



German Environmental Survey for Children (GerES IV) – First results

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Abstract

German Environmental Surveys (GerESs) are large scale population studies which have been carried out on adults in 1985/86, 1990/92 and 1998 and on children aged 6–14 years in 1990/92. GerES IV is the first survey focussing exclusively on children [Becker, K., Schulz, C., Babisch, W., Dürkop, J., Roskamp, E., Seiwert, M., Szewzyk, R., Ullrich, D., Seifert, B., 2005. German Environmental Survey for Children (GerES IV) 2003–2006. *Pollut. Atmos.* 188, 475–479]. GerES IV included a representative sample of 1790 children aged 3–14 of the participants of the National Health Interview and Examination Survey on Children and Adolescents.

The primary goal of GerES IV is not only to analyse and document the extent, distribution and determinants of German children's exposure to environmental pollutants but to discover links between environmental exposure and health. Results will help develop preventive measures and advance further research. They might provide the basis for environmental and public health policy decisions. Precondition to achieve this task is a description of the data on exposures and the data on health outcomes. This work is currently performed at the Federal Environment Agency.

First results show a remarkable decrease of the blood lead level of German children aged 6–14 years from 32.3 µg/l in 1990/92 (GerES II) to 16.3 µg/l in GerES IV which is the lowest mean lead concentration determined in German studies so far. None of the children had a value exceeding 100 µg/l.

In GerES IV, the following health-related issues will be primarily examined: the relationship between sensitisation against mould spores and the occurrence of mould in households, irritation of eyes and respiratory system caused by formaldehyde, other aldehydes, or total volatile organic compounds (TVOC); the impact of non-occupational noise on hearing loss, stress and sleep disturbances, and the connection between contact allergies, nickel and scents. 9.5% of the children showed a sensitisation to at least one of the moulds examined (*Penicillium (notatum) chrysogenum*, *Aspergillus versicolor*, *Wallemia sebi*, *Eurotium* spp., *Alternaria alternata*). The most frequent sensitisation was against *Penicillium chrysogenum*.

GerES IV might broaden the knowledge in terms of environmental causes of health outcomes. Children of smoking mothers showed higher mean cotinine concentrations than children living with a smoking father, regardless whether they smoked daily or occasionally. Results from the GerES IV pilot study showed a relation between environmental tobacco smoke (ETS) exposure and an increased susceptibility to infections and inflammations of the middle ear.

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Introduction

German Environmental Surveys (GerES) are large scale population studies which were carried out on adults in 1985/86, 1990/92 and 1998 and on children aged 6–14 years in 1990/92 by the German Federal Environment Agency (Seifert et al., 2000a,b; Becker et al., 2002, 2003). GerES IV for the first time was focussing exclusively on children aged 3 to 14 years (Becker et al., 2005).

All GerESs have been conducted in cooperation with the National Health Interview and Examination Surveys of the Robert Koch Institute (RKI, 2006; Kurth et al., 2002; Kamtsiuris et al., 2002). The surveys provide the representative basis for a nationwide environment and health surveillance system. For the first time data regarding the health situation (National Health Interview and Examination Survey on Children and Adolescents) and the burden of environmental pollutants (GerES IV) in children will be available. Such data are essential for the national observation of health and environmental health, and enable an improved health and environmental reporting.

The data will provide the basis for environmental and public health policy decisions and for the identification of health risks in children and adolescents. They will help to develop preventive measures and advance further research. Temporal, spatial and regional differences of prevalences of diseases, health-related behaviour and exposure to environmental pollutants can be identified in the future.

Population sample

The target population for the National Health Interview and Examination Survey on Children and Adolescents comprised a representative sample of children aged 0 to 17 years, randomly selected in a multistage random sampling procedure from the population registry offices. At 167 sampling points approximately 18,000 children and adolescents together with their parents were interviewed and examined from May 2003 to May 2006.

GerES IV included a representative sample of 1790 children aged 3 to 14 years at 150 sampling points from the participants of the National Health Interview and Examination Survey on Children and Adolescents. A randomly selected sub-sample of 600 children took part in an extended monitoring of the domestic environment.

Field work

After written consent given by the parents and the children/adolescents, field work was conducted using a

combination of several tools including questionnaires, interviews, human biomonitoring and indoor environmental sampling. After having taken part in a self-reported questionnaire, a medical interview and a physical examination, blood and urine samples were collected from the participants.

The participating children of GerES IV provided information on individual domestic factors such as nutrition, noise, spare time habits, exposure to different chemicals, and environment-related behaviour by means of standardised interviews. Children aged 8 years and older were interviewed personally. Questions concerning the younger ones were answered by their parents. Noise measurements, hearing tests, sampling of house dust, indoor air and tap water completed the programme.

Minor incentives were offered to the children and their families. The quality of the field work was being monitored by external and internal consultants.

Analytes and media

In GerES IV human biomonitoring was performed using morning urine and blood.

The blood of the children was analysed for heavy metals (lead, cadmium, mercury) and organochlorine compounds (PCBs, DDE, HCB, HCH, from the age of 7 years), and immune status.

Urine samples were analysed for heavy metals, arsenic, creatinine, nicotine and cotinine, stress hormones, chlorophenols including PCP and metabolites of PAHs, pyrethroids and insecticidal organophosphates.

Monitoring of the domestic environment included measuring the concentrations of different organochlorinated compounds and biocides (methoxychlorine, chlorpyrifos, propoxur, polychlorinated sulfonamide-diphenyl ether, DDT, HCH, HCB, PCBs and PCP) from dust of vacuum cleaner bags. Tap water samples were tested for lead, cadmium, copper, nickel, and uranium. Additionally chemical and biological pollutants in indoor air of the sub-collective were determined.

Chemical analyses

We present here results for lead, mould specific IgE and cotinine. Lead in the blood of the children was analysed by laboratories of the Federal Environment Agency applying atomic absorption spectroscopy with Zeeman compensation (Seifert et al., 2000b). Commercial and self-prepared standards were used for internal quality control. The laboratory successfully participated in round robin tests.

IgE in serum and cotinine in urine were analysed by contractor laboratories. These contractors had to

comply with the requirements to meet given demands concerning quality control. These included an established quality control system and successful participation in commercial round robin tests.

Nicotine and cotinine in urine were analysed by HPLC (Merkel, 1992) at the Institute of Microbiology and Hygiene, Rostock University. Allergic sensitisation was determined by analysing serum samples using a newly developed IgE detecting test panel for atopy ("AllergyScreen", Mediawiss Analytic) which had shown acceptable concordance to the skin-prick test and the in vitro IgE CAP system (Herzum et al., 2005). The allergen standard solutions for mould specific IgE detection which were not contained in commercially available allergy tests have been developed and prepared by the analysis performing company (Matritech, Freiburg, Germany).

Data analyses

Initial steps before analyses of data included quality control and assurance measures of data, matching different data files and applying weighting factors (according to the population characteristics age, gender, community size, and region). For the description of distributions common statistical parameters such as sample size, percentage of values below the limit of quantification, 10th, 50th, 90th, 95th, 98th percentile, maximum value, arithmetic mean, geometric mean (GM) and the 95% confidence interval of the GM were provided.

The distributions of substances in the different media were depicted for groups stratified by sampling characteristics like gender, age, social status, immigrant (yes/no), community size and region (former West-/East-Germany). Statistical tests (*t*-test or ANOVA) were carried out to detect differences of the GM between these groups. All statistical calculations were performed using SPSS 14.0 for MS Windows.

Results and discussion

The primary goal of GerES IV is not only to analyse and document the extent, distribution and determinants of German children's exposure to environmental pollutants but to discover links between environmental exposure and health. Precondition to achieve this task is a description of data on exposures and data on health outcomes. This work is currently performed at the Federal Environment Agency.

As a first step data on exposure are described by using a standard set of potentially influencing factors. These are gender, age, social status of the family, immigrant

status, region and community size. An example is shown in Table 1. The mean lead level in blood of German children aged 3–14 years is 16.3 µg/l. Boys show higher concentrations than girls, and the concentrations decrease with increasing age. Children with a lower social background have a higher mean concentration, while children of immigrant families show a slightly but significantly lower mean concentration ($p < 0.05$). Regional influences (differences between former East- and West-Germany or communities of different sizes) are not observed.

Blood lead levels are in general higher in boys than in girls and decrease with increase of age. This is well known and has been observed in former GerES and other major population studies (Becker et al., 2002; CDC, 2005).

GerES IV is the first GerES where emphasis was placed on the inclusion of immigrants. According to the definition used in GerES IV the percentage of children classified as immigrants amounts to 13%, originating mainly from Eastern Europe and the former Soviet Union. Immigrants more frequently have a lower social status than non-immigrants (Cramér's $V = 0.26$, $p \leq 0.001$). Considering this background it was assumed that children classified as immigrants might show elevated blood lead levels. This is apparently not the case and deserves further investigation.

A mean lead concentration of 16.3 µg/l is the lowest lead level determined in German studies so far. Fig. 1 illustrates this time trend by using also data of previous GerESs conducted on adults. The mean value determined for 6–14-year-old children in 1990/92 was 32.3 µg/l. The time trend observed for adults underlines the trend observed for children.

Studies from many other western countries also revealed a drastic decline of blood lead levels in the general population since the end of the 1970s (CDC, 2005; Pirkle et al., 1998; Schuhmacher et al., 1996; Strömberg et al., 1995; Wietlisbach et al., 1995; NIPH, 2001). The main, generally accepted reason is the reduction of airborne lead pollution due to the phasing out of leaded fuel and due to legal measures to reduce lead emissions from industrial sources. In consequence, the lead intake of the general population via inhalation and via food decreased also. The sales figures of leaded fuel in Germany declined to zero in 1997.

Although under discussion, the German Human Biomonitoring Commission still recommends to use the benchmark of 100 µg/l to assess the exposure of children aged up to 12 years (Schulz et al., 2007a). In 1990/92 1.1% of the children examined still had blood lead levels exceeding this value (Schulz et al., 2007b), while the maximum value in GerES IV is exactly 100.1 µg/l.

As aforementioned, the appraisal of GerES places emphasis not only on the description of exposure and

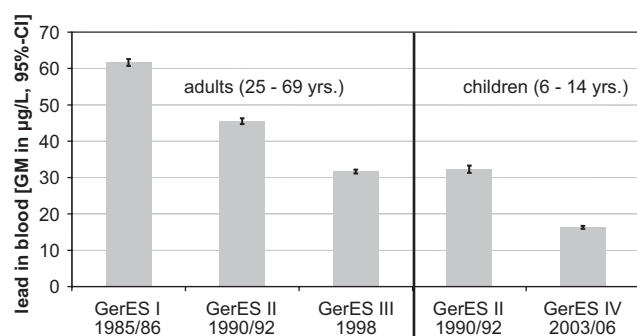
Table 1. Lead in blood (µg/l) of German children aged 3–14 years

	<i>n</i>	P10	P50	P90	P95	P98	MAX	AM	GM	CI GM
Total	1560	9.1	16.9	29.7	33.8	42.4	100	18.2	16.3	15.9–16.7
Gender***										
Boys	813	9.9	18.2	30.9	37.0	44.1	100	19.4	17.5	16.9–18.1
Girls	747	8.3	15.4	26.2	31.9	39.4	90.1	16.9	15.1	14.6–15.6
Age (years)***										
3–5	315	10.1	19.6	34.2	39.9	46.0	90.1	21.4	19.1	18.1–20.2
6–8	377	10.1	17.9	30.5	33.4	43.5	61.0	19.0	17.3	16.5–18.1
9–11	407	8.7	15.6	27.0	31.4	41.3	68.8	17.4	15.6	14.9–16.4
12–14	460	7.6	14.6	25.1	30.5	39.1	100	16.1	14.5	13.9–15.2
Social status**										
Low	357	10.1	17.1	30.4	37.1	48.4	61.0	19.3	17.4	16.6–18.2
Medium	721	9.1	16.9	30.4	33.2	41.3	100	18.3	16.3	15.7–16.9
High	469	8.5	16.5	26.5	31.1	43.3	71.8	17.4	15.5	14.8–16.3
Immigrants*										
Yes	187	8.3	15.6	25.7	32.7	39.1	46.1	16.6	15.1	14.1–16.2
No	1370	9.2	17.1	29.9	34.4	43.0	100	18.4	16.5	16.1–16.9
Region										
East	206	9.3	17.6	32.1	39.0	49.6	100	19.5	17.2	16.1–18.4
West	1354	9.0	16.8	29.2	32.8	41.3	61.0	18.0	16.2	15.8–16.6
Community size (inhabitants)										
< 100.000	738	9.6	16.8	30.0	34.7	44.5	100	18.4	16.5	15.9–17.1
≥ 100.000	822	8.7	17.0	28.6	33.7	40.6	90.1	18.1	16.2	15.7–16.8

Notes: *n* = sample size; P10, P50, P90, P95, P98 = percentiles; MAX = maximum value; AM = arithmetic mean; GM = geometric mean; CI GM = 95% confidence interval of GM.

Limit of quantification (LOQ) = 2.1 µg/l (less than 5% of the samples showed concentrations below the limit of quantification).

Test of significant differences of the GMs (*t*-test or ANOVA): **p* ≤ 0.05; ***p* ≤ 0.01, ****p* ≤ 0.001.

**Fig. 1.** Time trend of lead exposure in Germany.

influencing factors but also on the determination of links between environment and health. The following health-related issues will be primarily examined:

- the relationship between sensitisation against mould spores and the occurrence of mould in the household;
- the irritation of eyes and the respiratory system caused by formaldehyde, other aldehydes and total volatile organic compounds (TVOC);
- the impact of non-occupational noise on hearing loss, stress and sleep disturbances;

- the correlation between contact allergies, nickel and scents.

A cross-sectional study like GerES is not the ideal tool to investigate such correlations between environment and health. However, if the health-related symptom has a sufficient prevalence in the population examined and confounders can be controlled to a reasonable extent, such analysis might be worth to perform. In that regard, the first step in the evaluation of the GerES data is to describe the frequency of certain health-related symptoms in the study population such as the sensitisation against fungal allergens, the frequency of irritation of eyes or the respiratory system, as well as the rate of hearing loss, sleep disturbances and contact allergies.

As an example, Fig. 2 shows the frequency of IgE sensitisation status against fungal allergens among German children. In total 9.5% of the children show at least a sensitisation against one of the moulds investigated (*Penicillium (notatum) chrysogenum*, *Aspergillus versicolor*, *Wallemia sebi*, *Eurotium* spp., *Alternaria alternata*). The most frequent sensitisation (≥ 0.35 IU/ml) was against *Penicillium chrysogenum*.

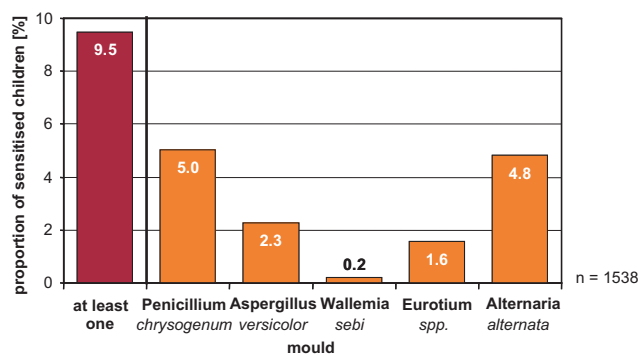


Fig. 2. Allergic sensitisation against mould spores.

The second most frequent sensitisation was against *Alternaria alternata* (4.8%). Sensitisation against *Wallemia sebi* had not been reported before. In our study, a low incidence of 0.2% was observed.

Respiratory allergies show a steadily increasing prevalence and incidence in industrialised societies. In Germany the rate of children suffering from respiratory allergies is about 14% (ISAAC, 1998). Indoor mould levels might play a role in increasing the risk of allergic sensitisation (Peat et al., 1998; Jacob et al., 2002). Although a sensitisation does not necessarily lead to the development of clinical symptoms of an allergy, the results show the importance of including indoor moulds in allergy test systems.

In addition to the evaluations of links already mentioned, GerES might broaden the knowledge in terms of environmental causes of health outcomes. One of the most relevant topics is the exposure to environmental tobacco smoke (ETS) and the related health effects. Again, the description of data is a prerequisite for such evaluation.

Fig. 3 shows the relation between the urinary concentration of cotinine and the parental smoking habit. Children of a smoking mother show higher mean cotinine concentrations than children living with a smoking father, regardless of whether one or both parents smoke only occasionally, or daily. The often more intensive contact between mother and child as compared to the interaction among father and child is an obvious explanation for this finding. Results from the GerES IV pilot study have shown a relation between ETS exposure and an increased susceptibility to infections and inflammations of the middle ear. Therefore, in the ongoing evaluation of data of the main study the cotinine levels will, inter alia, be correlated with the child's liability to infections or with allergic sensitisation.

Conclusions

The exposure situation of children in Germany is described in a status report in German firstly. This

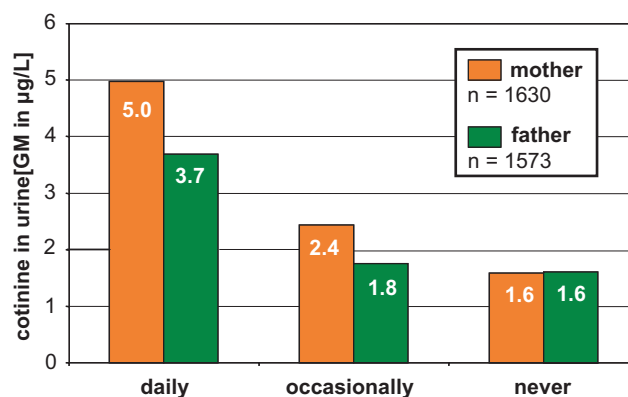


Fig. 3. Cotinine in urine of German non-smoking children and smoking habits of their parents.

report includes an overview of human biomonitoring data, stratified by exposure relevant characteristics and thus provides nationwide data suited for the evaluation of other exposure studies (Becker et al., 2007). A comparison with threshold values and data from international studies and an evaluation of exposure trends over time will be performed and published. It is planned to allow open access to the survey data by means of a public use file in autumn 2008.

GerES IV will provide for the first time representative data on exposure of children aged 3–14 years to environmental factors in Germany. Thus, higher exposed subgroups as well as factors contributing to an extended exposure can be identified. GerES IV will also help to elucidate the influence of selected chemical, biological and physical factors on health and well being of children. The reliable data from this study might provide the basis for the identification of health risks in children and for environmental and public health policy decisions. They will help develop preventive measures and advance further research.

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