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Determining the exposure factors of personal and home care products for exposure assessment

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ABSTRACT

An accurate understanding of the usage patterns of consumer products is important for realistic exposure assessment. Since such patterns differ by country, a Korean national database for exposure factors is needed. We determined the exposure factors of 10 consumer products (face cleanser, toothpaste, shampoo, hair conditioner, body wash, dish and laundry detergents, fabric deodorizer, antistatic spray, and shoe polish. Field survey staff visited homes and collected product use information by questionnaire. In total, 816 men and 2517 women aged 15 years and older from 2500 households completed the questionnaire. Field technicians also re-visited 85 households to investigate the circumstances of use and the reliability of the questionnaire data. Greater than 97% of the sampled population reported use of toothpaste and shampoo. Hair conditioner, body wash, and face cleanser were used by ~60% of the population and by specific age groups and genders. The amount of consumer products used was comparable between that reported in the questionnaire and that measured directly during house visits, and the ratios of usage amounts ranged from 0.75 to 1.69. The exposure factor data obtained from this study could be useful for regulatory agencies when setting safety guidelines for product use.

1. Introduction

Many consumer products (CPs) have been developed and are used daily for personal hygiene, home care, and disinfection. Although CPs may make our lives convenient and pleasant if they are used properly, they contain a variety of chemicals that can enter the body through inhalation, dermal contact, or ingestion. These chemicals may cause adverse health effects, ranging from acute symptoms such as irritation to chronic diseases. For this reason, there is growing concern about the use of CPs and a need to evaluate the exposure and risks arising from their use.

Recently in Korea, the inhalation of aerosolized water containing disinfectants from a humidifier led to serious lung injury, resulting in 52 deaths and 122 injuries (Park, 2013). This tragedy provoked public attention and concern. In 2013, to promote the safe use of products, the Korean government enacted regulations on chemicals in various CPs that could cause adverse health effects. CPs that fall under this regulation should undergo risk assessments to evaluate health and environmental hazards caused by product use. As a risk management action, safety standards should be set for chemical ingredients in products based on risk assessment data to prevent harm.

To assess exposure and risk for consumers, the exposure factors of CPs should be determined. Exposure assessments for chemicals in CPs require information on exposure factors, such as frequency of use and amount of product used per event, as well as information about the circumstances of use (Van Engelen et al., 2007). Exposure factors have been investigated previously in a US female population of regular product users (Loretz et al., 2006, 2008), California households (Wu et al., 2010), and in Europe (Biesterbos et al., 2013; Hall et al., 2007, 2011). However, exposure factors pertaining to consumer use patterns in Asian populations have not been reported. Given that the patterns of CP use in Korea may differ from those in other countries, a national database of exposure factors including data on consumer product use is needed.

The purpose of this study was to develop a database of exposure factors for aggregate consumer exposure assessment. We investigated five personal care products (PCPs) and five home care products (HCPs) to obtain exposure factor data among Koreans over 15 years old. The prevalence of use, frequency, amount per application, and daily use amount of the products were determined. These exposure factor data could be useful to regulatory agencies establishing safety guidelines to assure the safe use of products.

2. Methods

2.1. Study population

A total of 2500 households were selected from 15 metropolitan areas and provinces including rural areas in Korea. One province was excluded from the selection

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because of its relatively small population size. The study population included individuals 15 years and older. The number of households included in each province was based on the proportional population of the province relative to the total population. Within each province, survey locations were randomly selected, and for each survey location, the number of households was fixed. When a resident refused a survey or a house was empty, interviewers moved to the next house until the required number of households in each survey location was reached.

2.2. Data collection

Trained interviewers visited each household and conducted face-to-face interviews using a questionnaire between June and July 2012. We developed a questionnaire to investigate the use of CPs. This questionnaire contained information regarding demographics and life style, as well as the detailed use of CPs. Ten CPs including face cleanser, toothpaste, shampoo, hair conditioner and body wash used for personal hygiene and dish detergent, laundry detergent, fabric deodorizer, anti-static spray and shoe polish used for home care were assessed using questions regarding the frequency of use and the amount of product used per application.

Depending on the application type, different types of questions were asked to estimate the amount of usage. For spray-type products, the number of sprays per application was recorded. For liquid products, the amount of product used was estimated based on comparison with a 50-ml volume glass, the most popular glass size for liquor in Korea. For cream, lotion and foam products, we provided a card displaying five different sized circles (diameter 1–5 cm; Fig. 1) for the user to select from to estimate the amount of product used.

When products were dispensed using a pump, the number of pumps was recorded. The types of questions in the questionnaire are summarized in Table 1. The questionnaire included the brand name of the products and time spent using each product. Depending on the exposure characteristics of the products, some questions were added, such as questions regarding the incidence of dermal contact, where and how the products were applied, and when the products were used. All questions were limited to product use within the past 3 months.

We purchased the 10 most common products in each category from the supermarket. In the laboratory, we measured the amount dispensed per spray for spray products, the mass of each cup for liquid products, the amount of each sample on a printed circle card for cream/lotion products, and the amount dispensed per pump for pumped products.

A follow-up survey was conducted for validation of the questionnaire survey. Among the 524 households examined from the Seoul area, 85 households were selected for the follow-up survey. Field technicians revisited these 85 households to investigate the circumstances of use such as places where products were used, volume and ventilation of the places of use, ventilation and the reliability of questionnaire data. During the revisits, respondents were asked to pour the amount per application of PCPs and HCPs used at that time onto a pre-weighed weighing dish. The field technician then weighed the dish to determine the amount of each product used.

2.3. Data analysis

All statistical analyses were conducted using SAS v9.4 (SAS Institute Inc., Cary, NC, USA). Frequency tables were constructed to assess the usage rate of products. Chi-square tests were used to analyze the usage rates by gender, age group, level of education, and level of income. The mean amount of use per application (g/use) was calculated using questionnaire data for all CPs. The daily use amount (g/day) was calculated by multiplying the frequency (use/day) with the amount per application (g/use). ANOVA tests were used to analyze the frequency of use, amount of product per use, duration of use, and other variables by gender, age group, level of education, and level of income.

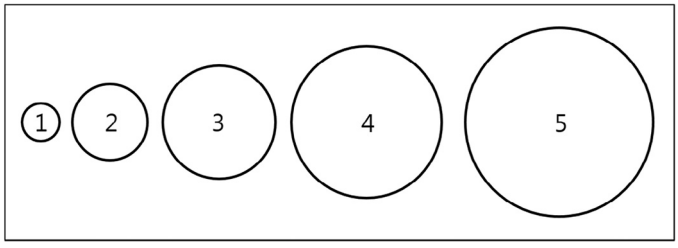

Fig. 1. Example card displaying five different sizes of circles (diameter 1–5 cm) to assess the amount of product used per application.

Table 1
Questions regarding product use in the questionnaire.

Category	Question
Personal/home care products	Experience of product use in last 3 months?
	Name of product
	Frequency of use
	Time spent using product
	Amount of use per application
Home care products	Dermal contact
	Usage of gloves

3. Results

3.1. Characteristics of the study population

In total, we obtained questionnaire data from 3333 participants representing 2500 households. Approximately 75.5% of respondents were female (2517 individuals). The demographic characteristics of the study participants are presented in Table 2.

Participants were divided into three age groups: young (15–34 years), middle-aged (35–49 years), and senior (50 + years), representing 20.9%, 46.7%, and 32.4% of the respondents, respectively. The level of education was divided into three categories: low level (middle school or less; 13%), medium (high school; 48%), and high level (college or more; 40%). The proportions of individuals in each salary group were similar for females and males (χ^2, $p = 0.21$), whereas those for education and age level differed by gender (both $p < 0.01$). In males, middle-aged group was the largest (40%) and the senior and young age groups made up ~ 30% each. However, in female, the young age group made up 18% of the sample, and the middle-aged group was the largest (53%). Approximately 25% of the participants did not provide their salary data because this is considered sensitive personal information.

3.2. Use rates of products

The product use rate was defined as the proportion of product users who responded that they used a given product at least once in the last 3 months. These results are summarized in Table 3. Among PCPs, toothpaste showed the highest use rate followed by shampoo. While shampoo was used by 97.2% of respondents, the hair conditioner use rate was 62.2%. For most products, the proportions of female users were significantly higher than those of males ($p < 0.001$).

For toothpaste, no difference was observed between genders, whereas for shoe polish, the male use rate was significantly higher than the female rate ($p < 0.001$). The use rates also differed by age group. Most PCPs were used more frequently by the young and middle-aged groups compared with the senior group.

Laundry and dish detergents as well as fabric deodorizer were most often used by the middle-aged group, while shoe polish was most often used by the senior group. No differences were found among age groups for antistatic sprays or toothpaste. The more highly educated and higher earning respondents were more likely to use

Table 2
Demographics of the study population.

Variable	Level	n	%
Gender	Male	816	24.5
	Female	2517	75.5
Age	Young (15–34 years)	697	20.9
	Middle (35–49 years)	1557	46.7
	Senior (>50 years)	1079	32.4
Salary	Low (<$2000)	268	8.0
	Medium ($2000–$4000)	1306	39.2
	High (>$4000)	926	27.8
	Missing	833	25.0
Education	Low (middle school or less)	420	12.6
	Medium (high school)	1582	47.5
	High (college or more)	1327	39.8
	Missing	4	0.1