Food and Chemical Toxicology 99 (2017) 128–134

Contents lists available at ScienceDirect

Food and Chemical Toxicology

journal homepage: www.elsevier.com/locate/foodchemtox

Exposure factors for cleaning, automotive care, and surface protection products for exposure assessments

Ji Young Park [a], Miyoung Lim [b], Wonho Yang [c], Kiyoung Lee [a, b, *]

[a] Institute of Health and Environment, Seoul National University, Seoul, Republic of Korea
[b] Department of Environmental Health, Graduate School of Public Health, Seoul National University, Seoul, Republic of Korea
[c] Department of Occupational Health, Daegu Catholic University, Daegu, Republic of Korea

ARTICLE INFO

Article history:
Received 8 October 2016
Received in revised form
21 November 2016
Accepted 23 November 2016
Available online 24 November 2016

Keywords:
Consumer products
Consumer exposure
Exposure factors
Exposure assessment

ABSTRACT

Accurately measuring the usage patterns of consumer products (CPs) is important to conduct realistic exposure assessments. We determined the exposure factors for 18 consumer products: household bleach, mold stain remover, all-purpose cleaner, washing machine cleaner, air conditioner cleaner, glass cleaner, drain cleaner, adhesive remover, liquid snow chain, tire shine spray, wheel cleaner, rain repellent, car wax spray, leather polish, furniture polish, anti-fog product, fabric waterproofing spray, and rust inhibitor. Field survey staff visited homes and collected product use information via face-to-face interviews. In total, 10,000 participants (5010 men and 4990 women) aged 15 years and older completed the questionnaire. Household bleach had the highest use rate of 47.4% and use rates for the other products ranged from 0.8 to 21.7%. The use rates of many CPs differed by age group and gender. Many household cleaning products were used regularly, but some products, such as air conditioner cleaner and liquid snow chain, were used in specific seasons or for specific purposes; therefore, they were used less frequently compared to cleaning products. These exposure factor data will be useful as input data for exposure and risk assessments and setting safety guidelines.

1. Introduction

Consumer products (CPs) are used for personal hygiene, home care, automotive care, and disinfection. While CPs have improved sanitation, their use can also result in exposure to various hazardous chemicals, which can be absorbed into the body via inhalation, ingestion, or dermal absorption. Exposure may lead to adverse health effects. Household bleach (i.e., hypochlorite solution) is the most commonly used cleaning product. It is an inexpensive method of disinfecting kitchen and bathroom surfaces and can effectively inactivate indoor allergens (Matsui et al., 2003). However, inappropriate use of household bleach can result in exposure to chlorine or chloramine gas, causing acute respiratory symptoms. Respiratory airways can be damaged by even short-term exposure to household bleach, which can trigger chronic diseases such as asthma and reactive airways dysfunction syndrome. Although regular use of bleach can protect children from indoor allergens, children regularly exposed to bleach are also at increased risk for recurrent bronchitis. Bleach use might release volatile by-products that can have detrimental effects on the respiratory tracts of children (Nickmilder et al., 2007).

In Korea, the Act on Registration and Evaluation of Chemicals in Korea (K-REACH) was passed on 30 April 2013 and came into force on 1 January 2015 to protect the environment and public health by registering and screening hazardous chemicals. In addition to managing chemicals, it required the establishment of regulations on chemicals in CPs. In 2014, the Korean government classified 12 CP and three biocidal product categories as 'risk-concerned products' (RCPs), including detergents, air fresheners, adhesives, polishes, fabric softeners, sanitizers, and preservatives, many of which are used for housekeeping or in daily life. This regulation is intended to reduce human health risks associated with CP use by applying safety limits or labeling standards for hazardous chemical substances in RCPs. RCPs not compliant with these safety standards are not permitted to be sold.

Risk and exposure assessments must be conducted to establish safety guidelines and labeling standards for RCPs. However, exposure assessments for chemicals in CPs require information on

* Corresponding author. Institute of Health and Environment, Seoul National University, Seoul, Republic of Korea.
E-mail address: cleanair@snu.ac.kr (K. Lee).

http://dx.doi.org/10.1016/j.fct.2016.11.024
0278-6915/

exposure factors, such as frequency of use and amount of product used per application, as well as data regarding the circumstances of use (Van Engelen et al., 2007). Exposure factors have been investigated in females who regularly use CPs (Loretz et al., 2006, 2008), California households (Wu et al., 2010), in Europe (Biesterbos et al., 2013; Hall et al., 2011, 2007), and in Korea (Park et al., 2015). However, exposure factors for RCPs are not available for Asian populations. A national database of exposure factors for RCPs is needed to conduct accurate risk and exposure assessments for RCPs, as nationally representative exposure factors can be used to determine exposure and risk levels among Koreans.

The purpose of this study was to develop a database of national representative exposure factors to conduct RCP exposure assessments. We investigated eight cleaning products, five surface protection products, and five automotive care products to obtain exposure factor data for Koreans aged 15 years or older. The usage rate, frequency, amount per application, duration of use, and daily use amount of the products were determined. These exposure factor data will be useful to regulatory agencies establishing safety guidelines to ensure the safe use of high-risk products.

2. Methods

2.1. Study population

We set 10,000 as the target study population to ensure that we obtained a substantial number of users of rarely used products. The exposure factor survey was conducted in 17 metropolitan areas and provinces, including rural areas, in Korea. The study population included individuals 15 years and older and the gender ratio in Korea was considered when selecting study participants. The number of participants 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 participants was fixed. When a resident refused a survey or a house was empty, interviewers moved to the next house until the required number of participants in each survey location was reached.

2.2. Data collection

Between November 2013 and January 2014, trained interviewers visited each household and conducted face-to-face interviews using a questionnaire. The questionnaire to investigate CP usage patterns collected information regarding demographics and lifestyle, as well as the detailed use of CPs. We assessed the frequency of use and the amount of product used per application for 18 CPs, including cleaning products (household bleach, mold stain remover, all-purpose cleaner, washing machine cleaner, air conditioner cleaner, glass cleaner, drain cleaner, and adhesive remover), automotive care products (liquid snow chain, tire shine spray, wheel cleaner, rain repellent, and car wax spray), and surface protection products (leather polish, furniture polish, anti-fog products, fabric waterproofing spray, and rust inhibitor).

Depending on the application type, different types of questions were asked to estimate the amount of product used per application. For trigger-type sprays, the number of sprays per application was recorded. For aerosol sprays, the duration of application was recorded. For liquid products, the amount of product used was estimated based on a comparison with a 50-mL 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; Park et al., 2015); respondents selected one to estimate the amount of product used. The questionnaire also collected the brand names of products and time spent using each product. All questions were limited to product use within the past 12 months. Next, we purchased the five most commonly used products in each category from retail shops. In the laboratory, we measured the amount dispensed per spray for trigger-type sprays, the mass of aerosol spray applied per unit time, the mass per cup of liquid products, and the amount of each sample corresponding to each printed circles for cream or lotion products.

2.3. Data analysis

All statistical analyses were conducted using SPSS ver. 22 (SAS Institute Inc., Cary, NC, USA). Frequency tables by product were constructed to assess the usage rate of products. Chi-square tests were used to analyze usage rates by gender, age group, level of education, and income level. The mean amount of product per application (g/use) was calculated using the questionnaire data for all CPs. The daily use amount (g/day) for each participant was calculated by multiplying the frequency (use/day) with the amount per application (g/use) and the mean daily use amounts were obtained for each product.

3. Results

3.1. Characteristics of the study population

We obtained exposure factor data using the questionnaire results of 10,000 participants. Approximately half of the respondents were female (4990 individuals). The demographic characteristics of the study participants are presented in Table 1. Participants were divided into three age groups: young (15–29 years), middle-aged (30–49 years), and older-aged (≥50 years), representing 31.6, 34.3, and 34.1% of the respondents, respectively. Education level was divided into three categories: low (middle school or less; 24.7%), medium (high school; 36.6%), and high (college or greater; 38.7%). The proportion of individuals in each income group was similar between genders (χ^2, $p = 0.21$), whereas the proportions of individuals in each education level and age level category differed by gender ($p < 0.01$). Among males, the middle-aged group was the largest (40%) and the older and young age groups made up 30% each. However, among females, the young age group made up 18% of participants and the middle-aged group was the largest (53%).

3.2. Product use rate

The product use rate was defined as the proportion of participants who responded that they used a given product at least once in the last 12 months. These results are summarized in Table 2. The use rates of cleaning products were higher than those of automotive care products and surface protection products. Among cleaning products, household bleach had the highest use rate, followed by

Table 1
Demographic characteristics of the study population.

Variable	Level	n	%
Gender	Male	5010	50.1
	Female	4990	49.9
Age	Young (15–34 years)	3162	31.6
	Middle (35–49 years)	3430	34.3
	Older (>50 years)	3408	34.1
Income	Low (<$2000)	1150	11.5
	Medium ($2000–$4000)	4799	48.0
	High (>$4000)	4051	40.5
Education	Low (middle school or less)	2471	24.7
	Medium (high school)	3660	36.6
	High (college or greater)	3869	38.7