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Usage patterns of personal care products: Important factors for exposure assessment

Jacqueline W.H. Biesterbos [a,*], Tatsiana Dudzina [b], Christiaan J.E. Delmaar [c], Martine I. Bakker [c], Frans G.M. Russel [d], Natalie von Goetz [b], Paul T.J. Scheepers [a], Nel Roeleveld [a]

[a] Radboud University Medical Centre, Department for Health Evidence, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands
[b] Swiss Federal Institute of Technology Zurich, Wolfgang-Pauli-Strasse 10, 8093 Zürich, Switzerland
[c] National Institute for Public Health and the Environment (RIVM), P.O. Box 1, 3720 BA Bilthoven, The Netherlands
[d] Radboud University Medical Centre, Department of Pharmacology and Toxicology, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands

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ABSTRACT

Complete information regarding the use of personal care products (PCPs) by consumers is limited, but such information is crucial for realistic consumer exposure assessment. To fill this gap, a database was created with person-oriented information regarding usage patterns and circumstances of use for 32 different PCPs. Out of 2700 potential participants from the Netherlands, 516 men and women completed a digital questionnaire. The prevalence of use varied by gender, age, level of education and skin type. A high frequency of use was observed for some products (e.g. lip care products), while toothpaste, deodorant and day cream were generally used once or twice a day. The frequency of use for other PCPs varied over a wide range. The amounts of use varied largely between and within different product groups. Body lotion, sunscreen and after sun lotion were often applied on adjacent body parts. The majority of PCPs were applied in the morning, but some products, such as night cream and after sun, were predominantly applied in the evening or night. As expected, the participants used several PCPs simultaneously. The database yields important personalized exposure factors which can be used in aggregate consumer exposure assessment for substances that are components of PCPs.

1. Introduction

In daily life, many people use numerous personal care products (PCPs), such as deodorant, facial moisturizer or night cream on a regular basis (Wu et al., 2010). PCPs are carefully prepared using intricate recipes and a variety of substances with diverse functions. These substances include active ingredients, but also solvents, preservatives and additives, some of which are suspected to affect the health of the consumer, e.g. phthalates, parabens or antimicrobials (triclosan/triclocarban), which may have endocrine disrupting properties (Chen et al., 2008; Lyche et al., 2009; Witorsch and Thomas, 2010). UV absorbers in sunscreens, such as dibenzoylmethanes and benzophenones, as well as fragrances and preservative agents in cosmetics, may initiate allergic or photo-allergic contact dermatitis (Goossens, 2011; Schauder and Ippen, 1997). Other PCPs contain heavy metals, such as mercury or cadmium that may lead to neurotoxicity (CDC, 2012; Ayenimo et al., 2010; Chan, 2011). Consumers are exposed to these substances in small amounts through various PCPs, via multiple routes including inhalation, dermal absorption and ingestion.

In order to assess potential health risks for consumers, it is necessary to conduct aggregate exposure assessments considering the simultaneous exposure to a substance from all possible sources and routes (Lorenz et al., 2011; von Goetz et al., 2010). A common approach is to aggregate deterministic worst-case assessments for all sources and routes, which results in highly unrealistic, but conservative, exposure levels. Therefore, refinement of these unrealistic exposure levels will often be needed. For aggregate exposure, the most effective refinement is to take into account co-use and non-use of products in a person-oriented approach (Cowan-Ellsberry and Robison, 2009). In order to do so, individual exposure factors, such as frequency and amount of use of single products, as well as specific information about the circumstances of use are needed (Van Engelen et al., 2007). In a series of three studies, Loretz and co-workers investigated the distribution of the frequency and amount of use of several cosmetics in a US female population of regular users (Loretz et al., 2005, 2006, 2008).

Abbreviation: PCP, personal care product.

* Corresponding author. Address: Radboud University Medical Centre, Department for Health Evidence (133), P.O. Box 9101, 6500 HB Nijmegen, The Netherlands. Tel.: +31 24 3613728; fax: +31 24 3613505.

E-mail addresses: J.Biesterbos@ebh.umcn.nl (J.W.H. Biesterbos), tdudzina@chem.ethz.ch (T. Dudzina), christiaan.delmaar@rivm.nl (C.J.E. Delmaar), martine.bakker@rivm.nl (M.I. Bakker), F.Russel@pharmtox.umcn.nl (F.G.M. Russel), Natalie.von.goetz@chem.ethz.ch (N. von Goetz), P.Scheepers@ebh.umcn.nl (P.T.J. Scheepers), N.Roeleveld@ebh.umcn.nl (N. Roeleveld).

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Wu and colleagues collected information on the usage patterns of 30 types of PCPs in Californian households (Wu et al., 2010). Special attention was paid to the distribution of the frequency of use of the investigated products. Hall and co-workers also provided distributions of daily amounts of use for several cosmetic products in Europe, including body lotion, facial moisturiser, hair styling products, hand cream, liquid foundation, mouthwash, shampoo, shower gel and toothpaste (Hall et al., 2007, 2011). The Scientific Committee on Consumer Safety used the data collected by Hall and co-workers to provide exposure data for some cosmetic products in their 7th notes of guidance (Scientific Committee on Consumer Safety (SCCS), 2010). All of these studies mainly focused on the frequency and amount of PCP use, but none addressed both the circumstances and patterns of individual product use. Circumstances of use are for example the presence of ventilation or the location of application (indoors/outdoors). Inhalation exposure will be relatively low when a product is used in a ventilated area. Therefore, the aim of the current study was to create a database containing information regarding the circumstances and patterns of individual PCP use. It provides important information on product use for different age and gender groups and can be used to calculate aggregate consumer exposure to various substances in PCPs, by incorporating the information on both product co-use and the circumstances of use.

2. Methods

2.1. Study population

We randomly selected one large (>100,000 inhabitants) and one small (<20,000 inhabitants) municipality in every province of the Netherlands for a total of 24 municipalities. These were requested to draw a random sample of inhabitants between 18 and 70 years of age from their population administration. Each large municipality provided 150 addresses and each small municipality 75 addresses, leading to a total of 2700 addresses of potential participants. We sent invitation letters for the study to all of these addresses, including an internet address linking to a digital questionnaire in November 2011. In early January 2012, a reminder was sent. We also offered the opportunity to complete the questionnaire on paper instead of through the internet.

2.2. Data collection

We developed a web-based questionnaire to assess the use patterns and circumstances of PCPs. This questionnaire contained general questions regarding demographics, lifestyle and skin type. The detailed usage patterns of 32 types of PCPs were assessed using questions regarding the frequency of use and the amount of product used per application. We used photographs to visualize the amount of product used in the following product categories: general hygiene (e.g. deodorant), shaving products, hair care, skin care and tanning products. The photographs contained three images displaying an increasing amount of product (Fig. 1). We recorded the weight of the amount of product shown in each of the images. This information was used to transform the categorical data provided by the respondents (e.g. an amount equal to picture A or an amount between pictures A and B) into numerical values (e.g. 2.5 g) for actual exposure calculation.

For the following PCPs the visual display of amounts was not meaningful: deodorant spray, perfume or eau de toilette, aftershave spray, hair spray, eye shadow, mascara, eye pencil, eyebrow pencil, lip pencil, lipstick, lip balm and nail polish. For these products, we developed alternative questions to describe the amounts used such as: "how often did you spray?" (spray products), "where exactly did you apply the product?" (eye shadow, eye pencil and lip pencil), "how many layers did you apply?" (mascara, eyebrow pencil, lip pencil, lipstick, lip balm and nail polish). A small experimental study was performed and the mean amounts used were calculated by weighing before and after application of the product.

In addition, the questionnaire contained questions regarding the type and brand of the product, the application area on the body, the time of day a product was used (e.g. morning or evening), the location of use (indoors or outdoors) and the presence of ventilation. All of the questions concerned use within the past 6 months, except for the questions regarding tanning products, which covered the past year to minimize seasonal influences.

2.3. Data analysis

Frequency tables were used to describe the prevalence of PCP use. This variable was analyzed by gender (male, female), age group (18–39, 40–54, 55–71), level of education (low, intermediate, high), skin type (dry/sensitive skin, oily/combined skin, normal skin), skin colour (Northern European, Southern European) and lifestyle (non-smoking/no use of alcohol, smoking/use of alcohol) using Chi-square tests. The frequency of use, amount of use, application area on the body, time of application, location of use and the presence of ventilation were also analyzed by gender, age group and level of education using Chi-square tests. In addition, the co-use of products was analyzed using Cohen's kappa, which reflects the level of agreement corrected for agreement by chance between the use of two products. The brand loyalty of the respondents was described by the proportion of respondents using a specific brand per product. Data were analyzed using SPSS version 18.0. Differences with a p-value of less than 0.05 were considered to be statistically significant unless noted otherwise.

3. Results

The results presented below give a general overview; more detailed information is available as Supplementary material.

3.1. Demographics

In total, 516 out of the 2700 potential participants completed the questionnaire and 27 invitation letters were returned to sender. Therefore, the minimum adjusted response rate was 19.3%. A small proportion of the respondents did not provide information on the demographic variables. Among the ones who did, 210 respondents (41.0%) were male and 302 respondents (59.0%) were female. We constructed three age groups: young (18–39), middle aged (40–54) and senior (55–71). These groups contained 21.6%, 36.9% and 41.5% of the respondents, respectively. Furthermore, the respondents were divided into three groups based on the level of education: low (24.2%), intermediate (38.6%) and high (37.2%), defined as the completion of 6–10 years, 11–14 years and 15 years or more of education. Additionally, the parameter skin type was divided into three groups: dry/sensitive skin, oily/combined skin and normal skin for future detailed exposure assessment. Male respondents mostly reported to have normal skin (68.0%), whereas 21.5% and 10.5% had a dry/sensitive or oily/combined skin, respectively. The proportion of women in the three groups was evenly distributed, being 32.6%, 35.5%, 31.9% in the dry/sensitive skin, oily/combined skin and normal skin group, respectively. Only eight respondents had an Asian skin colour and no respondents had a Negroid skin. Therefore, the parameter skin colour was divided into two groups: Northern European (69.3%) versus Southern European (30.7%).

3.2. Prevalence of use

The prevalence of use was defined as the proportion of users that reported the use of a PCP at least once in the past 6 months. Table 1 shows an overview of the percentages of users per product. Although the percentages of users for most general hygiene products were high, approximately 10% of the respondents reported not to have used deodorant or toothpaste in the last 6 months. Of the hair care products, shampoo was used by 96.7% of the respondents while conditioner was used by 33.5%. The majority of the respondents who used conditioner used a rinse off product (84.4%), while others used a leave on product (6.4%) or a combination of both (9.2%). The percentages of female users were higher ($p < 0.05$) compared to the percentages of male users for all PCPs studied, except for shaving products (Fig. 2). For most products, the percentage of users in the age group 18–39 (young) was higher compared to the percentages of users in the older age groups (data not shown). However, hair dye was most often used by middle aged and low/intermediately educated respondents. In addition, the level of education influenced the use of several other PCPs. More users with a high level of education used aftershave (32.8%) compared to users with an intermediate or low level of education (25.1% and 16.0%, respectively; $p < 0.05$). These figures were 42.2%, 41.2% and 17.6%