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Mini-Review

Overview of the study design, participation and field work of the German Environmental Survey on Children 2003–2006 (GerES IV)

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ABSTRACT

The German Federal Environment Agency carried out its fourth German Environmental Survey (GerES IV), which is the first survey on children only and the environment-related module of the German Health Interview and Examination Survey for Children and Adolescents (German acronym: KiGGS), conducted by the Robert Koch Institute (RKI). The German Environmental Surveys are nationwide population studies conducted to determine the exposure to environmental pollutants, to explore exposure pathways and to identify sub-groups with higher exposure. GerES IV was conducted on randomly selected 1790 children aged 3–14 years from the cross-sectional sample of KiGGS. The participants of GerES IV lived in 150 sampling locations all over Germany. Field work was carried out from May 2003 to May 2006. The response rate in GerES IV was 77.3%. Due to the fact that participation in GerES IV was limited to children that had previously participated in the KiGGS study, the total response rate in GerES IV resulted in 52.6%. Response rates did neither differ significantly between West and East Germany, nor between different community sizes, age groups and gender. The basic study programme included blood samples, morning urine, tap water and house dust as well as comprehensive questionnaire-based interviews. In addition, subgroups were studied with regard to "noise, hearing capacity and stress hormones", "chemical contamination of indoor air" and "biogenic indoor contamination". A key element of the field work in GerES IV was a home visit to carry out interviews, conduct measurements and collect samples. An exception was blood sampling which was carried out within KiGGS. The quality of field work, data collection, evaluation, and chemical, biological and physical analyses was successfully evaluated by internal and external quality assurance. This comprehensive overview aims at giving other research groups the opportunity to compare different study designs or to adapt their own design to get comparable results.

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Abbreviations: As, arsenic; BBP, butylbenzylphthalate; BMBF, Federal Ministry of Education (German acronym: Bundesministerium für Bildung und Forschung); BMU, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and Research (German acronym: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit); Cd, cadmium; CAPI, Computer Assisted Personal Interview; COPHES, Consortium to Perform Human Biomonitoring on a European Scale; DBP, dibutylphthalate; DEHP, di(2-ethylhexyl)phthalate; DEMOCOPHES, Demonstration of a study to Coordinate and Perform Human Biomonitoring on a European Scale; EEA, European Environmental Agency; GerES, German Environmental Survey; GM, geometric mean; GSD, geometric standard deviation; GSF, GSF-National Research Centre for Environment and Health, *Neuherberg, Germany*: re-named to HelmholtzZentrum München – German Research Center for Environmental Health; HBM, human biomonitoring; Hg, mercury; IgE, immunglobulin E; KiGGS, German Health Interview and Examination Survey for Children and Adolescents (German acronym: Kinder- und Jugendgesundheitssurvey); *N*, sample size; NHANES, National Health and Nutrition Examination Survey; PAH, polycyclic aromatic hydrocarbons; Pb, lead; PCB, polychlorinated biphenyls; PDF, portable document format; QNA, quality-neutral non-respondents (German acronym: qualitätsneutrale Ausfälle: QNA); REACH, Registration, Evaluation and Authorisation of Chemicals; RKI, Robert Koch Institute, Germany; RV_{95}, reference value; SES, socio-economic status; SPSS, Statistical Package for the Social Sciences; UBA, German Federal Environment Agency; VOC, volatile organic compounds; WHO, World Health Organization.

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Introduction

Exposure assessment is one of the key elements of the risk assessment procedure which has been developed to evaluate environmental pollutants. An essential step in exposure assessment is the evaluation of the dose that enters the human body and the analysis of different environmental media that can affect humans. In this sense exposure assessment focuses on the initial portion of the environmental health paradigma: from sources, to environmental concentrations, to exposure, to dose. In studies on human exposure assessment, emphasis is placed on estimating the magnitude, duration, and frequency of exposure, as well as estimating the number of people exposed to various concentrations of the agent in question (WHO IPCS, 2000).

Until the mid 1980s knowledge of human exposure to environmental pollutants resulted from occupational studies and small-scale studies conducted on selected population groups in specific areas. The findings of these studies could not be extrapolated to the general population.

As a consequence, in Germany epidemiologic studies screening the general population for their exposure to chemicals – especially lead – were launched. Monitoring programmes focus on the determination of the internal exposure by human biomonitoring (HBM), the measurement of concentrations of chemicals or their metabolites in human body fluids on tissues, such as blood or urine.

In 1985, Germany started a series of repeated cross-sectional studies: the German Environmental Survey (GerES). GerES is a nationwide population representative study on human exposure to various environmental chemicals and its sources. GerES comprises three main instruments of investigation: HBM, monitoring of the domestic environment, and collecting information on exposure pathways and living conditions via questionnaires. The first three surveys, GerES I in 1985/1986, GerES II in 1990/1992 and GerES III in 1998 comprised only adults – with one exception: 6- to 14-year-old children living in the households of the adult participants were also included in GerES II (Becker et al., 2002, 2003; Hoffmann et al., 2000a,b, 2001; Schulz et al., 2007; Seifert et al., 2000a,b). In the 1980s and early 1990s, the only large-scale nation-wide population-based survey with a comprehensive biomonitoring programme comparable to GerES was the National Health and Nutrition Examination Survey (NHANES) in the U.S. conducted by the Centers of Disease Control and Prevention's (CDC's) National Center for Health Statistics. NHANES is a series of surveys designed to measure and monitor the health and nutritional status of the U.S. population (CDC, 2009).

Among the early studies on human environmental exposure, the "Cadmibel study" is regarded as groundbreaking. From 1985 to 1989 it examined the exposure of the Belgian population to cadmium and its health effects (Buchet et al., 1990; Lauwerys et al., 1993, 1994).

In Germany, besides GerES several other projects focusing on human biomonitoring have recently been or are being performed in specific regions on specific age groups. Such projects are the studies in hot spot and control areas of North Rhine-Westphalia (Wilhelm et al., 2007), the sentinal health department project on 10-year-olds in Baden-Württemberg (Link et al., 2007), and the Integrated Exposure Assessment Survey (INES) in Bavaria (Fromme et al., 2007).

Important current or recently finished population-based exposure-oriented studies in other countries are e.g. the surveys in Canada (Health Canada, 2010), the Environmental Health Monitoring System (EHMS) in the Czech Republic (Černá et al., 2011), the French National Nutrition and Health Program (ENNS): 2001–2006–2010 (Hercberg et al., 2008), the Flemish Environment and Health Study (FLEHS) (Den Hond et al., 2009), the Middle Eastern Regional Cooperation Project, 1996–2000 (Safi et al., 2006), the investigations in Vietnam (Agusa et al., 2009; Minh et al., 2008). All of these surveys comprise several age groups of participants (among them children) and are/were performed in different regions to explore the exposure of the investigated populations.

Children are, for a variety of reasons, particularly vulnerable to the impact of environmental pollutants (EEA/WHO, 2002; Au, 2002; Chaudhuri and Fruchtengarten, 2005). Hence, the protection of children is of particular importance for environmental and health politics. Improving the protection of children from environmentally caused health risks requires the systematic and continuous monitoring of the exposure of children to chemical, biological and physical environmental pollutants. Additionally, the factors influencing their exposure need to be investigated.

In 2002, the WHO and EEA issued the joint report "Children's Health and Environment – A Review of Evidence" (EEA/WHO, 2002) and emphasised a lack of information and research data.

Therefore the fourth German Environmental Survey examined only children (GerES IV). Like the preceding GerESs, GerES IV was carried out by the German Federal Environment Agency (UBA) in close cooperation with the "German Health Interview and Examination Survey for Children and Adolescents" (German acronym: KiGGS), conducted by the Robert Koch Institute (RKI) (Kurth et al., 2008). GerES IV consists of the core survey and three additional survey programmes. Fig. 1 outlines the relation of the KiGGS and the GerES IV sample as well as the different additional survey programmes conducted on different subsamples of GerES IV.

In this article a comprehensive overview of the study design, participation, and the field work of GerES IV is given for the first time. Detailed method descriptions as well as results on children's exposure can be found in the specific basic reports and articles covering human biomonitoring, house dust, drinking water, indoor air, and noise (UBA, 2008).

Objectives

The general objectives of the German Environmental Survey on Children (GerES IV) are the collection, provision, updating and evaluation of representative data for a health oriented environmental monitoring and environmental reporting on a national level. The representative data also serve to:

- provide a basis for establishing reference values for the exposure of children to environmental contaminants as a basis for a consistent evaluation throughout Germany,
- detect temporal trends and regional differences in exposure,
- identify and quantify exposure sources and pathways,
- determine connections between certain environmental factors and the health situation of children,
- establish concepts for prevention, intervention and reduction strategies in the context of measures of health and environmental policies,
- evaluate the success of policy and exposure reduction measures, and
- identify emerging chemicals in stored samples with recently developed or future analytical methods, such as phthalates and bisphenol A in urine (Becker et al., 2009).

The pilot study of GerES IV

The concept of GerES IV was tested in a pilot study with 550 participating children and adolescents aged 0–17 years over one year (from March 2001 to March 2002). The pilot study was carried out in close cooperation with the pilot study of the National Health Interview and Examination Survey for Children and Adolescents of the RKI (Kamtsiuris et al., 2000; Kamtsiuris and Lang, 2000). The

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