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Exposure to environmental chemicals among Korean adults-updates from the second Korean National Environmental Health Survey (2012–2014)

Wookhee Choi[a], Suejin Kim[a,*], Yong-Wook Baek[a], Kyungho Choi[b], Keejae Lee[c], Sungkyoon Kim[b], Seung Do Yu[a], Kyunghee Choi[a]

[a] Environmental Health Research Department, National Institute of Environmental Research, Incheon, South Korea
[b] Department of Environmental Health Sciences, Graduate School of Public Health, Seoul National University, Seoul, South Korea
[c] Department of Information and Statistics, College of Natural Science, Korea National Open University, Seoul, South Korea

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ABSTRACT

National biomonitoring program can offer solid scientific evidence on exposure profiles of environmental chemicals at a national level, and provide a snapshot of changing exposure level over time. Therefore, several countries have maintained such programs for developing environmental health policies. The Korean National Environmental Health Survey (KoNEHS) was designed to understand the level of human exposure to environmental chemicals by time and location, and to identify possible sources of such exposure. The 2nd stage of KoNEHS, which was conducted between 2012 and 2014, examined a total of 6478 adult subjects over 19 years of age, and measured 21 environmental chemicals of major policy concern. Compared to the findings from the first stage monitoring (2009–2011), slightly higher levels of blood lead were observed, while those of mercury remained similar. Blood metal concentrations, however, were higher than those reported from national biomonitoring programs of United States, Germany and Canada. The urinary concentrations of phthalates metabolites were lower, but those of t,t-muconic acid and BPA were higher than those reported in the first stage survey. The urinary cotinine level decreased perhaps reflecting general declining patterns of first- and second-hand smoking. The results of the second stage survey were made available for public use since April 2016.

Some policy efforts appear to be at least in part effective on mitigating chemical exposure among people, e.g., urinary phthalate metabolites and cotinine, while further confirmations are warranted. In-depth assessments will be conducted to identify vulnerable groups and important exposure pathways.

1. Introduction

Human Biomonitoring (HBM) of environmental chemicals is a useful measure to understand exposure profiles among people. National HBM programs can provide profiles of chemical exposure and their temporal trends that are representative at country level. In addition, depending on the design, national HBM programs can also be used to identify environmental health problems and their causes. Several countries, e.g., United States, Germany and Canada, have developed and conducted national HBM programs. In the United States, for example, hundreds of chemicals have been measured from the general population through National Health and Nutrition Examination Survey (NHANES). In the United States, another survey, National Human Exposure Assessment Survey (NHEXAS) has been conducted in order to identify major exposure sources (CDC, 2015; Pellizzari et al., 1995). In Germany, a series of the German Environmental Survey (GerES) has been carried out since 1985, with an emphasis not only on exposure levels but also determinants of exposure, which then can be possibly applied to the development of environmental health policy (UBA, 2016a). In the similar vein, Canada has developed, Canadian Health Measures Survey (CHMS), which has been conducted for three cycles since 2007 (Health Canada, 2015).

In Korea, according to the Article14 of the Environmental Health Law and the Ten-Year Environmental and Health Plan (National Institute of Environmental Research, 2011a,b, 2013, 2014a, 2014b), the Korean National Environmental Health Survey (KoNEHS) and

* Corresponding author at: Environmental Health Research Department, National Institute of Environmental Research, Environmental Research Complex, 42, Hwangyeong-ro, Seogu, Incheon, 22689, South Korea.
E-mail address: suenier@korea.kr (S. Kim).

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Environmental Exposure and Health Survey in Children and Adolescents (KorEHS-C) were implemented, and examined the level of exposure to environmental chemicals and their associations with health conditions. The KoNEHS aims to monitor trends in exposure to environmental chemicals and to identify major determinants of exposure. Currently, the survey has been conducted on a triennial basis from 2009 and completed its first and second stage surveys, with the original data of the first monitoring (2009–2011) which has already been published online for public use. The KorEHS-C was designed as a part of preliminary survey for KoNEHS; nationally and regionally representative children and adolescents of age between 3 and 18 years were selected and investigated for exposure level to major environmental chemicals and for general health conditions since 2012 for three years (Park et al., 2016a,b; Burm et al., 2016). The results and experiences of KorEHS-C were reflected in designing the third stage of KoNEHS which was initiated from 2015.

In the second stage survey (2012–2014), about 6000 adults of over 19 years of age from 400 sampling districts were systematically chosen, and were assessed for the general level of exposure to environmental chemicals, demographic and lifestyle characteristics, and certain clinical measure (National Institute of Environmental Research, 2012a). In this paper, we aim to present the levels of major environmental chemicals among Korean adults and to compare with those reported from the first stage survey.

2. Data and method

2.1. Study design

The second stage of the KoNEHS followed the same sampling strategy to assure comparability with those from the first stage KoNEHS, while to obtain nationally representative sample. Based on the 2010 Population and Household Census by Korea National Statistical Office, we first stratified the samples based on geography using administrative districts and geographic (costal) stratum (National Institute of Environmental Research, 2012a).

The second stratification was based on the proportion of residential complex areas and of residents involved in primary manufacturing such as farming and fishing, which are closely linked to socio-economic status. In addition, 42 areas were chosen which had air pollution monitoring stations. As these areas were also included in the first stage, temporal changes relative to the first stage findings could be captured.

To prevent the over-sampling of the urban residents of heavily populated areas, the sampling units were drawn proportional to the square root of the population size of the stratum. Accordingly, we chose total 400 sampling districts—358 general districts and 42 biased (pre-selected for air pollution monitoring data) districts—and systematically selected a representative household in each stratum in a way that about 15 subjects per stratum were interviewed. As seasonal variations in the concentration of environmental chemicals were observed from the first stage survey, the second stage survey was conducted between June 2012 and May 2014 to incorporate possible variations by season.

2.2. Recruitment of subjects and survey procedure

National Institute of Environmental Research of Korea served as a main hub, in collaboration with special task-force research teams consisting of related experts in each stage of the survey; these specific research teams were responsible for (1) recruiting potential respondents and confirming the selected household profile, (2) running the survey in the field while collecting the blood and urine samples, (3) delivering, splitting, and preserving the collected samples and conducting clinical tests, and (4) analyzing the environmental chemicals in biological samples. The same teams and organization were maintained throughout the survey to assure consistency and comparability of survey processes and responses over the survey period.

Table 1
Clinical laboratory test items.

Classification	Number of tested items	Items
General chemistry	4	AST (SGOT), ALT (SGPT), γ-GTP, Creatinine
Hematology	5	WBC, RBC, PLT, Hb, HCT
Lipids	4	Cholesterol, HDL, TG, Total lipid
Plasma protein	2	IgE, β2-MG
Endocrine hormones	4	FSH, T3, T4, TSH

To recruit subjects, we first chose easily accessible locations after consulting with the community center officer in a respective sampling district. A final list of potential subjects was completed after a field recruiting officer confirmed the list of households registered on the Statistics Korea and marked their locations on the map. The sample household was selected after aforementioned stratified sampling process. The interviewer visited the selected households, explained the survey objectives and procedure, and asked for subjects' consent to participate. Written informed consents were obtained from all the participating subjects (National Institute of Environmental Research, 2012b).

The field survey team consisted of an interviewer and a trained phlebotomist. The on-site interview proceeded with a general physical check-up. Under the supervision of the doctor, the phlebotomist collected about 23 mL blood and 80 mL of urine sample from the subjects. The twenty-minute questionnaire consisted of 10 categories with total 142 items inquired into subjects' demographics, socioeconomic backgrounds, in/outdoor environment, modes of transportation and recent life styles (National Institute of Environmental Research, 2012c).

2.3. Clinical laboratory test and environmental chemical analysis

The second stage survey included health related tests that examined clinical markers of liver, kidney, and the endocrine system (See Table 1). The target environmental chemicals were chosen based on the first stage results. These chemicals, included 21 chemicals such as three heavy metals, four polycyclic aromatic hydrocarbons (PAHs), five volatile organic compounds (VOCs) metabolites, five phthalate metabolites, two environmental phenols, pyrethroid pesticide metabolites, and environmental tobacco smoke metabolites (Table 2).

Several chemicals such as some PAHs metabolites and triclosan, were included in the second survey considering their exposure among general population. Urinary total arsenic was dropped from the analytical list. Inorganic arsenic will be added in the list in the future.

Blood Pb and urinary Cd were measured by graphite furnace atomic absorption spectrometry (Analyst 800, PerkinElmer). Total mercury in blood and urine were analyzed by flow injection cold-vapor atomic absorption spectrometry (DMA-80, Milestone). The metabolites of phthalates, environmental phenols (Xevo TQ-S, Waters) and hippuric acid (Flexar SQ300, PerkinElmer) were analyzed using a UPLC–MS/MS. The metabolites of VOCs except for hippuric acid were determined by HPLC–MS/MS (Agilent 6420, Agilent). The metabolites of PAHs (Clarus 680T, PerkinElmer), 3-PBA (Clarus 600T, PerkinElmer) and urinary cotinine were determined by GC–MS. Details of the methods were described elsewhere (National Institute of Environmental Research, 2015a,b).