FACTORS INFLUENCING INTERNAL EXPOSURE TO PHTHALATE AND BPA

Lim J-A[a], Kwon H-J[b]*, Ha M[c], Oh SY[d], Park J-D[e], Pyo H[f]

[a, b, c] Department of preventive medicines, Dankook University College of medicine, Cheonan, Korea;
[d] Department of Food & Nutrition, Kyung Hee University College of Human Ecology, Seoul, Korea;
[e] Department of Preventive Medicine, Chung-Ang University College of Medicine, Seoul, Korea;
[f] Molecular Recognition Research Center, Korea Institute of Science and Technology, Seoul, Korea

* Correspondence to: Ho-Jang Kwon, MD, MPH, PhD
Department of Preventive Medicine, Dankook University College of Medicine,
Dandae-ro 119, Cheonan, Chungnam, Korea, 330-714
Tel: 82 41 550 3879, Fax: 82 41 556 6461, e-mail: hojangkwon@gmail.com

Introduction

Phthalate and BPA are environmental chemicals. Phthalates used to make plastics more flexible (plasticizers), some phthalates are used as solvents (dissolving agents) for other materials since the 1930s. They are used in hundreds of products, such as vinyl flooring, adhesives, detergents, lubricating oils, automotive plastics, plastic clothes (raincoats), plastic bags, garden hoses, blood-storage containers, medical tubing, children's toys and personal-care products (soaps, shampoos, hair sprays, and nail polishes)[1, 2]

Bisphenol A (BPA) is used to many plastic bottles and metal-based food and beverage cans since the 1960s[3]. It also used to compact disks, impact-resistant safety equipment, automobile parts, toys, and dental sealants[1,7]. People are exposed to phthalate by eating and drinking foods that have been in contact with containers and products containing phthalate. To a lesser extent exposure can occur from breathing in air that contains phthalate vapors or dust contaminated with phthalate particles. General exposure to BPA at low levels comes from eating food or drinking water stored in containers that have BPA. Dental treatment with BPA-containing sealants also results in short-term exposure. Young children may have a greater risk of being exposed to phthalate particles in dust and materials containing BPA than adults because of their hand-to-mouth behaviors. Once phthalates enter a person's body, they are converted into breakdown products (metabolites) that pass out quickly in urine[1]. Phthalate metabolites showed statistically significant correlations with abdominal obesity and insulin resistance[4], lipid metabolism[8]. BPA exposure can influence several mechanisms important for body weight regulation[5]. BPA were associated with diabetes and cardiovascular disease[6]. Some types of phthalates and BPA have affected the reproductive system of laboratory animals. More research is needed to understand the human health effects of exposure to Phthalates and BPA[1].

The aims of this study are to identify phthalate and BPA exposure level in all ages across the country, and to analyze factors that have influences on phthalate and BPA's exposure.

Materials and methods

Study subjects were 2,491 persons (male: 1,223, female: 1,268) who measured phthalate metabolite and BPA in 12 hours urine using the cohort based on the whole the nation established in Korean Research Project on the Integrated Exposure Assessment to Hazardous Materials for Food Safety (KRIEFS) from 20120 to 2011. "Korean research project on the integrated exposure assessment to hazardous materials for food safety (KRIEFS)" is established by Korean food & drug administration in March 2010. KRIEFS was designed to conduct nationwide integrated dietary exposure assessment on hazardous materials include health-functional food and herbal medicine under real-life pattern, to compare the results of the dietary exposure on hazardous materials with the internal exposure (individual urinary or blood levels of hazardous materials) and to estimate the health effect by dietary exposure on hazardous materials.

Samplings were conducted in complete nation area, except Jeju Island. (Included 15 metropolitans and provinces). Sampling methods were considered the proportion of living area (metropolitan, middle town, and rural area). For adults sampling, minimum numbers of samples were allotted according to regions, gender, and ages. Adult's samples were extracted by random sampling using a method of the square root proportional allocation of sampling unit (35 study areas and 102 sample collection points) based on distribution proportion of the population. For children and adolescent sampling, sampling regions allotted according to the representative region by of living area, conducted a cluster sampling method centering on schools or organizations in three or four regional base on an each city. The adolescent sampling recruited from school (elementary school, middle school, and high school) in 15 metropolitans and provinces by cluster sampling. The children sampling selected from kindergartens, health centers, and hospitals in 15 metropolitans and provinces by cluster sampling.

With regard to factors having influences on the level of exposure to a human body by focusing on estimation of dietary exposure as a result of evaluation of urine samples, physical examination, questionnaire on dietary, and food analysis results collected from the subjects. Dietary exposure survey was conducted through individual dietary intake survey (food frequency questionnaire; FFQ, twenty four hours recall for discontinuous two days; 24hr recall for 2days) develop a questionnaire so as to get their dietary lifestyle patterns, specifically includes survey for herbal medicines and health functional food intake. Dietary questionnaires were consisted with dietary intake research (frequency of eating out, meal balance, frequency of intake health functional food and herbal medicine, history of infant feeding for children) and dietary habit survey(it was Included dietary intake pattern, preferred food, frequency of eat out, the used canned food, plastic container). Biomonitoring for BPA, phthalates were measured in 12 hours urine. Health questionnaire on human exposure assessment was consisted with demographic features index, socio-economic feature index, environmental exposure index, drinking water index, and life habit index. For 19yr and older subjects, includes clinical symptoms, pesticide and life type questionnaire items.

Analysis has been made by seven categories demographic factors, socioeconomic factors, environmental factors, dietary factors, health behavior factors, and regional factors. Statistical analysis was performed using R statistical software Version 2.15.2. Phthalate and BPA concentration by general characteristics of this study subjects used technological statistics, Wilcoxon tests and Kruskal-Wallis tests. For a level of exposure to a human body and its relevance of each factor used multiple leaner regression analysis. For paths having impacts on the level of phthalate and BPA's exposure to a human body used a structural equation modeling analysis.

Table1. Variables for factors influencing internal exposure to phthalate and BPA

Classification	Variables
Demographic factors	Age, Sex
Socioeconomic factors	Living area, education level, house hold income
Environmental factors	House type, duration of residence, drinking water type, use air freshener, use pesticide, exposure to environmental tobacco smoke, exposure to plastic fume, paint fume, solvent, and bond resin.
Dietary factors	Food, health functional food, herbal medicines, frequency of eat out, use delivery food, dietary diagnosis index, use plastic container in microwave oven, frequency intake canned food
Health behavior factors	Smoking, drinking, Exercise
Regional factors	Residence region based environment(industrial complex, pollution facilities, and thoroughfare)

Results and discussion

As a result, urinary BPA level (ug/g cr) were showed a higher level in the male group (GM 2.19) than the female group (GM 2.43). From the age-specific perspective, age groups of 1–5 (GM 4.84), 6-11 (GM 3.0) showed higher levels than those of adolescent and adults. (*p-value* <0.0001)

For higher educated people, they showed higher BPA level (more than 13 years GM 2.57, p-value <0.0001); a middle-lower group out of four income level groups showed the highest of GM 2.6; as for analysis on intake frequency of canned-type food, a group having more than one canned food showed the highest (GM 3.19, *p-value* <0.0001).

Urinary DEHP level (ug/g cr) showed a higher level in the male group of 104.1 than that of female of GM 100.5(*p-value* <0.0001). From socioeconomic factors point of view, rural areas (GM 117.9) showed higher levels than that of metropolitan cities of GM 104.72 small and medium-sized cities of GM 89.4(*p-value* <0.0001). As for household income levels, a middle-lower group out of four income level groups showed the highest of 115. With regard to DEHP concentration distribution (ug/g cr) by frequency of eating out and delivered food for a recent one year, a group with more than one time a month showed the highest (GM 137.2, p-value 0.04); and a group lived within 50 meter distance from the closest road (intra-city buses are available on the road) showed the highest of GM 108.22. (*p-value* 0.03)

As for BPA results about confirmatory factor analysis using a structural equational modeling, socioeconomic latent variables and observed variables of dietary exposure showed statistical significance paths in a hypothesis models; on the other hand, gender, age and region, environmental latent variables showed no statistical significance. As long as socioeconomic factors increase, the BPA concentration showed decreasing statistical significance (β-0.073, *p-value* 0.001); as long as BPA exposure amount per one day based on unit weight increases, the BPA concentration values also increased. (β 0.207, *p-value* 0.001).

Table2. Factor coefficients from the confirmatory factor analysis on urinary BPA level

Factor		Unstandardized factor coefficient	Standardized factor coefficient	P-value
Sex	Urinary BPA	-0.055	-0.025	0.194
Age	Urinary BPA	0.001	0.023	0.245
Socioeconomic	Urinary BPA	-1.324	-0.073	<0.001
Environment	Urinary BPA	-0.001	-0.002	0.813
Dietary	Urinary BPA	7.239	0.207	<0.001
Living area	Socioeconomic factors	1.000	0.077	
Income		-2.577	-0.156	<0.0001
Education level		-84.398	-1.810	0.377
Nearly thoroughfare	Environmental factors	1.000	2.958	
Nearly industrial complex		0.014	0.095	0.750
Nearly pollution facilities		0.013	0.067	0.751
Socioeconomic factors ↔ Environmental factors		0.000	0.955	

Paths showed a statistical significance in hypothesis models of DEHP were related to age, socioeconomic latent variables and dietary exposure amount, rather than region and environmental factors. As long as age gets older, and socioeconomic factors increase, DEHP concentration showed a decreasing statistical significance, β-0.064, *p-value* 0.001; β-0.0088, *p- value* 0.001, respectively. Meanwhile, as long as DEHP's exposure amount based on unit weight per one day increases, DEHP concentration values showed the increasing statistical significance (β 0.347, *p-value* 0.001).

Table3. Factor coefficients from the confirmatory factor analysis on urinary DEHP level

Factor		Unstandardized factor coefficient	Standardized factor coefficient	P-value
Sex	Urinary DEHP	-0.030	-0.015	0.455
Age	Urinary DEHP	-0.003	-0.064	0.001
Socioeconomic	Urinary DEHP	-1.452	-0.088	<0.001
Environment	Urinary DEHP	0.219	0.016	0.157
Dietary	Urinary DEHP	0.701	0.347	<0.001
Living area	Socioeconomic factors	1.000	0.079	
Income		-2.524	-0.159	<0.0001
Education level		-79.818	-1.777	0.317
Nearly thoroughfare	Environmental factors	33.433	1.939	0.441
Nearly industrial complex		1.059	0.146	0.0001
Nearly pollution facilities		1.000	0.103	
Socioeconomic factors ↔ Environmental factors			0.000	0.955

Dietary factors of BPA and DEHP have statistical significance impacts on their exposure to a human body compared with other factors like socioeconomic, environmental, gender and age.

Acknowledgements

This research was supported by a grant (10162KFDA994) from Korea Food & Drug Administration in 2012.

References

1. CDC (2009); Phthalates. Available from: http:// www. cdc. gov/ biomonitoring/ pdf/ Pthalates_FactSheet. pdf. AcessedNov.1, 2012.
2. Schettler T (2006); Human exposure to phthalates via consumer products. Int J Androl. 29(1):134–139. discussion 181–135.
3. CDC (2010); Bisphenol A (BPA). Available from: http:/ /www.cdc.gov/ biomonitoring /pdf /BisphenolA_FactSheet.pdf. Accessed Nov.1, 2012.
4. Stahlhut RichardW, Edwinvan Wijngaarden, Dye TimothyD, Cook Stephen, Swan Shanna H(2007); Concentrations of Urinary Phthalate Metabolites Are Associated with Increased Waist Circumference and Insulin Resistance in Adult U.S. Males Environmental Health Perspectives 115(6): 876-82.
5. Beverly S. Rubin, AnaM.Soto (2009) BPA: Perinatal exposure and body weight 304(1–2); 55–62
6. IainA.Lang, TamaraS.Galloway, AlanScarlett, WilliamE. Henley, Michael Depledge, Robert B. Wallace, David Melzer (2008); Association of Urinary BPA Concentration With Medical Disorders and Laboratory Abnormalities in Adults. 300(11): 1303-10.
7. Fung EY, Ewodsen NO, St Germain Jr HA, Marx DB, Miaw CL, Siew C, Chou HN, Gruninger SE, Meyer DM.(2000). Pharmacokinetics of bisphenol A released from a dental selant. J Am Dent Assoc 131:51-58.
8. Bell FP (1982). Effects of phthalate esters on lipid metabolism in various tissues, cells and organelles in mammals, Environ Health Perspect 45: 41-50.