International Symposia on Integrated Exposure Assessment for Hazardous Materials

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Objectives On September 2, 2010 and November 25, 2011, the Korean Research Project on Integrated Exposure Assessment to Hazardous Materials for Food Safety (KRIEFS) organized two international symposia in Seoul, Korea. KRIEFS, established by the Korean Food and Drug Administration in March 2010, envisioned these international symposia as means to obtain advanced experiences from other countries and to reflect on and refine the KRIEFS’s survey design and methods.

Methods For the first symposium KRIEFS invited human biomonitoring (HBM) experts from Germany, the US, and Canada. The visiting HBM experts shared the details of their national studies while the KRIEFS discussed study design, as well as the methods, results and policymaking processes of the KRIEFS project. The second symposium was organized to share the survey design and results on endocrine disruptors from Taiwan.

Results The Speaker from Germany introduced the German Environmental Survey and shared their experiences in HBM design, such as the process of developing reference values, and discussed the new HBM plan in Germany and the European Union. The Representative from Canada shared insights from national HBM approach. In the case of the US, the speaker focused on risk communication with subjects in epidemiological studies. In the second international symposium, the speaker shared the experience of endocrine disruptors’ studies from Taiwan.

Conclusions KRIEFS was able to better understand previous nationwide HBM research designs, policy making process, and risk communication with research subjects.

Keywords Hazardous materials, Exposure, Assessment, Cohort studies

Background

The Korean Research Project on Integrated Exposure Assessment to Hazardous Materials for Food Safety (KRIEFS) was assembled by the Institute of Food and Drug Safety Evaluation, a subsidiary of the Korea Food and Drug Administration, on March 2010, to conduct a nationwide survey of infants, children, teenagers, and adults in order to observe and assess their dietary intake and exposure to hazardous materials. By understanding the exposure level of hazardous materials and the health impacts of food, oriental herbs, and health supplements, the project is building an empirical foundation for policies related to the regulation of hazardous materials.

KRIEFS held two international symposia on integrated exposure assessment for hazardous materials. In conjunction with the Korean Society of Environmental Health and Toxicology, these symposia focused on fostering a dialogue over local and international experiences with human biomonitoring (HBM) as a means to assess human exposure to hazardous materials.

For the first symposium, KRIEFS invited HBM experts from Germany, the US, and Canada to share the details of their projects. The KRIEFS introduced their own HBM project and was...
able to receive feedback and advice from experts in their field.

The second international symposium focused on developing proper research methods for HBM projects, featuring presentations such as ‘Groundwork Studies for Domestic Environments and Public Health’ and “Research Methods in Endocrine Disruptor Studies in Taiwan.”

At the close of each symposium, there were large discussions where reports such as those previously presented by the KRIEFS project and the speakers from Germany, the US, Canada, and Taiwan, were shared in greater detail.

### Introducing KRIEFS

The KRIEFS project was initiated to address several public health concerns. Public exposure to hazardous materials from food, oriental medicine, and health supplements is on the rise in Korea. At the same time, there is an increase in social demands for the integrated control of materials hazardous to children, and the elderly. The risk assessment methods for hazardous materials are changing from evaluating a single medium to evaluating multiple simultaneous exposures. This means that when it comes to integrated control, new studies can only take limited advantage of previous studies because each study has different objects, methods, and research periods. Finally, governments are beginning to look into establishing policies that diminish exposure to hazardous materials by addressing the actual pathway of exposure to hazardous materials.

KRIEFS is performing a nationwide study that evaluates integrated exposure to hazardous materials through the intake of foods, oriental medicine, and health supplements. These surveys will be conducted for three years, the first two years having already concluded in 2010 and 2011, and will build a nationally-representative cohort of 4,000 people, including infants (ages 0-6) and their mothers, children (ages 7-12), teenagers (ages 13-18), and adults (20 years and older).

The method for building the nationwide study cohort for adults was to choose subjects by square-root proportional allotment after dividing the minimum number of subjects by geographic area, sex, and age group. Cluster sampling was used after allotting the minimum number of subjects by geographic area, sex, and age group for infants, children, and teenagers.

For the 4,000 subjects, dietary exposure to hazardous materials and the health impact of dietary exposure to hazardous materials were measured.

Exposure to hazardous materials by dietary intake is monitored and the identification of their sources is conducted through repeated tracking surveys of the highly exposed group in 2012, the third year of the study.

Exposure to lead, cadmium, mercury and methyl mercury was studied in the first year. The following year examined phthalates, aflatoxin, and bisphenol A exposure. The third and final year of study will add supplementary analysis where needed to augment the first and second year data, as well as an analysis of lead, cadmium, and mercury for the high exposure group, which was entered into the repeated tracking survey.

KRIEFS anticipates accompanying outcomes such as understanding the extents and pathway of exposure, reaching conclusions about the early health influence of exposure to hazardous materials, building age group cohorts of infants, children, teenagers and adults, and preparing exposure scenarios for highly exposed people by a repeated tracking survey.

### The Difference KRIEFS Project and Previous Studies

Before KRIEFS survey, nationwide projects such as the Korea National Environmental Health Survey (KoNEHS) and Korea National Health and Nutrition Examination Survey (KNHANES), had already been performed to assess the realities of exposure to hazardous materials.

The Korea Centers for Disease Control and Prevention rolled out the KNHANES [1] in 1998, based on article 16 of the National Health Improvement Law. The survey has been performed every three years since. Its objective is to collect representative and dependable statistical data from each administrative district unit of government (city-province-nationwide) regarding population health, health awareness, and behaviours affecting health, which include diet and nutrition. These data are useful when constructing and evaluating public health policies such as developing a general national health improvement plan or developing specific health improvement programs.

The survey is composed of a health questionnaire, a nutritional analysis, and a medical examination. Each survey subject has blood and urine samples taken to be measured for heavy metals and other hazardous materials. Subjects aged 20 years and older since 2005 have their samples analysed for mercury, lead, cadmium, manganese and arsenic. Younger subjects aged 10 years and older since 2010 are included in a wider pool of subjects whose levels of lead, cadmium and mercury are measured.

The KNHANES is a cross-sectional study, so it is able to evaluate the extent of exposure to hazardous factors in a nationally representative group at one point in time. However, it cannot elucidate the sequential relationship between exposure and health impacts because it simultaneously examines participants’ exposure to hazardous factors and any diseases they already have. The KNHANES investigated heavy metal level from persons...
20 years and older in 2009 to persons 10 years and older after 2010, but did not include minors under 10 or infants in the study.

The KNHANES more focus on nutrition survey, KRIEFS, by contrast, more focus on dietary exposure to hazardous materials, investigates food intake using food frequency questionnaire (FFQ), and 24-hour recall method, which uses a specific questionnaire adapted to the characteristics of each hazardous material. KRIEFS performs the survey for health influence index, such as, N-acetyl-β-D-glucosaminidase, β2-microglobulin, and malondialdehyde.

KoNEHS [2] was organized by National Institute of Environmental Research, which is the base study on national environmental and public health. KoNEHS evaluates the concentration of hazardous materials in the human body. The aims of the KoNEHS are to evaluate the human exposure level by hazardous materials and furnish basic data for developing environmental and public health policy.

KoNEHS was performed in conjunction with the KNHANES in 2005, but it has been performed by the Ministry of Environment alone since 2007. A full preliminary HBM project was rolled out in 2007 and 2008. HBM studies will be conducted every 3 years to provide official national statistics on hazardous materials contamination.

KoNEHS survey with detailed questions related to environmental contamination and exposure, such as residential environment, living conditions, exposure to contaminants at work, lifestyle, and dietary habits. It also evaluates levels of exposure to hazardous materials such as heavy metals, polycyclic-aromatic-hydrocarbons, endocrine disruptors, agricultural chemicals, and volatile organic compound, by measuring lead, mercury, cadmium, manganese, arsenic, PAHs metabolites, cotinine, phthalates, bisphenol A, pesticide metabolite (pyrethroid). KoNEHS, like

| Table 1. Representative nationwide bio monitoring in Korea |
|----------------------------------------------------------|
| **Title** | Korean Research Project on the Integrated Exposure Assessment to Hazardous Materials for Food Safety | Korean National Health and Nutrition Examination Survey | Korea National Environmental Health Survey |
| **Sponsor** | National Institute of Food and Drug Safety Evaluation | Korea Centers for Disease Control & Prevention | National Institute of Environmental Research |
| **Object** | To assess exposure to hazardous materials through dietary intake | To produce nationwide statistics on health and nutrition | To evaluate the degree of human exposure to hazardous materials |
| **Sampling** | Population: individuals nationwide (except Jeju island) | Population: households and individuals nationwide | Population: 19 y and older individuals nationwide |
| | Methods: proportional allocation, at the city scale, and farming and fishing villages | Subjects: 10 y and older (after 2010, before 2010, 20 y and older) Size: 2,000 (each y) | Methods: proportional allocation, at the seaside district level Subjects: more than 19 y old Size: 2,000 (each y) |
| **Research scope and contents** | Diet survey Diet recall (24 hr recall, 2 times) Food Frequency Questionnaire (FFQ) | Nutrition survey Diet recall (24 hr recall) FFQ (more than 12 y old) | Exposure pathway of environmental Pollution materials survey Environmental exposure questionnaire (residential environment, indoor and outdoor environment, lifestyle, job history, diet, etc.) |
| | Health survey Health examination Health questionnaire | Health survey Health examination Health questionnaire | |
| | Food survey Food (nationwide sample) Herbal medicine and health supplement (from research subjects) | | |
| **Biologic samples** | Blood, urine (12 hr, spot) All ages | Blood: more than 19 y old Urine: more than 10 y old | Blood, urine: more than 19 y old |
| **Materials analysed in biomonitoring samples** | Heavy metal: lead, mercury, cadmium, methyl-mercury, EDCs: phthalate metabolites, bisphenol A aflatoxin | Heavy metal: lead, mercury, cadmium, manganese, arsenic (after 2010, excluded manganese, added zinc) Cotinine | Heavy metal: lead, mercury, cadmium, manganese, arsenic Cotinine PAHs metabolites (2-Naphthol, 1-OHP) EDCs: phthalate metabolites, bisphenol A Pesticide metabolite (pyrethroid) VOCs metabolites |

From Korea Centers for Disease Control and Prevention. The fourth Korean National Health and Nutrition Examination Survey (KNHANES IV-3) 2009. Seoul: Korea Centers for Disease Control and Prevention: 2010, p. 2-6 [1].

From National Institute of Environmental Research. The first 2nd year annual report on Korea national environmental health survey. Incheon: National Institute of Environmental Research; 2010, p. 3-8 [2].

VOCs, volatile organic compounds; EDCs, endocrine disrupting chemicals; PAHs, polycyclic aromatic hydrocarbons.
the KNHANES, is also a cross-sectional study and cannot establish a causal relationship between environmental exposure and the concentration of hazardous material in the human body.

Though KoNEHS does investigate the influence of general environmental exposures such as living and working conditions, the survey ultimately focuses more on exposure to hazardous materials through surrounding environment. KoNEHS does not perform any extra medical examinations or index surveys to detect early health influences of hazardous materials. It only samples adults over 19 years old.

Table 1 shows a cross-comparison of HBM projects in KRIEFS, KNHANES and KoNEHS.

**Human Biomonitoring in Germany**

Dr. Marike Kolossa-Gehring (Federal Environment Agency-Toxicology) presented on human biomonitoring in Germany and the European Union (EU) [3,4]. She cited large-scale cattle deaths by heavy metal contaminants as well as a poisoning of children living near a battery manufacturer in the 1970’s as examples of public health disasters that transformed the legislation and regulation of harmful chemicals into a serious German social issue. Since 1979, Germany built up the Environmental Specimen Bank, started HBM project.

The German Environmental Survey (GerES) is a German human biomonitoring project that is performed once every 3 to 5 years with a sample group representing the national population. The population sample was derived by dividing the country into 100 to 150 survey areas based on population density and demographic variables such as age and sex. The survey collected data from nearly 4,800 subjects aged 3 to 69 at that time.

The GerES I was held in West Germany 1985 to 1986 with 2,700 participants between the ages of 25 and 69. They followed up in 1990-1991 with the GerES IIa. The GerES IIb in East Germany surveyed 4,000 subjects aged 25 to 69 and 730 between the ages of 6 and 14 in 1991-1992. GerES III collected data from 4,800 inhabitants in unified Germany between the ages of 18 and 69 in 1998. The GerES IV-pilot survey looked at nearly 4,800 subjects between the ages of 20 and 29. Blood and urine are analysed for their levels of lead, cadmium, mercury, methyl mercury, and 18 kinds of PAHs and chlorinated hydrocarbons.

The HBM projects in Germany are achieved through collaboration between the Ministry of Environment, the Federal Environment Agency, German Chemical Industry Association, and other professional organizations. In February 2010, they agreed to collaborate on developing analysis methods for 50 new chemicals. Dr. Kolossa-Gehring reported that they are making progress toward this goal.

Germany is one of the EU nations that, in 2004, entered into the ‘Environment and Health Action Plan 2004-2010’ They are making consistent strides towards expanding and improving their national HBM program.

They take the reference values and measurement values of When HBM I and II as standards of control. HBM I is exceeded, alerts about the minor health impact from exposure should be made. Similarly, when HBM II is exceeded, significant health impacts are likely and immediate measurement is called for.

The Consortium to Perform Human Biomonitoring on a European Scale (COPHES) has been a project to build a pan-EU HBM project from 2009 to 2012. COPHES is a driving force for building comprehensive guidelines, integrating data flows, and streamlining material expenditures in both national and international HBM.

**Human Biomonitoring in the US**

Dr. Gayle C. Windham from the California Department of Public Health presented a lecture entitled ‘HBM in the US: Communicating Individual Level Biomarker Data to Participants in Epidemiological Studies’ The US has two major projects that evaluate human exposure to hazardous materials, the National Human Exposure Assessment Survey (NHEXAS) [6] and the National Health and Nutrition Examination Survey (NHANES) [7].

NHEXAS is managed by the US. Environmental Protection Agency, have been conducting surveys to evaluate various sources of environmental contamination as well as the levels and effects of human exposure to such chemicals since 1995.
Through blood and urine samples collected from survey subjects, NHEXAS measures about 120 toxic materials, including heavy metals and agricultural chemicals. It also uses a questionnaire to investigate daily food intake and other lifestyle information that may impact health. Additionally, NHEXAS evaluates exposure to hazardous chemicals by studying media such as air, water, soil, dust, and food. Repeated tracking surveys for both highly exposed sample groups are also conducted as a follow up.

NHANES, designed by the US Centers for Disease Control and Prevention, is a combination of medical examinations, survey questionnaires, blood and urine analysis, and nutrition studies intended to comprehensively evaluate population health on a national level. NHANES has taken place every other year since the 1960s, using 10,000 subjects chosen by cohort, sex, race, and geographic location.

NHANES investigate human exposure to environmental chemicals using blood and urine samples collected from 2,500 subjects chosen through random sampling. The results are used as the basis of national regulations for each hazardous material. The EPA has issued reports the National Report on Human Exposure to Environmental Chemicals [8], which outlined 27 hazardous chemicals in 2001, 116 hazardous chemicals in 2003 in their second report, 148 hazardous chemicals in their third report in 2005, and 223 poisonous materials in their fourth and most recent report.

These reports show levels of human exposure to poisonous heavy metals, endocrine disruptors, pesticide and PAHs grouped by the age, sex and race of the subjects. This report included contamination sources and comparison statistics with preceding studies. These studies have become the practical guidelines around which national regulations are built to address hazardous materials, their use, their storage, and their disposal.

Dr. Windham insisted on the need for HBM projects on a state-by-state basis to better capture the influence of the particular population structure, such as race and age, and particular environmental factors, such as climate, air pollution, and major industries, which are unique to each state and may influence contamination.

In particular, reports were developed to deliver the results of analysis in an accessible way to the participants at focus group meetings that some of the research participants attended. Moreover, the final written reports provided content accessible to the participants using graphics that compared their own results to the national and California state averages and regulatory standards.

**Human Biomonitoring in Canada**

Mr. Douglas Haines from Health Canada presented on HBM in Canada. The Canadian government has built a Chemicals Management Plan to protect public health and support the efficient management of dangerous chemicals. The Canadian government runs three HBM studies, the Canadian Health Measures Survey (CHMS), the Maternal-Infant Research on Environmental Chemicals (MIREC), and the Northern Contaminants Program (NCP).

CHMS [9] is a standard HBM project in Canada that performs health questionnaire surveys and medical examinations to collect basic information about Canadians’ general health, life habits, infectious disease rates, and lifestyle factors like exercise and nutrition. It also takes blood and urine samples from subjects to look for poisonous heavy metals and trace elements like lead, cadmium, mercury, insecticides like dichloro-diphenyl-trichloroethane, polychlorinated biphenyls, brominated flame retardants, bisphenol A, phthalates, and cotinine.

To prepare for the first CHMS survey, CHMS stratified the entire country into 5 regions and 257 survey districts and, out of 15 districts chosen randomly from that sample, gathered data from a total of 5,600 subjects aged 6 to 79 (2007-2009). The follow up survey, conducted from February 2009 to December 2011, achieved the same sample size but included children between the ages of 3 and 5 and performed the same survey included an additional survey on indoor air quality.

MIREC analysis health impacts on pregnant women by heavy metals like lead, cadmium, arsenic, mercury and hazardous materials like bisphenol A and PCBs. It is also a project whose mission is to build national guidelines based on the information obtained about children, foetuses, and pregnant women’s exposure to environmental contamination. MIREC is conducted in connection with 10 medical institutions nationwide and, from 2007 to 2012, has taken samples from 2,000 mothers and babies.

NCP is a project aimed at determining levels of exposure to hazardous materials like heavy metals and persistent organic pollutants. The NCP is a multi-agency operation that has surveyed aboriginal food intake in the Canadian Arctic region since 1991. Umbilical fluid and blood samples from expectant mothers are analysed to glean the level of aboriginal women’s exposure to hazardous materials through food. The survey data is used to develop regulatory standards around the presence of mercury, cadmium, lead, DDT, PCBs, and other hazardous materials in the aboriginal food supply.

Table 2 shows a cross-country comparison of HBM projects in Germany, the US and Canada.

**Endocrine Disruptor Studies in Taiwan**

The second international symposium organized focused on de-
Table 2. Biomonitoring in Germany, U.S., Canada

| Research | German Environmental Survey | National Health and Nutrition Examination Survey | Canadian Health Measures Survey |
|----------|-----------------------------|-----------------------------------------------|---------------------------------|
| Sponsor  | Federal Environment Agency-Toxicology | US Centers for Disease Control and Prevention | Health Canada |
| Object   | To provide background level of exposure for a defined group of the general population: Reference values | To assess the health and nutritional status of adults and children | To establish nationally representative blood and urine concentrations for environmental chemicals |

| Research contents | Biomonitoring samples | Analysis materials in monitoring samples |
|-------------------|-----------------------|-----------------------------------------|
| Ambient monitoring | Blood, urine, scalp hair | Blood: lead, cadmium, mercury, PCB, DDE, HCB, HCH, IgE, FEP |
| Tap water         |                       | Urine: creatinine, arsenic, cadmium, mercury, chromium, copper, nickel, uranium, PCP, further chlorophenols (cortisol, adenalin, noradrenalin), lead, platinum, aurum, lindane, nicotine/cotine, stress hormones |
| House dust        |                       | Metabolites of: PAH, pyrethroids, organophosphorous compounds, DEHP |
| Indoor air        |                       | Scalp hair: elements, nicotine/cotine |
| Personal air      |                       | Questionnaire: Diet, (24 hr recall) health-related questions |

From Becker K, et al. German Environmental Survey (GerES): human biomonitoring as a tool to identify exposure pathways. Int J Hyg Environ Health 2007;210:267-269 [3].
From Schulte C, et al. Twenty years of the German Environmental Survey (GerES): human biomonitoring--temporal and spatial (West Germany/East Germany) differences in population exposure. Int J Hyg Environ Health 2007;210:271-297 [4].
From Wiesmüller GA, et al. The Environmental Specimen Bank for Human Tissues as part of the German Environmental Specimen Bank. Int J Hyg Environ Health 2007;210:299-305 [5].
From Clayton CA, et al. National Human Exposure Assessment Survey (NHEXAS): distributions and associations of lead, arsenic and volatile organic compounds in EPA region 5. J Expo Anal Environ Epidemiol 1999;9(5):381-392 [6].
From Centers for Disease Control and Prevention. National health and nutrition examination survey (Internet) [7].
From Health Canada. Report on human biomonitoring of environmental chemicals in Canada; results of the Canadian health measure survey cycle 1 (2007-2009) (Internet)[9].

PCBs, polychlorinated biphenyls; DDE, dichlorodiphenylchloroethylene; HCB, hexachlorobenzene; HCH, hexachlorocyclohexane; IgE, immunoglobulin E; FEP, fluorinated ethylene propylene; PCP, phencyclidine; PAH, polycyclic aromatic hydrocarbons; DEHP, di-(2-ethylhexyl)-phthalate.

Developing methods in endocrine disruptors’ survey. Professor Pau Chung Chen from the Institute of Occupational Medicine and Industrial Hygiene, National Taiwan University, College of Public Health presented on studies of endocrine disruptors in Taiwan.

The definition of endocrine disruptors is that they are synthetic chemicals that disrupt normal endocrine system functions, such as the production, secretion, transfer, metabolism, combination and excretion of hormones by acting like hormones, due to their structural similarities, when they are absorbed into the human body [10].

The public awareness around endocrine disruptors in Korea was detected in containers of pre-packaged noodles in 1998. Dioxin also was detected in feed for fowls and pigs imported from Belgium in 1999.

Di-2-ethylhexyl phthalate was used food additives in Taiwan (2011) this incidents became major social issue in Taiwan.

The Taiwan Birth Panel Study (TBPS) [11] researched the incidence of health outcomes related with endocrine disruptors in Taiwan. It investigated exposure to perfluorinated compounds (PFCs) by analysing umbilical cord blood and placenta specimens from 486 infants born in Taipei Hospital from 2004 to 2005, as well as blood and urine from their mothers, and conducted a questionnaire survey about environmental exposure to PFCs.

TBPS periodically conducts new surveys until the babies reach the age of six, for a total of 5 interventions over time that analyse the children’s growth, document their allergies, note living conditions and sanitation, and collect blood, urine and hair samples.

Studies similar to the TBPS of Taiwan are being performed in Japan and Korea as well. The Mothers and Children’s Environmental Health study in Korea (infants ages 0-5, 2006-2010) [12], the Hokkaido Study on the Environment and Children’s Health in Japan (ages 0-7, 2002-2005) [13], and the Japan Environmental and Children Study (ages 0-12, 2010-2012).
Specifically, three studies have analysed children’s growth, development, allergies, exposure to heavy metals and endocrine disruptors using human specimen collected from birth to a specific age.

Conclusion

Two symposia gave participants and particularly the KRIEFS, the opportunity to understand international trends in methods and technology related to HBM. The examples given by Germany, the US and Canada demonstrated good practices on how to design research and how to use the study result to build better policy and public health programs. KRIEFS were able to solicit each others’ opinions and reflect on vital aspects of their own project management, such as processing project results into useable data, incorporating study methods that reflect government policy, and communicating risks to research subjects.

Because it built an evaluation model of exposure hazards based on survey data, the example of the German Environmental Surveys ably demonstrated practical methods for applying project results to policy. Further, the German example shows a collaboration between various divergent interest groups, such as the German Chemical Industry Association, the Ministry of Environment, and other manufacturer and professional organizations, that has resulted in an agreement to jointly develop analysis methods for 50 new chemicals within the next 10 years and to conduct the project collaboratively.

In the US, the national reports on 300 different chemicals are being put into practical use to build national regulatory standards. Of special note in the case of communicating risk, commendably, US researcher shared the experience of the risk communication of the survey result with the research subjects.

In Korea, if information can be shared smoothly across governmental agencies and different levels of administration, the worthy project of conducting HBM of environmental or dietary exposure to hazardous materials will be performed more efficiently. Solid HBM research results can be the foundation for more accurate and effective regulation of hazardous chemicals, allowing government and industry to work together for public health.

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Conflict of Interest

The authors have no conflict of interest to declare on this study.

References

1. Korea Centers for Disease Control and Prevention. The fourth Korean National Health and Nutrition Examination Survey (KNHANES IV-3) 2009. Seoul: Korea Centers for Disease Control and Prevention; 2010, p. 2-6 (Korean).

2. National Institute of Environmental Research. The first stage (09-11), 2nd year annual report on Korea national environmental health survey. Incheon: National Institute of Environmental Research; 2010, p. 3-8 (Korean).

3. Becker K, Conrad A, Kirsch N, Kolossa-Gehring M, Schulz C, Seiwert M, et al. German Environmental Survey (GerES): human biomonitoring as a tool to identify exposure pathways. Int J Hyg Environ Health 2007;210:267-269.

4. Schulz C, Conrad A, Becker K, Kolossa-Gehring M, Seiwert M, Seifert B. Twenty years of the German Environmental Survey (GerES): human biomonitoring—temporal and spatial (West Germany/East Germany) differences in population exposure. Int J Hyg Environ Health 2007;210:271-297.

5. Wiesmüller GA, Eckard R, Dobler L, Günsel A, Oganowski M, Schröter-Kermani C, et al. The Environmental Specimen Bank for Human Tissues as part of the German Environmental Specimen Bank. Int J Hyg Environ Health 2007;210:299-305.

6. Clayton CA, Pellizzari ED, Whitmore RW, Perritt RL, Quackenboss JJ. National Human Exposure Assessment Survey (NHExAS): distributions and associations of lead, arsenic and volatile organic compounds in EPA region 5. J Expo Anal Environ Epidemiol 1999;9(5):381-392.

7. Centers for Disease Control and Prevention. National health and nutrition examination survey [cited 2012 Apr 10]. Available from: http://www.cdc.gov/nchs/nhanes/nhanes2007-2008/nhanes07_08.htm.

8. Centers for Disease Control and Prevention. National report on human exposure to environmental chemicals [cited 2012 Apr 10]. Available from: http://www.cdc.gov/exposurerreport/index.html.

9. Health Canada. Report on human biomonitoring of environmental chemicals in Canada; results of the Canadian health measure survey cycle 1 (2007-2009) [cited 2012 Mar 30]. Available from: http://www.hc-sc.gc.ca/ewh-sgmt/pubs/contaminants/chms-eems/index-eng.php.

10. Yang M, Park MS, Lee HS. Endocrine disrupting chemicals: human exposure and health risks. J Environ Sci Health C Environ Carcinog Ecotoxicol Rev 2006;24(2):183-224.

11. Hsieh CJ, Hsieh WS, Su YN, Liao HF, Jeng SF, Taso FM, et al. The Taiwan Birth Panel Study: a prospective cohort study for environmentally-related child health. BMC Res Notes 2011;4:291.

12. Kim BM, Ha M, Park HS, Lee BE, Kim YJ, Hong YC, et al. The Mothers and Children’s Environmental Health (MOCEH) study. Eur J Epidemiol 2009;24(9):573-583.

13. Kishi R, Sasaki S, Yoshioka E, Yuasa M, Sata F, Saigo Y, et al. Cohort profile: the Hokkaido study on environment and children’s health in Japan. Int J Epidemiol 2011;40(3):611-618.