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ORIGINAL ARTICLE

U Heudorf · M Schümann · J Angerer · M Exner

Dermal and bronchial symptoms in children: are they caused by PAH containing parquet glue or by passive smoking?

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Abstract *Objective*: In 1997 a new source of potential polycyclic aromatic hydrocarbon (PAH) exposure was discovered: very high levels of (PAHs) and benzo-a-pyrene (BaP) were detected in household dust from former American Forces housing in Frankfurt am Main, Germany, built in 1955/1956. This contamination was caused by a parquet glue containing coal tar, the use of which was formerly a standard building practice in Germany. Children were considered to be at special risk for exposure to PAHs when playing on the floor via mouthing. Therefore, the children's symptoms and complaints were analysed for association with PAH contamination in parquet glue and household dust as well as with internal exposure to PAHs via determination of 1-hydroxypyrene in urine samples. *Participants and methods*: Two hundred and eighty seven children <6 years of age living more than 12 months in the former US-housing estates are enrolled in this analysis, representing 22.3% of the children <6 years of age living there. Their spot urine samples were analysed for 1-hydroxypyrene. The level of BaP in parquet glue and in household dust was available in the homes of 215 and 212 children, respectively. There were no hints for differences in PAH contamination in parquet glue or in household dust of the participants' flats compared to the flats of the non responders. In 246 cases data on environmental tobacco smoke exposure at home was known as well. Data on symptoms and complaints observed by their parents during the preceding 12 months (1-year prevalence) were obtained using the ISAAC questionnaire (modified). *Results*: The following 1-year prevalences were reported: 15% itching eczema in elbows, 10% itching and urticaria, 6% itching in the palate and throat, 20% sneezing and running nose or stuffed nose, 15% nosebleed; 25% wheezing, 42% dry cough, and 60% frequent infectious disease. No consistent associations between symptoms and BaP in parquet glue or in household dust or urinary levels of 1-hydroxypyrene in the children could be found. However, associations between symptoms and exposure to environmental tobacco smoke at home were to be seen, significant for dermal and bronchial symptoms. *Conclusion*: Informed about PAHs in parquet glue and household dust many parents demanded for total redevelopment of their flats. According to statistical evaluation of the children's symptoms, observed by their parents, no hints for an association with exposure via BaP in parquet glue or household dust were found. However, significant associations between symptoms and the exposure to environmental tobacco smoke were observed, especially bronchial and dermal symptoms. Therefore instead of redevelopment of flats with parquet glue containing coal tar, intensified information on the harmful effects of passive smoking in childhood seems to be mandatory.

Keywords Polycyclic aromatic hydrocarbons (PAHs) · Parquet glue containing PAHs · PAHs in household dust; internal PAH exposure · Urinary hydroxypyrene · Symptoms of skin and bronchiae

U Heudorf (✉)
Public Health Services of the City of Frankfurt on the Main,
Braubachstr. 18-22, 60311, Frankfurt/M, Germany
E-mail: ursel.heudorf@stadt-frankfurt.de
Tel.: +49-212-36980
Fax: +49-212-30475

M Schümann
Epidemiology working Group, Institute for Medical Biometry and Epidemiology, Hamburg, Germany

J Angerer
Department and out-patient clinic for Occupational, Social and Environmental Medicine,
University Erlangen-Nuremberg, Bavaria, Germany

M Exner
Institute for Hygiene and Public Health,
University of Bonn, Bonn, Germany

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a group of several hundred substances, including Benzo(a)pyrene

(BaP), which was classified by IARC in Group 2A (for substances probably carcinogenic to humans) (IARC 1983). PAHs form during incomplete combustion of wood, oil, coal and gas, and also other organic substances e.g. during roasting of meat and smoking of tobacco (WHO 1987).

In 1997 a new source of potential PAH exposure was discovered: very high levels of PAHs and BaP were detected in household dust from former American Forces housing in Frankfurt am Main, Germany, built in 1955/1956. Odour problems were not reported. Further investigations revealed that the contamination of the household dust samples was caused by a parquet glue containing coal tar, the use of which was formerly a standard building practice in Germany. These glues were taken off the market in about 1972, when other and better adhesives were introduced (Heudorf and Moriske 1999; Heudorf and Schubert 2000)

In Frankfurt am Main, the former US housing estates comprise about 2,800 flats and nearly 100 houses. Because of great public concern, parquet glue and household dust ware analysed for BaP in all flats, and the occupants were offered the opportunity of receiving consultation arranged by the local health department of Frankfurt am Main and taking part in biomonitoring examinations for PAH metabolites.

In general, infants and small children are considered to be at risk from increased exposure to PAHs in the parquet glue due to the ingestion and/or dermal absorption of contaminated household dust while crawling and playing on the floor. Therefore, the aim of this exposure and risk analysis was to study the association of PAH exposure at home, including passive smoking, with dermal and respiratory symptoms of children under 6 years of age.

Participants, material, methods

The possibility of consultation and biomonitoring was offered in February 1998, via the mass media and the distribution of leaflets. All inhabitants of the former US housing estates—at that time a total 9,548 persons—were invited to take part in the tests without any preclusion criteria. Until December 1998, 1,213 inhabitants had visited the consultation hours, among them a total of 347 children <6 years of age, representing 27% of the children in this age group. Most of them were seen from February to June, 1998. In all of them, 1-hydroxypyrene was tested in spot—urine samples (Heudorf and Angerer 2000, 2001a) using a high performance liquid chromatographic (HPLC) method with fluorescence detection—with a limit of detection of 5 ng/l (Angerer et al. 1997; Lintelmann et al. 1994; Lintelmann and Angerer 1998).

In the questionnaire [a modified ISAAC-questionnaire "International Study of Asthma and Allergy in Children" (Asher et al. 1995)], symptoms and complaints were assessed, which had been observed by their parents during the last 12 months, i.e. 1-year-prevalence. Thus, 287 children living for 1 year or more in these flats were included in the following analysis, representing 22.3% of the children of that age living in 7% of the 2,900 flats/houses of the former US housing area.

The questionnaire comprised, among other items, questions on dermal and respiratory symptoms, such as itchy rash affecting following places: the folds of the elbows, behind the knees, in front of the ankles; itchy, reddish urticaria; itching on lips, palate or throat; running eyes; sneezing or a running nose without a flue; itchy or blocked nose; nosebleed; wheezing and dry cough during or after exercise,respectively, during a cold or without a cold, especially during the night or especially when exposed to cold air; restlessness; lack of concentration; nausea; vomiting; and diarrhoea (Asher et al. 1995).

For 215 and 212 children the results of BaP-analyses in the parquet glue or in household dust of their homes, respectively, were available as well. Most of the samples were taken from May to June, 1998. The samples were analysed by gas chromatography/mass spectrometry; the limit of detection was 0.1–1 mg BaP/kg glue, and about 0.1 mg/kg household dust. In one third of the flats the level of BaP in parquet glue was below 10 mg/kg, in one third it was in the range 10–$<3{,}000$ mg/kg, and in one third it was above 3,000 mg/kg. BaP in household dust was below 1 mg/kg in 89% of the flats, compared to 90% in all flats. Thus, there is no evidence that the level of BaP in parquet glue and in household dust of the study participant's flats differs from the levels found in all the flats in the former US housing areas in Frankfurt/M. For 246 of the children data on smoking in the flat, i.e. environmental tobacco smoke in the homes, were known as well—indicated as "never", "only on balcony", "seldom", "regularly".

SPSS-programme version 8 was used for statistical analyses: Spearman rank correlation (two-tailed), partial correlation, and odds-ratios.

Results

Two hundred and eighty seven children, living for 1 year or more in these flats, were included in the following explorative analysis; 53% of the participants were boys and 47% of them were girls. Mean age was 3.6 ± 1.3 years (range 0.2–5.9 years). No correlation between PAH levels in parquet glue or in household dust and urinary levels of 1-hydroxypyrene of the occupants could be found (Heudorf and Angerer 2000, 2001a).

The following 1-year prevalences of various symptoms in their children were reported by the parents: 15% itching eczema in elbows; 10% itching and urticaria; 6% itching in the palate and throat; 20% sneezing and running nose or stuffed nose, 15% nosebleed; 25% wheezing; 42% dry cough; and 60% frequent infectious disease (Table 1). The prevalences due to external exposure to BaP in parquet glue and in household dust

Table 1 Prevalence of various symptoms in children under 6 years of age, living for more than 12 months in the former US housing, with respect to their exposure to BaP in parquetgue and in household dust, to urinary levels of 1-hydroxypyrene, and to passive smoking

In the last 12 months, has your child had...	All children	Parquet glue (mg BaP/kg)			Household dust (mg BaP/kg)			1-Hydroxypyrene in urine (quartile ng/g creatinine)				Passive smoking in the flat			
		< 10	10–< 3,000	≥3,000	< LOD	< 1	≥1	1.	2.	3.	4.	Never	Balcony	Seldom	Regular
Number of children	**287**	**66**	**73**	**76**	**138**	**50**	**24**	**69**	**71**	**72**	**69**	**111**	**40**	**70**	**25**
Symptoms of skin and mucosae	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Itchy rash in in the folds of the elbows, behind the knees, in front of the ankles	**14.6**	15.2	16.4	14.5	17.4	10.0	16.7	14.5	18.3	12.5	13.0	8.1	10.0	20.0	20.0
Itchy, reddish urticaria	**10.8**	6.1	13.7	15.8	10.1	12.0	20.8	7.2	9.9	12.5	14.5	8.1	15.0	14.3	16.0
Itching on lips, palate, and throat	**5.6**	6.1	9.6	6.6	8.0	2.0	16.7	5.8	4.2	6.9	5.8	2.7	2.5	11.4	4.0
Running eyes	**14.6**	10.6	20.5	14.5	13.8	16.0	25.0	8.7	21.1	8.3	21.7	9.0	10.0	17.1	24.0
Sneezing, running nose without a flue	**20.6**	18.2	26.0	23.7	21.0	20.0	37.5	14.5	25.4	22.2	20.3	13.5	17.5	30.0	24.0
Itchy, blocked nose	**20.6**	13.6	32.9	22.4	21.7	22.0	33.3	18.8	22.5	22.2	20.3	16.2	20.0	21.4	32.0
Nosebleed	**13.9**	15.2	19.2	13.2	15.9	12.0	20.8	11.6	16.9	16.7	11.6	5.4	15.0	17.1	24.0
Wheezing	**24.4**	28.8	23.3	27.6	25.4	32.0	25.0	14.5	25.4	22.2	37.7	17.1	15.0	41.4	40.0
During or after exercise	**4.9**	6.1	4.1	5.3	5.1	6.0	4.2	2.9	4.2	4.2	8.7	0.9	0	15.7	8.0
During a cold	**17.1**	18.2	20.5	15.8	19.6	14.0	20.8	10.1	11.3	23.6	24.6	14.4	10.0	22.9	36.0
Without a cold	**7.0**	4.5	6.8	10.5	5.8	14.0	4.2	5.8	9.9	1.4	11.6	1.8	2.5	17.1	12.0
Nocturnal	**17.1**	18.2	20.5	18.4	18.1	24.0	20.8	10.1	19.7	16.7	23.2	9.9	12.5	25.7	28.0
When exposed to cold air	**0.7**	0.0	1.4	1.3	0.7	0.0	4.2	1.4	1.4	0	0	0	2.5	1.4	0
Dry cough	**42.9**	42.4	52.1	43.4	48.6	46.0	37.5	39.1	46.5	37.5	49.3	40.5	32.5	51.4	56.0
During or after exercise	**8.0**	7.6	8.2	13.2	8.0	14.0	12.5	4.3	9.9	9.7	8.7	4.5	5.0	18.6	12.0
During a cold	**26.1**	31.8	30.1	21.1	32.6	20.0	16.7	24.6	22.5	27.8	30.4	27.9	27.5	22.9	36.0
Without a cold	**19.5**	13.6	26.0	28.9	21.0	30.0	20.8	14.5	25.4	20.8	18.8	15.3	12.5	28.6	24.0
Nocturnal	**30.7**	27.3	31.5	30.3	30.4	34.0	16.7	27.5	36.6	29.2	29.0	27.9	20	32.9	48.0
When exposed to cold air	**3.8**	3.0	2.7	7.9	5.1	6.0	0	5.8	4.2	4.2	1.4	1.8	2,5	7.1	8.0
Increased infections	**62.4**	57.6	65.8	65.8	62.3	68.0	54.2	65.2	53.5	61.1	71.0	63.1	67,5	68.6	60.0
More than 5 during the last 12 months	**31.7**	34.8	34.2	28.9	33.3	32.0	20.8	30.4	29.6	30.6	37.7	28.8	35.0	41.4	36.0
Additional symptoms															
Restlessness	**18.1**	15.2	24.7	17.1	19.6	18.0	16.7	14.5	16.9	16.7	26.1	18.0	25.0	18.6	16.0
Lack of concentration	**8.0**	7.6	8.2	9.2	9.4	6.0	4.2	8.7	8.5	2.8	13.0	4.5	5.0	14.3	12.0
Nausea	**8.4**	7.6	11.0	11.8	11.6	8.0	8.3	8.7	12.7	8.3	4.3	1.8	2.5	18.6	12.0
Vomiting	**14.3**	18.2	17.8	11.8	18.8	12.0	8.3	11.6	16.9	13.9	15.9	9.0	7.5	24.3	8.0
Diarrhoea	**14.6**	25.8	15.1	7.9	20.3	6.0	12.5	13.0	14.1	12.5	20.3	12.6	10.0	20.0	16.0

as well as to environmental tobacco smoke and to internal exposure, i.e. urinary levels of 1-hydroxypyrene, are listed in Table 1.

For assessing potential associations between symptoms and BaP in parquet glue or household dust or urinary 1-hydroxypyrene, Spearman rank correlations between symptoms and the levels of BaP in parquet glue and household dust and PAH metabolites excreted by the participants were calculated, as well as partial correlation tests adjusting for the other variables respectively. As a result, most correlations between symptoms and external BaP exposure via parquet glue and household dust and internal PAH-exposure were low and insignificant—both unadjusted and adjusted for levels of BaP in parquet glue and in household dust, and in the urinary levels of PAH metabolites. On the other hand, significant associations were found between passive smoking and dermal/bronchial symptoms, and with nausea and lack of concentration (Table 3).

With regard to odds-ratios (symptoms vs. minimum and maximum exposure status, i.e. <10 mg BaP/kg parquet glue vs. $>3{,}000$ mg BaP/kg parquet glue; $<$LOD BaP/kg household dust vs. >1 mg BaP/kg household dust; 1st vs. 4th quartile 1-hydroxypyrene in urine; never vs. regular passive smoking in the flat), similar results were obtained: exposure to environmental tobacco smoke showed odds-ratios >2 to nearly all symptoms, significant for running eyes, nosebleed, wheezing, and nausea. Odds ratios between symptoms and external exposure to BaP in parquet glue and in household dust were insignificant with the exception of odds-ratio between dry cough without a cold and BaP in parquet glue (Table 2).

Discussion

When "new pollutants" are detected, risk assessment and effective risk management is mandatory in order to minimise risks for the populations exposed. In Germany, hygiene and population based preventive environmental medicines are central tasks of the public health authorities. Therefore, in the example presented, the local public health authorities inaugurated risk assessment of the new problem parquet glue containing PAHs and offered consultation hours for environmental medicine.

Generally, infants and small children are considered to be at risk from exposure to pollutants in household dust due to the ingestion and/or dermal absorption of contaminated household dust while crawling and playing on the floor (Calabrese et al. 1989; Finley et al. 1994). Therefore, when the new source of potential indoor contamination had been discovered, interest was focussed on infants. Though PAHs are not known to exhibit acute symptoms, parents claimed that the health status of their children had become worse after moving into the homes with parquet glues containing PAHs. Thus, the effect of indoor contamination (PAH contamination in parquet glue and in household dust and environmental tobacco smoke) on symptoms was assessed in the children under 6 years of age, with focus on symptoms which had been reported most often, i.e. dermal and respiratory symptoms.

Before discussing the results, some limitations of our study have to be mentioned. These are not the results of an epidemiological study with a representative collective including matched controls. The investigation of an appropriate control group was not possible for financial reasons. An internal "not exposed or control group" was formed from children living in flats where parquet glue without increased BaP levels had been used. On the other hand, all the investigations were double blind: neither the parents nor the physician was aware of the exposure status of the children to PAH in parquet glue or household dust when the questionnaire was filled in. Thus, "self selection bias" with regard to the levels of individual PAH exposure by parquet glue or household dust can be ruled out. Moreover, levels of BaP contamination in parquet glue and in household dust of the participants' flats did not differ from the levels of BaP found in the flats where inhabitants did not participate in the study.

It seems probable, that especially parents who were very concerned and who had observed increased symptoms in their children in the last 12 months may have brought their children to the consultation hours. However compared with some other studies enrolled by children of that age in the region, the 1 year prevalence of bronchial and dermal symptoms of the children living in the former US housing areas were not different (Stadtgesundheitsamt 2002).

As a result, glue containing PAHs had obviously been used in about 60% the flats only. In about 90% of the household dust samples, the BaP level was below 1 mg/kg, and in about 1% of cases 10 mg BaP/kg household dust were exceeded. No correlations could be found between the levels of BaP in the parquet glue and the household dust samples, confirming data from other parts in Germany (Heudorf and Angerer 2001a; Dieckow et al. 1999; Public Health Department 1999). Regarding internal exposure, no correlation between PAH levels in parquet glue or in household dust and urinary levels of 1-hydroxypyrene of the occupants could be found as well, neither in all of the 1,213 inhabitants tested—children and adults—nor in the group of children under 6 years of age (Heudorf and Angerer 2000, 2001a); thus, the results were consistant with another study conducted in Bavaria (Lederer et al. 1998). In adults, however, we found significant and dose related associations of smoking to internal PAH exposure (Heudorf and Angerer 2001b) and in a subgroup of children an impact of passive smoking on urinary 1-hydroxypyrene level was seen as well (Heudorf et al. 2001).

Another important limitation may be that we did not include objective measurements of passive smoking, such as urine cotinine concentrations in all children. In a

Table 2 Associations of various symptoms in children under 6 years of age with their exposure to BaP in parquetgue and in household dust, to urinary 1-hydroxypyrene, and to passive smoking—odds ratios

In the last 12 months, has your child had...	BaP in parquet glue (< 10/ > 3,000 mg BaP/kg)		BaP in household dust (< LOD/ > 1 mg BaP/kg)		1-Hydroxypyrene in urine (1st/4th quartile)		Passive smoking in the flat (never/regular)	
	OR	95 CI	OR	95 CI	OR	95 CI	OR	95 CI
Number of children	142		162		138		136	
Symptoms of skin and mucosae								
Itchy rash in in the folds of the elbows, behind the knees, in front of the ankles	0.948	0.375–2.397	0.950	0.298–3.031	0.885	0.336–2.334	2.833	0.859–9.348
Itchy, reddish urticaria	2.906	0.889–9.498	2.331	0.753–7.212	2.169	0.701–6.718	2.159	0.607–7.671
Itching on lips, palate, and throat	1.093	0.281–4.245	2.309	0.670–7.961	1.000	0.240–4.170	1.500	0.149–15.051
Running eyes	1.426	0.519–3.920	2.088	0.736–5.925	**2.917**	1.058–8.041	**3.189**	1.036–9.820
Sneezing, running nose without a flue	1.397	0.616–3.168	2.255	0.897–5.672	1.502	0.616–3.660	2.021	0.695–5.875
Itchy, blocked nose	1.825	0.752–4.427	1.800	0.703–4.609	1.097	0.473–2.544	2.431	0.912–6.480
Nosebleed	0.848	0.329–2.185	1.388	0.469–4.108	1.000	0.353–2.836	**5.526**	1.611–18.956
Wheezing	0.944	0.454–1.965	0.981	0.361–2.667	**3.567**	1.558–8.169	**3.228**	1.261–8.266
During or after exercise	0.861	0.207–3.587	0.814	0.096–6.927	3.190	0.621–16.39	9.565	0.832–109.979
During a cold	0.844	0.351–2.031	1.082	0.371–3.158	**2.896**	1.115–7.519	**3.340**	1.262–8.840
Without a cold	2.471	0.628–9.727	0.707	0.084–5.919	2.131	0.611–7.439	**7.432**	1.172–47.119
Nocturnal	1.016	0.433–2.385	1.189	0.405–3.489	**2.674**	1.023–6.990	**3.535**	1.210–10.331
When exposed to cold air	**0.532**	0.456–0.621	5.957	0.360–98.619	**0.496**	0.419–0.588	0	–
Dry cough	1.042	0.535–2.028	0.636	0.261–1.550	1.511	0.769–2.970	1.867	0.777–4.482
During or after exercise	1.848	0.598–5.714	1.649	0.424–6.410	2.095	0.502–8.740	2.891	0.643–12.998
During a cold	0.571	0.268–1.218	0.413	0.133–1.281	1.338	0.632–2.834	1.452	0.581–3.628
Without a cold	**2.580**	1.092–6.099	0.989	0.340–2.875	1.370	0.556–3.375	1.746	0.609–5.006
Nocturnal	1.157	0.558–2.401	0.457	0.147–1.420	1.074	0.512–2.254	2.382	0.981–5.786
When exposed to cold air	2.743	0.34–14.081	**0.845**	0.790–0.904	0.239	0.026–2.195	4.739	0.634–35.402
Increased infections	1.417	0.718–2.798	0.715	0.298–1.712	1.307	0.637–2.680	0.879	0.361–2.135
More than 5 during the last 12 months	0.762	0.375–1.547	0.526	0.185–1.499	1.382	0.681–2.803	1.389	0.557–3.464
Additional symptoms								
Restlessness	1.156	0.470–2.841	0.822	0.260–2.604	2.082	0.882–4.916	0.867	0.268–2.803
Lack of concentration	1.238	0.373–4.102	0.418	0.052–3.353	1.575	0.529–4.693	2.891	0.643–12.998
Nausea	1.639	0.521–5.160	0.693	0.149–3.228	0.477	0.114–1.991	**7.432**	1.172–47.119
Vomiting	0.604	0.237–1.541	0.392	0.087–1.771	1.446	0.543–3.850	0.878	0.180–4.282
Diarrhoea	**0.247**	0.091–0.671	0.561	0.156–2.016	1.697	0.680–4.232	1.320	0.395–4.413

Bold significant

Table 3 Correlations of various symptoms in children under 6 years of age to their exposure to BaP in parquetgue and in household dust, to urinary 1-hydroxypyrene, and to passive smoking

In the last 12 months, has your child had	Parquet glue (mg BaP/kg)		Household dust (mg BaP/kg)		1-Hydroxypyrene in urine (ng/g creatinine)		Passive smoking in the flat	
	Correl	Correl, adjusted	Correl	Correl, adjusted	Correl	Correl, adjusted	Correl	Correl, adjusted
Number of children	215	174	212	174	281	174	246	174
Symptoms of skin and mucosae								
Itchy rash in in the folds of the elbows, behind the knees, in front of the ankles	−0.044	−0.050	−0.060	−0.080	−0.016	0.048	**0.156***	**0.174***
Itchy, reddish urticaria	**0.139***	0.157	0.081	−0.02	0.089	0.095	0.097	0.079
Itching on lips, palate, and throat	0.017	0.060	−0.001	−0.024	0.023	0.012	0.115	0.108
Running eyes	0.023	0.004	0.065	0.012	0.073	0.074	**0.141***	0.136
Sneezing, running nose without a flue	0.027	−0.004	0.075	0.087	0.059	0.034	**0.157***	0.134
Itchy, blocked nose	0.061	0.048	0.043	0.060	0.017	0.011	0.104	0.090
Nosebleed	−0.035	−0.026	0.011	0.019	−0.008	−0.012	**0.198****	**0.192***
Wheezing	−0.041	0.011	0.034	−0.096	**0.166****	**0.160***	**0.236****	**0.246****
During or after exercise	0.015	0.085	0.007	−0.072	0.095	0.083	0.223**	0.221**
During a cold	−0.040	0.012	−0.031	−0.063	**0.170****	**0.156***	**0.151***	**0.162***
Without a cold	0.083	0.109	0.068	−0.088	0.037	0.032	**0.225****	**0.228****
Nocturnal	−0.032	−0.007	0.033	−0.091	0.114	0.093	**0.197****	**0.209****
When exposed to cold air	0.067	0.117	0.051	0.011	−0.055	0.068	0.048	0.031
Dry cough	−0.001	0.033	−0.062	−0.133	0.052	0.040	0.108	0.134
During or after exercise	0.090	**0.172***	0.083	−0.051	0.077	0.057	**0.174****	**0.165***
During a cold	−0.072	0.024	**−0.151***	−0.118	0.057	0.055	0.000	0.022
Without a cold	**0.143***	**0.149***	0.054	−0.080	0.025	0.027	**0.126***	0.128
Nocturnal	0.001	0.049	−0.045	−0.146	0.002	−0.014	0.099	0.133
When exposed to cold air	0.108	**0.188***	−0.037	−0.120	−0.067	−0.071	**0.126***	0.140
Increased infections	0.078	0.129	0.005	−0.075	0.065	0.065	0.022	0.182
More than 5 during the last 12 months	−0.035	0.021	−0.063	−0.084	0.059	0.048	0.100	0.105
Additional symptoms								
Restlessness	0.019	0.043	−0.017	−0.007	0.093	0.101	−0.001	−0.013
Lack of concentration	0.023	0.056	−0.070	−0.105	0.029	0.022	**0.143***	**0.155***
Nausea	0.057	0.121	−0.041	−0.107	−0.070	−0.077	**0.234****	**0.245****
Vomiting	−0.075	−0.014	−0.088	−0.088	0.031	0.021	0.116	0.125
Diarrhoea	**−0.189****	−0.106	**−0.142***	−0.032	0.062	0.048	0.071	0.082

Bold significant; $*P < 0.05$; $**P < 0.01$; *Adjusted* adjusted for each of the other factors

subgroup of about 100 children, however, we had found a tendency for higher levels of urinary cotinine with anamnestic exposure to environmental tobacco smoke (mean levels: never 1.9 µg/l, only on balcony 2.3 µg/l, seldom 4.9 µg/l, regularly 10.1 µg/l) (Heudorf et al. 2001), thus giving no hint for the incorrect answers of the parents.

We had used the ISAAC questionnaire, with some modifications. Nevertheless, a direct comparison of our results to the data obtained and published by the ISAAC study (ISAAC study group 1998a, b) is not possible, because in the ISAAC protocol children aged 6–7 and 13–14 years were enrolled, whereas in our analysis mean age of the children was 3.6 years with a range from 0.2 years to 5.9 years.

In our study, many parents stated, that they had observed many symptoms after moving into the new flats, especially symptoms of skin and bronchiae, though prevalence of these symptoms did not exceed prevalences found in some former smaller studies enrolled in this region (no former US housing areas) (Stadtgesundheitsamt 2002). Moreover, no significant associations were found between these symptoms and the external exposure to PAHs in parquet glue and household dust, with the exception of one significant Odds-ratio of 2.5 (95CI 1.09–6.09) between PAH in the parquet glue and dry cough without having a flue and some significant correlations between bronchial symptoms and levels of BaP in parquet glue and household dust. However, these results were not consistent; some symptoms were even negatively correlated with levels of external exposure and might be an effect of multiple exploratory testings. With regard to internal exposure, i.e. levels of urinary 1-hydroxypyrene, no significant negative associations with symptoms were found. In former studies no associations between external and internal levels of PAH exposure had been found (Heudorf and Angerer 2000, 2001a), but positive associations had been seen between internal PAH exposure (1-hydroxypyrene) and the exposure to environmental tobacco smoke stated by the parents and confirmed by elevated levels of urinary cotinine cotinine (Heudorf et al. 2001). Thus, though the main source of PAH exposure is the diet, 1-hydroxypyrene might be taken as

an indicator for exposure to environmental tobacco smoke as well. In conclusion, positive associations between internal exposure and symptoms might be the effects of passive smoking. This hypothesis is supported by the fact that only in symptoms showing positive associations with passive smoking, positive associations with internal PAH-exposure were to be seen, most of them with lower statistical significance.

In effect, many dose related associations with the levels of exposure to environmental tobacco smoke were found, significant for running eyes, nose bleed, and wheezing during and without having a flue as well as nocturnal wheezing. These results were plausible with regard to the data on toxicological effects of environmental tobacco smoke. Similar associations were observed between these symptoms and internal PAH exposure. Additionally, a significant odds-ratio of 7.4 (CI 1.17–47.1) was found between passive smoking and nausea. (With regard to other parameters such as pesticides analysed in household dust and in body fluids, some significant associations were found as well; the publication of these data is being prepared).

Environmental tobacco smoke contains many potent respiratory irritants. Up to now, there is an abundance of studies showing passive smoking as related to respiratory symptoms in children as well as in adults. In the cross-sectional European Community Respiratory Health Survey passive smoking was significantly associated with all types of respiratory symptoms and current asthma in adults (Janson et al. 2001). In a systematic quantitative review of evidence relating parental smoking to symptoms and diseases of their children (Cook and Strachan 1999) significant and broadly consistent associations were found with lower respiratory illness in infancy and childhood (Strachan and Cook 1997), with prevalence of respiratory symptoms and asthma (Strachan and Cook 1998c), with bronchial reactivity and peak flow variability (Cook and Strachan 1998; Cook et al. 1998) and with allergic sensitation in children (Cook and Strachan 1997; Strachan and Cook 1998b); additionally, significant associations were seen for middle ear disease in infancy (Strachan and Cook 1998a) and for sudden infant death syndrome (Anderson and Cook 1997).

Informed about PAHs in parquet glue and household dust many parents demanded for total redevelopment of their flats. Based on exposure assessment of inhabitants of those flats regarding internal and external exposure, the Commission for Indoor Air Quality of the Federal Environmental Agency, Germany, and the Working Group of the Public Health Authorities of the Countries in Germany stated that an increased risk creating the obligatory redevelopment of these flats could not be found. For reasons of hygiene and prevention, however, it was recommended to minimise BaP contamination in household dust above 10 mg/kg (Bauministerkonferenz 2000; Heudorf and Schubert 2000). In accordance with those exposure and risk analyses, statistical evaluation of the symptoms of the children living in these homes did not exhibit consistent associations with the levels of BaP in parquet glue or in household dust.

Instead, significant associations between symptoms and exposure to environmental tobacco smoke were observed, especially, to dermal and bronchial symptoms. These data exhibit biological plausibility and are consistent with many other studies on the effect of environmental tobacco smoke in infancy and childhood.

Hence, risk management for minimizing risks of children due to exposure to environmental toxins such as PAHs should focus on reducing exposure to environmental tobacco smoke. If parents could be convinced to stop smoking substantial benefits to children would arise. Therefore, public health authorities should intensify their distribution of information on the harmful effects of passive smoking during childhood.

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