roads with very heavy traffic (20.3%) compared to heavy (19.3%), medium (15.7%) and low traffic (11.2%). This might indicate an influence of motor traffic exhaust on sick leave from kindergarten. Some differences in mean absence rates were also related to the heating system (indicating air pollution from indoor sources): single-room heating 18.4%, single-story heating 16.7%, central/remote heating 13.5% absence rate. Diaries further showed a mean incidence of 18% days with colds while attending kindergarten. In 19 children with respiratory infection at a day of examination 27 of 120 nasal smears proved a virus infection (mainly Rhinoviruses). Virology was positive more frequently in children from lower social class. No Influenza, Parainfluenza or Respiratory Syncytial Virus was found during kindergarten attendance. Therefore no severe confounding of our results from virus infections can be assumed.

Tables 1-3 show effects on the lung function parameter tPTEF/tE estimated after exclusion of a positive virology on the day of examination.

Table 1.
Effects on tPTEF/tE (β).

	β	P
Sex (male)	0.85	0.544
Age	0.49	0.615
Social status (low)	- 1.66	0.338
Temperature	- 0.12	0.141
Breathing frequency	0.11	0.403
Phase shift of breathing	0.11	< 0.001
PM _{1.0} (TEOM, 24 h)	- 0.10	0.060

P: Level of significance.

After adjusting for sex, age, social status, temperature, breathing frequency, phase shift and kindergarten (fixed errors) and observer (random error), the mixed model showed most pronounced negative effects for increase of PM_{1.0} (Tables 1, 2). For total carbon (measured in PM_{2.5}) the negative influence on lung function was significant (Table 2, p. 386).

The negative effects of PM_{1.0} seem to be acute effects of peaks, because they were less pronounced after averaging concentrations over the last 7 days before the lung function test (Table 3, p. 386).

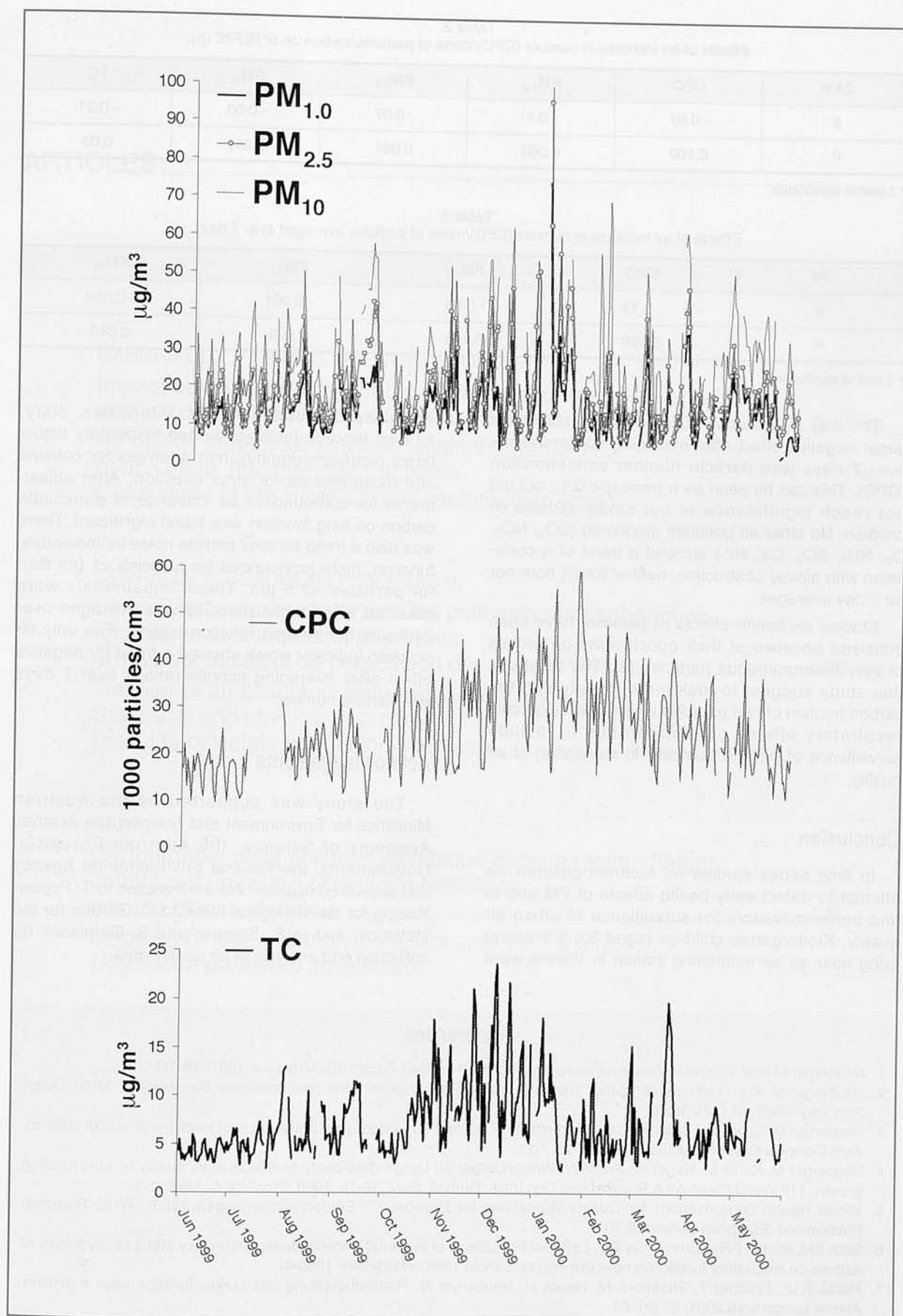


Figure 1.
Mass ($\text{PM}_{1.0}$, $\text{PM}_{2.5}$, PM_{10}) and number (CPC) concentrations of particles and total carbon (TC).

Table 2.
Effects of an increase in number (CPC)/mass of particles/carbon on tPTEF/TE (β).

24 h	CPC	PM _{1.0}	PM _{2.5}	PM ₁₀	TC
β	- 0.07	- 0.1	- 0.07	- 0.03	- 0.21
P	0.160	0.060	0.091	0.241	0.03

P: Level of significance.

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

7d	CPC	PM _{1.0}	PM _{2.5}	PM ₁₀
β	- 0.13	- 0.08	- 0.001	- 0.009
P	0.098	0.415	0.979	0.840

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, NH₄, SO₄, Ca, etc.) showed a trend of a correlation with airway obstruction, neither for 24 hour nor for 7 day averages.

Studies on health effects of particles have been criticised 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 inductance plethysmography), hair analyses for cotinine and nasal smears 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 $< 1 \mu\text{m}$ than for particles $< 2.5 \mu\text{m}$. 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.

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References

1. Neuberger M et al. Grippe, Luftverunreinigung und Mortalität in Wien. Forum Städtehygiene 1987; 38: 7-11.
2. Neuberger M et al. Luftverunreinigung, Kochen, Heizen, Passivrauchen und respiratorische Symptomatik. Mittlg Österr San Verw 1986; 87 (12): 363-6.
3. Neuberger M, Kundi M, Haider M. Combined effects of outdoor and indoor air pollution on lung functions of school children. Arch Complex Environ Studies 1995; 7 (1-2): 7-11.
4. Neuberger M, Kundi M, Hager W, Krejci W, Wiesenberger W. Longitudinal study on effects of air quality on lung function growth. 11th World Clean Air & Environment Congress, Durban, Sept. 14-18, 1998, Proc.Vol. 5, 14B2: 1-6.
5. World Health Organisation: Air Quality Guidelines for Europe, 2nd Edition (Copenhagen 2000). WHO Regional Publications, European Series, No 91.
6. Stick SM, Burton PR, Gurrin L, Sly PD, LeSouef PN. Effects of maternal smoking during pregnancy and a family history of asthma on respiratory function in newborn infants. Lancet 1996; 348 (9034): 1060-4.
7. Horak F Jr, Frischer T, Studnicka M, Hauck H, Neuberger M. Partikelbelastung und Lungenfunktion beim Kleinkind. Atemw Lungenkrkh 2001; 27 (2): 85.
8. Dab W et al. Pollution atmosphérique et santé : Corrélation ou causalité ? Le cas de la relation entre l'exposition aux particules et la mortalité cardio-pulmonaire. J Air Waste Manage 2001; 51: 203-19.