



Usage pattern of personal care products in California households

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ABSTRACT

Given the concern over the potential for health risks associated with certain ingredients (e.g., phthalates) in personal care products, usage patterns of ~30 types of personal care products (e.g., shampoo, sunscreen, fragrance, etc.) were collected in 604 California households through a telephone interview. Preferences in selecting products, e.g., scented or unscented, aerosol, and brand loyalty, were also investigated. Participants were recruited in three age groups, children (mostly preschoolers), their parents, and adults age 55 or older. Use frequencies of various product types varied by sex, age group, race, education, and climatic region. Product use by parent and child from the same household were correlated. Use frequencies of products in the same class (e.g., skincare) were moderately correlated, which may impact aggregate exposures. Use frequencies observed in this study were generally in the same range as those reported in the EPA Exposure Factor Handbook, but we found differences for some individual products. Our study provides additional data on population-based usage patterns of a large collection of commonly used personal care products pertaining to several age groups and socio-demographic strata. This information will be valuable for exposure and risk assessments.

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1. Introduction

Personal care products are widely and regularly used by people, often on a daily basis. Some chemicals that are found in personal care products, e.g., phthalates, oxybenzone, triclosan, heavy metals (e.g., lead and arsenic), nitrosamines, hydroquinone, and 1,4-dioxane, may be related to allergy, endocrine disruption, neurotoxicity, birth defects, or cancers (CDC, 2005; Golden et al., 2005; Levy et al., 1999; Schettler, 2006; Stickney et al., 2003; Szczerko et al., 1994; Topping et al., 2007). While applying personal care products, people may be exposed to these constituent chemicals through multiple exposure routes, including dermal absorption, inhalation and ingestion.

To assess exposure to chemicals in personal care products, one must know the ingredients of products and the relevant exposure scenarios, including both the use frequency and the amount of product used per time (Engelen et al., 2007). Further, to assess the potential health risks for the population, probabilistic models

are often used, requiring distributions of product use across the population to generate a distribution of exposure (McNamara et al., 2007; Van Veen et al., 2001). However, as pointed out by Weegels and van Veen (2001), there is great variability in product usage between individuals. To quantify such population variability requires data collected in large-scale population-based studies (Wormuth et al., 2005).

In recent years, the European Union has established exposure factor databases for European population (Hall et al., 2007; US GAO, 2005; Vuori et al., 2006). The EIS-ChemRisks toolbox (<http://web.jrc.ec.europa.eu/eis-chemrisks/toolbox.cfm>) and the TNS European Toiletries and Cosmetics Database (<http://www.tns-global.com/uk/etcdneeds>) contain information on exposure factors, exposure scenarios, and measured and modeled exposure data. In the US, the EPA Exposure Factors Handbook provides what the US EPA determines to be the most relevant information (US EPA, 1997). Studies conducted by cosmetic companies or their associations mostly targeted at user groups, in order to obtain information on the amount of product used (Loretz et al., 2006, 2008, 2005; Weegels and van Veen, 2001). Additional data on use prevalence and use frequency of personal care products are needed to establish distributions of use for populations.

As a part of the Study of Use of Products and Exposure-Related Behavior (SUPERB), use patterns of more than thirty types of

Abbreviations: SUPERB, Study of use of products and exposure-related behavior.

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personal care products were investigated among California residents. In this paper, we focus on the distribution of use frequency for personal care products as reported in the baseline survey of two population subgroups, and present a preliminary exploration of product perception and preference.

2. Methods

2.1. Study population

A total of 655 households participated in this study which included multiple elements, of which 604 completed the section on personal care products. Of these, 453 were households from northern California with young children (97% had a child 5 years or younger). These were identified from birth certificate records of children born between 2000 and 2005 in this area (Hertz-Picciotto et al., *in press*). Households in which the mother had less than 12 years of education were oversampled, as a means to counter the well-known low rates of participation in research for this socio-demographic group (Korkeila et al., 2001). In each household, we enrolled two family members: one adult and one child (not necessarily the child identified through the birth certificate). The other 151 households included an older adult (generally aged 55 or above) living in the southern portion of California's Central Valley (hereafter referred to as central California), a population-based sample selected randomly from housing units (Hertz-Picciotto et al., *in press*). Thus, the study population consisted of several age groups, which allowed us to examine the variability of use patterns across age.

2.2. Data collection

Thirty and twenty-five types of personal care products were investigated in this study for adults and children respectively (see Tables 1 and 2 for a full list), including general hygiene products (e.g., bath products and hand soaps), skincare, makeup, hair styling products, and special care products (e.g., nasal spray and contact lens solution). These classes of products were selected because they are widely used by consumers. We investigated use frequency, purchase frequency, and product perception and preference.

Trained interviewers collected data through structured questionnaires in three consecutive annual telephone interviews between October 2006 and November 2009. The team of interviewers included bilingual staff (English/Spanish) and the questionnaires used were the same throughout the study, except for some questions on products we added or removed in the second year. More details on the study design of the SUPERB are available in Hertz-Picciotto et al., *in press*. This paper presents data collected during the first year telephone interview only. Data collected in the following years and variation of use over time will be presented in future publications.

2.3. Data analysis

Distributions of use frequencies for personal care products are summarized by age group, younger adults (parents of young children, 99% under 55-years of age), older adults (98% at 55 or above), and children (1–16 years old) respectively. We examined the differences in prevalence of use and differences in the distribution of use frequency by sex (male/female), adult's age (noting that these two populations live in different regions of California); child's age (5 years or younger/over 5 years), and education (adults with/without college degree), using the Chi-square or Fisher test (for differences in prevalence of use) and the Wilcoxon–Mann–

Whitney test (for differences use frequency). Variation by race/ethnicity (African American/Asian/White (not Latino)/Multiple races (not Latino)/Other races (not Latino)/Latino) was evaluated among northern California female participants using the Kruskal–Wallis test. Spearman correlation coefficients for the use frequencies between adult and child in the same household were calculated. The correlations between use frequencies of different products and between use frequency and purchase frequency were calculated for selected products. Furthermore, we compared our data with comparable statistics from the EPA Exposure Factors Handbook (US EPA, 1997).

We additionally describe the proportions of participants who used scented vs. unscented bath products, who used aerosol products, and who self-treated their hair and nails vs. seeking professional care. We also present data on participants' brand loyalty.

As an internal consistency check, we asked "when was the last time you used the product" and determined if the answer was consistent with use frequency reported. For example, a response for last use as "today" or "within the last 3 days" would be considered consistent with a use frequency of once per day. Over ninety percent of responses (91–99%, depended on product) appeared to be consistent. In order to check for possible systematic error related to the season in which the interview was conducted, we also examined whether participants' responses regarding usual use of products were likely to have a seasonal trend varied by the season in which they were surveyed.

For questions about frequency of use, the respondent provided the number of times, and then selected whether it was per day, week, month or year. In evaluating outliers during the data cleaning step, we searched for numeric peaks that were indicative of the wrong unit having been selected. For example, if shampoo was reported to have been used 7 times a day, we recoded the answer to be 7 times a week. In other cases, outliers were excluded from further data analysis. All analyses were performed using SAS Version 9.2. Statistical significance was set as 0.05, where a *p*-value less than 0.05 was considered a statistically significant difference, unless otherwise noted.

3. Results

3.1. Demographics

We considered four age groups: children 5 years or under, children above age 5, parents of young children (mostly under 55), and older adults (mostly aged 55 or above). We have more female than male adult respondents in this study in both northern (83%) and central (66%) California. The younger adult cohort is race-diversified, with 55% White (not Latino), 22% Latino (regardless of race), 12% Asians (not Latino), 3% African Americans (not Latino), and 15% multiple or other or missing races; the older adult cohort was predominantly White (78%), reflective of the less diverse population of older adults living in this region of the state. Sixty-four percent of the adult participants had a college degree. Other demographic information on our study population can be found elsewhere (Hertz-Picciotto et al., *in press*).

3.2. Use patterns among adults

Both the proportion of the population using the products and the frequency of use varied greatly among products. Table 1 gives the summary data for adult participants by age group and sex. Most personal hygiene products, e.g., shampoo and deodorant, were – as expected – widely used by adult participants and use varied greatly by sex and age group. Use of skincare, makeup, and hair styling products was less prevalent, with various products

Table 1
Summary of usage frequency (per month) of personal care products for adult participants^a.

Product	Female										Male										Comp ^b			
	Parents of young children (N = 374)					Older adults (N = 99)					Parents of young children (N = 79)					Older adults (N = 52)								
	User%	Mean	SD	Med	P90	User%	Mean	SD	Med	P90	User%	Mean	SD	Med	P90	User%	Mean	SD	Med	P90				
General Hygiene	Shampoo	100%	22	9.7	21.7	30	98%	16	9.9	13	30	94%	25	11.4	30	30	85%	23	10.5	30	30	g	f	-
	Hair conditioner	92%	21	10.1	17.4	30	72%	13	9.9	8.7	30	56%	19	12.2	16.3	30	40%	19	11.2	17.4	30	-	f	-
	Bath gel	41%	15	14.3	13	30	34%	17	12.9	17.4	30	15%	28	14.6	30	30	10%	25	14.7	30	45	g	-	-
	Body lotion	85%	25	15.9	30	30	75%	25	11.9	30	30	32%	16	12.6	13	30	17%	14	12.5	8.7	30	g	-	-
	Hand lotion	95%	56	54.7	30	120	96%	57	85.6	30	120	66%	26	43.7	15.2	30	79%	18	19.3	10.9	30	g	-	-
	Deodorant	92%	31	10.9	30	30	93%	30	7	30	30	81%	30	10.8	30	30	92%	27	9.6	30	30	-	-	-
	Liquid soap (antibacterial) ^c	75%	116	130	90	240	68%	138	130	113	300	68%	122	163	90	240	67%	98	120	75	180	-	-	-
	Liquid soap (not antibacterial) ^c	58%	101	86.3	90	210	54%	96	121	60	210	51%	77	50.9	60	150	54%	94	138	60	225	-	-	-
	Waterless hand sanitizer ^c	65%	41	72.6	13	120	50%	87	250	8.7	240	57%	24	52.2	4.3	43	41%	13	25.9	1.5	60	g	-	-
Skincare	Facial cleanser	73%	35	18.8	30	60	59%	30	15.6	30	60	23%	23	14.5	30	30	12%	21	23.5	17.2	60	g	-	-
	Facial moisturizer	81%	33	15.9	30	60	74%	34	14.3	30	60	29%	17	18.1	10	30	19%	15	11.9	13	30	g	-	-
	Mask / Deep cleanser	51%	2.8	6.3	1	4.3	47%	2.4	3.6	1	11	22%	11	13.9	7	30	17%	0.8	-	0.8	0.8	-	-	-
	Anti-aging or overnight cream	40%	27	16.3	30	60	41%	29	12	30	30	6%	18	24.5	13	60	4%	22	12	21.5	30	-	-	-
	Lip Balm/Lipstick ^d	95%	43	50.1	30	90	93%	45	49.8	30	90	64%	8.5	15.3	2.5	30	40%	17	28.8	1.6	75	g	-	-
	Sunscreen - hot season	88%	25	19	30	60	67%	20	15	30	30	87%	15	16.7	8.7	30	58%	8	10.1	2.3	26	g	-	m
	Sunscreen - cool season	53%	20	14	30	30	33%	23	14	30	30	39%	7.0	10.8	1	30	22%	0.9	0.8	1	2.0	g	-	m
Hair style	Hair dye	63%	0.4	0.4	0.3	1.0	51%	0.7	0.5	0.7	1.0	3%	0.2	0	0.2	0.3	4%	1.0	0	1	1.0	-	f	-
	Hair perm ^e	6%	0.3	0.3	0.2	0.8	18%	0.5	0.9	0.3	0.3	1%	0.5	.	0.5	0.5	2%	0.5	.	0.5	0.5	-	-	-
	Hair spray	55%	17	13.9	13	30	70%	18	13.9	17.4	30	10%	7.6	9.1	3.2	22	29%	26	14.3	30	30	-	-	m
	Hair mousse	63%	17	12.1	17.4	30	61%	11	9.7	8.7	30	49%	16	11.4	15.2	30	19%	27	9.2	30	30	-	f	m
	Foundation ^g	65%	17	13	17.4	30	61%	21	12.7	28	30	-	-	-	-	-	-	-	-	-	-	-	f	-
Makeup	Mascara ^g	79%	16	12.1	17.4	30	51%	20	11.9	30	30	-	-	-	-	-	-	-	-	-	-	-	f	-
	Nail polish (professional) ^g	81%	0.6	0.7	0.3	2.0	77%	1.1	1	1	2.0	-	-	-	-	-	-	-	-	-	-	-	f	-
	Nail polish (self) ^g	53%	1.1	1.4	0.5	3.0	39%	2.1	2.4	1	4.3	-	-	-	-	-	-	-	-	-	-	-	f	-
	Fragrance ^g	76%	14	12.6	8.7	30	70%	15	12.8	13	30	-	-	-	-	-	-	-	-	-	-	-	-	-
	Aftershave ^g	-	-	-	-	-	-	-	-	-	-	38%	11	10.4	8.7	30	48%	20	14	17.4	30	-	-	m
	Special care	Contact lens solution	20%	31	21.7	30	60	6%	14	13.9	10.9	30	16%	18	18.4	15.2	30	6%	29	27.5	17.4	60	-	-
Ear wax removal		5%	8.0	13.5	0.2	30	11%	0.7	1.3	0.2	1.8	10%	1.2	1.7	0.1	4.3	16%	2.8	5.2	0.2	15	-	-	-
Nasal Spray		22%	9.2	16.2	1	30	39%	16	19.5	4.3	60	27%	9.0	12.2	2.5	30.0	38%	7.2	10.9	1	30	-	-	-
Insect Repellent		47%	2.4	5.3	0.4	8.7	28%	3.9	12.3	0.3	4.3	46%	1.6	2.8	0.8	4.3	0.4	0.5	0.8	0.2	1.3	-	-	m
Shampoo for lice		2%	1.6	3.5	0.1	8.7	1%	0.1	-	0.1	0.1	0%	-	-	-	-	0%	-	-	-	-	-	-	-

^a Summary is based on Year 1 data, except for liquid soaps and hand sanitizer. Mean and 90th percentile were calculated based on use frequency among users.

^b Comparisons of use frequencies by sex and location were conducted: g – statistically significantly different by sex (pooled location data); f – statistically significantly different by location for female; m – statistically significantly different by location for male; products used by one sex only were not included in the comparison.

^c Questions were asked since Year 2. Statistics are based on Year 2 data. Ns are 252 for mother of young children, 79 for older females, 47 for father of young children, and 40 for older males.

^d Use of lip balm and lipstick was asked together.

^e Hair perm: hair permanently treated, including chemical straightening or relaxing.

^g Females asked only.

^g Males asked only.

Table 2
Summary of usage frequency (per month) of personal care products for child participants^a.

user%		5 yr-old and younger										Over 5-yr-old										Comp ^f		
		Female (N = 185)					Male (N = 171)					Female (N = 31)					Male (N = 39)							
		Mean	SD	Med	P90	user%	Mean	SD	Med	P90	user%	Mean	SD	Med	P90	user%	Mean	SD	Med	P90				
General Hygiene ^b	Hair conditioner	65%	13.5	9.8	13	30	27%	12.6	11	13	30	90%	14.1	10	13	30	43%	14.9	11	11.9	30	x	y	z
	Baby oil	21%	11.1	27	1	30	17%	9	14	2	30	16%	6.5	13	1	30	14%	16.3	13	13	30	-	-	-
	Bath gel	74%	13.3	13	13	30	65%	13	11	9.3	30	45%	7.6	11	3.2	30	37%	12.7	13	6.5	30	x	-	-
	Body lotion	71%	16.5	17	13	30	62%	16.7	14	13	30	70%	20.9	19	13	30	38%	23.7	14	25.9	30	x	-	z
	Hand lotion	68%	18.7	30	8.7	30	55%	16.1	19	8.7	30	70%	22.5	24	13	60	47%	23.7	14	30	30	x	y	-
	Deodorant [‡]	-	-	-	-	-	-	-	-	-	-	42%	27.9	17	30	60	-	32.5	17	30	60	-	-	-
	Liquid soap (antibacterial)	83%	71.2	70	60	150	82%	66.4	61	45	150	83%	103	89	77.6	210	79%	78.9	58	60	150	x	-	-
	Waterless hand sanitizer ^c	81%	25	34	8.7	75	78%	20.7	32	8.7	60	68%	23.6	30	8.7	90	58%	41.4	85	4.3	150	x	-	-
Skincare	Facial cleanser [‡]	-	-	-	-	-	-	-	-	-	42%	21.2	20	19.3	60	11%	10.8	7.9	13	17	-	-	z	
	Lip Balm/Lipstick ^d	65%	17.4	60	4.3	30	49%	9.9	22	1	30	90%	26.7	57	8.7	60	55%	10.1	12	4.3	30	x	y	z
	Sunscreen - hot season	96%	24	19	21.7	60	92%	22.9	17	21.7	60	100%	23.5	15	30	30	89%	17.1	14	13	30	-	-	-
	Sunscreen - cool season	47%	10.4	14	4.3	30	39%	10.3	12	4.3	30	55%	10	13	4.3	30	29%	5.3	8.5	1.8	8.7	-	-	z
Hair style	Hair dye ^{**}	-	-	-	-	-	-	-	-	-	0%	.	.	.	.	0%	.	.	.	.	-	-	-
	Hair perm ^e	1%	0.4	0.1	0.4	0.5	0%	.	.	.	.	10%	0.1	0	0.2	0.2	0%	.	.	.	.	-	-	-
	Hair spray [‡]	-	-	-	-	-	-	-	-	-	56%	5.5	9.5	1	22	33%	18.9	13	26	30	-	-	-	
	Hair mousse	30%	13	12	8.7	30	31%	7.2	9.7	2	30	66%	11.3	12	8.7	30	45%	17	14	17.4	30	x	y	-
Makeup	Mascara ^{**}	-	-	-	-	-	-	-	-	-	21%	16.2	16	17.2	30	-	-	-	-	-	-	-	-	
	Nail polish (self) [‡]	45%	1.4	2	0.8	4.3	-	-	-	-	79%	1.5	1.4	1	4.3	-	-	-	-	-	-	x	-	-
	Fragrance ^{**}	-	-	-	-	-	-	-	-	-	26%	17.4	14	21.7	30	-	-	-	-	-	-	-	-	
	Shaving or tanning cream [*]	-	-	-	-	-	-	-	-	-	26%	19.7	14	30	30	-	8.8	7	6.5	17	-	-	-	
	Aftershave ^{‡**}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42%	21.8	24	13	60	-	-	-	
Special care	Ear wax removal	9%	0.5	1	0.2	0.6	14%	2.6	6.6	0.3	4.3	16%	3	1.9	4.1	4.3	13%	0.3	0.4	0.3	1	-	-	-
	Nasal Spray	10%	7	11	2	30	14%	6.2	10	1.3	30	7%	1.6	2	1.6	3	13%	10.2	13	2	30	-	-	-
	Insect Repellent	47%	3.4	6.9	0.4	8.7	46%	1.9	3.2	0.4	7.5	55%	3.5	5	0.8	13	45%	1.3	1.6	0.4	4.3	-	-	-
	Shampoo for lice	1%	0.3	0.3	0.3	0.5	1%	2	.	2	2	3%	0.8	.	0.8	0.8	5%	0.1	0	0.1	0.1	-	-	-

^a Summary is based on Year 1 data, except for hand sanitizer.

^b Shampoo was not included in the child questionnaire.

^c Questions were asked since Year 2. Statistics are based on Year 2 data. Ns are 236 for children aged 5 and under, 59 for children above 5.

^d Use of lip balm and lipstick were asked together.

^e Hair perm: hair permanently treated, including chemical straightening or relaxing.

^f Comparison of percentage of users (prevalence) and use frequency: x- statistically significantly different of either prevalence or frequency by age group (pooled sex data); y- statistically significantly different prevalence or frequency by sex for children at 5 years or under; z - statistically significantly different prevalence or frequency by sex for children above 5.

[‡] Females asked only.

[‡] Males asked only.

^{*} Question was asked for children ages 8 to 17.

^{**} Question was asked for children ages 12 to 17.

used by 34–88% of all adults and 40–95% of all female adults. All special care products (e.g., nasal spray, ear wax removal product, and contact lens solution) – except insect repellent – were used by less than 30% of the adult participants.

To further explore the variability of use patterns, both the percent of users and the distribution of frequency of use were compared across age group, sex, race, education level, climate, and survey season. The outcome of sex and age comparisons is shown in Table 1. As expected, females were more likely to use personal care products than males, with 18 out of the 25 gender-neutral products being used by a higher percent of females. Females also used some products (8 out of 25) more often than males, as indicated in Table 1. However, though males were less likely to use shampoo and bath gel, those who did use these products reported a higher use frequency than female users. The percent of males and females using liquid soaps and special care products were similar.

We compared the difference in use patterns between the two age groups, parents of young children and older adults, noting that there might be a confounding effect due to geographic differences of the two cohorts. The difference between age groups was examined among females and males separately. The younger female adults in northern California had a higher prevalence of using many personal care products than the older female adults in central California. The use frequencies of shampoo, conditioner and hair mousse were higher for the younger female adults. In contrast, older female adults reported a higher prevalence of using hair spray, permanent hair treatment, and ear and nasal care products, and they reported higher use frequencies of foundation, mascara, nail polish and hair dye than younger female adults. Younger male adults were more likely to use sunscreen and hair mousse, and used them more often than older male adults, while the latter used hair spray and aftershave products more often.

Given that the majority of older adult participants were White, race/ethnicity differences were examined only for younger female adults. Males were not included because of the small sample size. We observed great variations of prevalence and use frequency of personal care products across race/ethnicity (Fig. 1). African Americans used shampoo and hair conditioner less frequently and were more likely to have their hair treated permanently (which includes chemical straightening or relaxing), probably due to differences in hair texture and cultural practices. Asian females generally used skincare products more often but makeup products and deodorants less often than other females. However, we note that people of different races/ethnicities also reported different education attainment levels, with the highest proportion (83%) among Asians and females of “Other race (not Latino)” holding a college degree, compared to the lowest proportion (33%) among Latino females, which might be confounding the crude comparisons by race/ethnicity. Unfortunately, the small sample size of some race/ethnicity groups does not allow further comparison with education controlled. Some comparisons across race/ethnic groups may be subject to small sample biases.

Results (Fig. 2) show that a greater portion of people with college education used sunscreen (in both hot and cold seasons), insect repellent, and used professional services to have their nails painted and hair dyed. In addition, they used facial cleanser and sunscreen (in the hot season) more frequently. In contrast, participants with less education were more likely to use hair spray and deodorant, and they reported a higher use frequency for nasal spray.

We investigated whether certain products for which use might be associated with certain seasons (sunscreen, body lotion, hand lotion, and lip balm), might be reported differently depending on the season in which the interview was conducted. We compared the reported use frequency of such products for households inter-

viewed in the warm season (May to October) vs. the cool season (November to April). The only difference we observed was for lip balm ($p < 0.001$), with higher use frequency reported if the interview was conducted in the hot season, potentially because California has a dry summer season or people use products with SPF in summer. This suggests that for most products, interview season is unlikely to bias the response. From these data, it appears likely that respondents are able to report their average annual use even for products used less commonly during the season of interview. The data from this baseline questionnaire do not allow us to determine if there are actual seasonal differences in use patterns as we asked about average use over the past year only.

3.3. Use pattern of children

The SUPERB study collected use frequency of twenty-five personal care products by children in northern California households (Table 2). The variation of children's use patterns are examined by age and sex.

Differences by age were examined only for products used by all children i.e. older and younger than 5 years of age; questions about the use of makeup or aftershave products were not asked for children aged 5 years or younger. Younger children were found more likely to use bath gel and body lotion than older children, whereas older children were more likely to use hair conditioner, lip balm, hair mousse, nail polish, and waterless hand sanitizer. Older children used body lotion, hand lotion, antibacterial soap, and lip balm more frequently than younger children.

Given special concerns regarding exposures for infants, we further broke down the two age groups into smaller groups: 1 year old vs. 2–5 years old (in the group aged 5 and younger); 6–8 years old vs. above 8 years (in the group > 5 years of age). As expected, the use of personal care products on 1-year-old children was remarkably different from children at 2–5 years old (Fig. 3, more data are available in Supplement). Children aged 2–5 years were more likely to use and more frequently used hair conditioner, hand lotion, lip balm, hair mousse, and insect repellent, while a larger proportion of parents applied sunscreen on 1-year-old babies in the cool season. However, not many differences were observed for the older children, except that children above 8 years of age were more likely to use hair conditioner and used hair conditioner and deodorant more often than children between 6 and 8 years of age.

Sex differences were less frequent in children than adults but a trend for greater personal care product use by girls was present. Statistically significant differences were only observed for a few products, specifically, hair conditioner, body lotion, hand lotion, facial cleanser, lip balm, and sunscreen.

Use frequencies by parents and children in the same household were moderately correlated (nonusers included) in both age groups of children, with Spearman R ranging from 0.18 to 0.65 for many products, including hair conditioner, body lotion, hand lotion, antibacterial liquid soaps, hand sanitizer, sunscreen, nasal spray, and insect repellent. In addition, correlation with parent's use of bath gel ($R = 0.35$), lip balm ($R = 0.27$), and nail polish self-treatment ($R = 0.33$) were only observed for children at 5 or under, while a correlation with parental use for hair mousse ($R = 0.30$) was observed in older children only.

3.4. Correlation between use frequencies of different products

Co-use of products that contain the same chemicals contributes to aggregate exposures, which is important information for risk assessment. We therefore examined the correlations of use frequencies in adults for 26 personal care products (Table 3, including

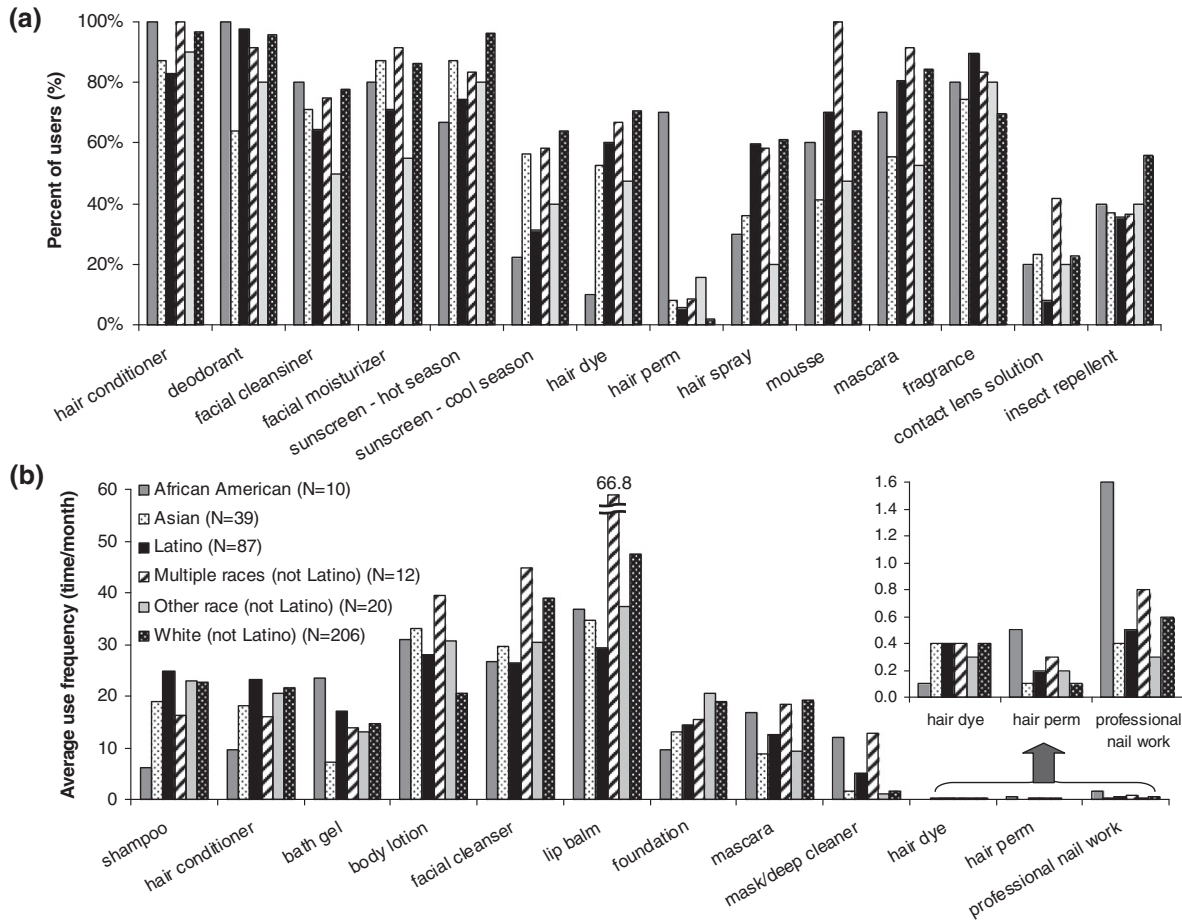


Fig. 1. Comparison by race among females with young children (18 to 55 years old) in northern California: difference of (a) percent of users and (b) average use frequency among users (ONLY products with differences with $p < 0.05$ were shown).

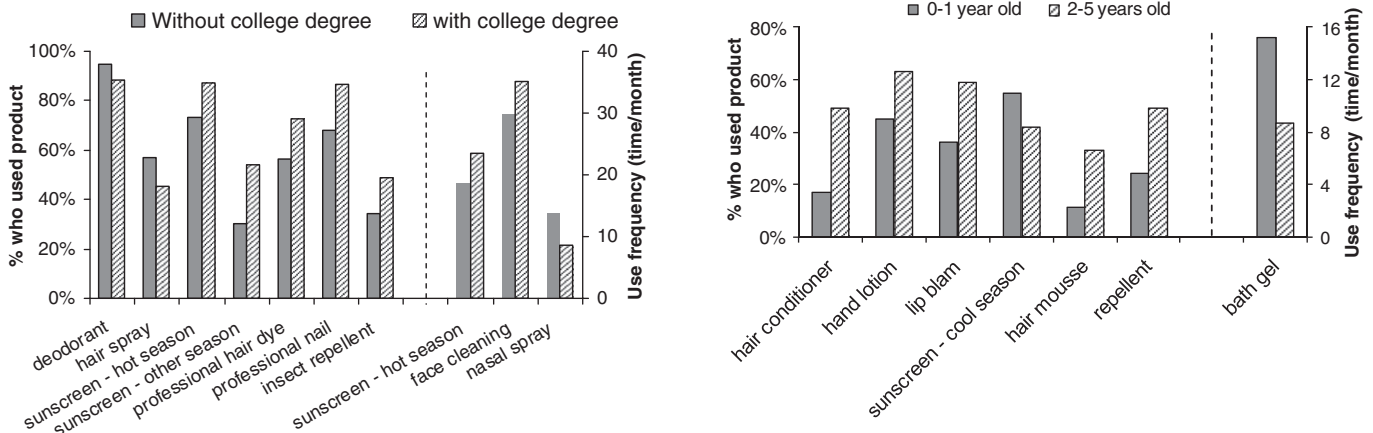


Fig. 2. Comparison of product use by education (with vs. without a college degree) among adults (ONLY differences with $p < 0.05$ were shown).

Fig. 3. Comparison of product use between children of 1 year old and children of 2–5 years old (ONLY differences with $p < 0.05$ are shown).

participants who did not use products). Of these, 17 products were correlated with more than 10 other types of personal care products.

Use frequencies of many hygiene products were correlated with each other, as indicated in Table 3, with p -values less than 0.01, for example, body lotion and hand lotion ($R = 0.61$), and shampoo and hair conditioner ($R = 0.43$). Use frequencies of skincare products were moderately correlated with each other ($R = 0.28–0.54$) as

well. Use frequencies of some skincare products had moderate correlation with hygiene products, e.g., face moisturizer with body and hand lotion.

Use frequencies of makeup products were correlated with each other, e.g., use of foundation was correlated with use of mascara ($R = 0.47$, $p < 0.0001$). Both foundation and mascara were correlated with hair styling products ($R = 0.18–0.33$) and face cleaning products ($R = 0.29$ and 0.36 respectively), but not necessarily with hygiene products and other skincare products.

Table 3
Correlation between use frequencies of different products across product classes for all subjects^a.

Spearman Correlation (R)	General Hygiene Products										Skincare					Hair style					Makeup and fragrance					
	Shampoo	Hair conditioner	Bath gel	Body lotion	Hand lotion	Deodorant	Facial cleanser	Facial moisturizer	Mask/Deep cleanser	Anti-aging or overnight cream	Lip Balm/ Lipstick	Sunscreen -hot season	Sunscreen -cool season	Hair dye	Hair perm	Hair spray	Hair mousse	Foundation	Mascara	Nail polish (professional)	Nail polish (self)	Fragrance (Female only)	Fragrance (Male only)	Aftershave		
General Hygiene	Shampoo	0.43																								
	Hair conditioner		0.23																							
	Bath gel			0.23																						
	Body lotion				0.61																					
	Hand lotion					0.13																				
	Deodorant						0.15																			
Skincare	Facial cleanser							0.54																		
	Facial moisturizer								0.17																	
	Mask / Deep cleanser									0.37																
	Anti-aging or overnight cream										0.34															
	Lip Balm/ Lipstick											0.22														
	Sunscreen - hot season												0.45													
	Sunscreen - cool season													0.46												
	Hair dye														0.37											
	Hair perm															0.27										
	Hair spray																0.31									
	Hair mousse																	0.21								
	Foundation																		0.33							
	Mascara																			0.28						
	Nail polish (self)																				0.11					
	Nail polish (professional)																					0.28				
	Fragrance (Female only)																						0.36			
	Aftershave (Male only)																							0.24		
Hair style	Hair dye																									
	Hair perm																									
	Hair spray																									
	Hair mousse																									
	Foundation																									
	Mascara																									
	Nail polish (self)																									
	Nail polish (professional)																									
	Fragrance (Female only)																									
	Aftershave (Male only)																									
	Shampoo																									
	Hair conditioner																									
	Bath gel																									
	Body lotion																									
	Hand lotion																									
	Deodorant																									
	Facial cleanser																									
	Facial moisturizer																									
	Mask / Deep cleanser																									
	Anti-aging or overnight cream																									
	Lip Balm/ Lipstick																									
	Sunscreen - hot season																									
	Sunscreen - cool season																									
	Hair dye																									
	Hair perm																									
	Hair spray																									
	Hair mousse																									
	Foundation																									
	Mascara																									
	Nail polish (self)																									
	Nail polish (professional)																									
	Fragrance (Female only)																									
	Aftershave (Male only)																									

^a Spearman correlation coefficients were used. Zero-use was included. Only correlation with $p < 0.05$ were shown.

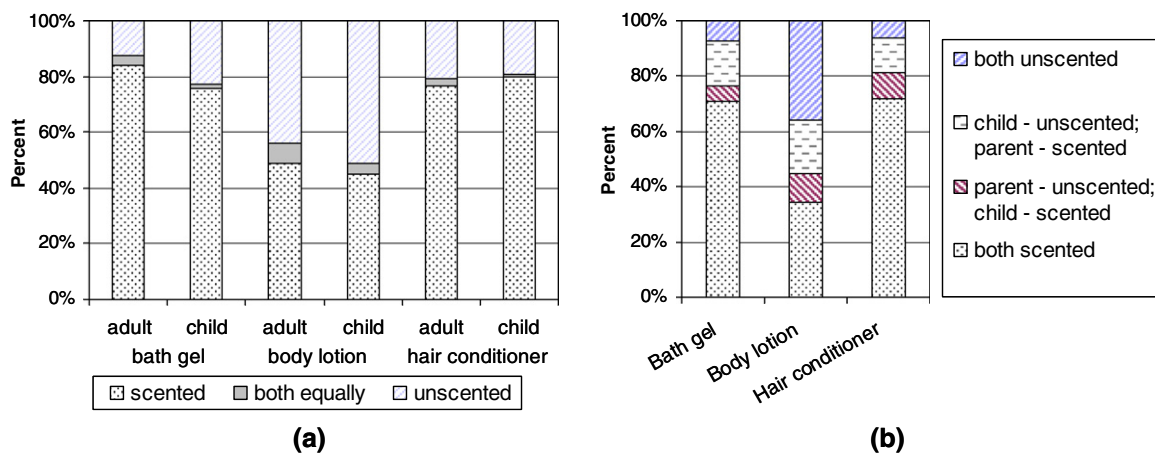


Fig. 4. Preference for using scented or unscented hygiene products: (a) scented or unscented hygiene products used by adults and children, with the adult category including both northern and central California adults. (b) overlap of using scented or unscented hygiene products by parent and child in the same northern California household (Note: Those who answered using scented and unscented products “both equally” made up a small percentage (<5%) and were placed in “unscented” category. Participants who answered “don’t know” were not included in this figure.).

Correlations among hair products were complex. Hair dye was correlated with hair conditioner ($R = 0.27$, $p < 0.0001$), but not with shampoo. anent treatment was negatively correlated with shampoo ($R = -0.19$, $p < 0.0001$), but not correlated with conditioner use. Finally, hair spray and mousse were not correlated with hair perm, and only weakly with hair dye.

3.5. Product preference

3.5.1. Unscented products

As shown in Fig. 4a, half of the participants used scented body lotion, while the majority (>70%) the participants used scented bath gel and hair conditioner, possibly because there are fewer unscented bath gel and hair conditioner products available. The percentages of children using unscented hygiene products (20% ~ 55%) were slightly higher than for adults (15% ~ 50%).

We further examined the overlap of parents and children using unscented products among the households with young children. In 31% of the households, parents and children both use unscented body lotion, but the overlap of using unscented bath gel and hair conditioner was small (5.2% and 7.4%) (Fig. 4b). In a number of families (18–50%), parents did not use unscented products but their children did.

3.5.2. Aerosol

In our study, 59%, 36% and 4% of the adult participants reported using aerosol hair spray, insect repellent, and deodorant respectively, with a higher proportion of the older adults using aerosol hair spray and deodorant than parents of young children. Adults with a college degree used aerosol hair spray ($p = 0.03$) and insect repellent ($p < 0.01$) less frequently.

3.5.3. Professional services

The majority of adult participants who had their hair dyed (66%) or permanently treated (84%), had it done by professionals. Eighty percent of the women in the survey had their nails painted professionally in the last year, and half of the women had painted their nails themselves in the last year.

3.5.4. Brand loyalty

Adult participants were asked how long they have used the same brands of personal care products they currently reported using. Brand loyalty varied greatly by products, with less brand

loyalty for anti-aging products, antibacterial liquid soaps, and hair mousse, and significant loyalty for contact lens solution, aftershave, and insect repellent, presented in Fig. 5.

The responses on brand loyalty did not vary by sex, except that men showed more loyalty to their commonly-used brands of antibacterial liquid soaps and lip balm. However, remarkable differences were observed for younger and older adults. Younger adults tended to change brands more frequently, with 42–69% of participants using the same brand for less than four years and 76–100% for less than ten years. In contrast, older adults stayed loyal to one brand longer, with up to 69% of participants having used the same brand for more than ten years. In particular, 56% of the older males used a single brand of aftershave products for more than twenty years. A small number (0–14%) of participants reported “buying a new brand each time or whatever is on sale”, for both younger and older adults.

3.6. Correlation between usage frequency and purchase frequency

To determine if purchase information can be an alternate way to explore use frequency, we calculated the correlation between the two measures for selected products. We found that use frequency was correlated, but not strongly so, with purchase frequency. The Spearman correlation coefficients were 0.31 ($p < 0.0001$) for shampoo, 0.40 ($p < 0.0001$) for body lotion, 0.20 ($p = 0.0042$) for antibacterial soap, and 0.66 ($p < 0.0001$) for hair spray.

4. Discussion

This study provides information on current usage patterns of about thirty widely used personal care products for a cohort of California residents. Unlike previous consumer behavior studies, this survey was conducted in a general population sample and not limited to users of certain products. We therefore are able to report information on the prevalence of product use in this population. As use frequency is needed for estimating exposure to ingredients in personal care products, data from this study can serve as input to exposure and risk modeling.

We found that use patterns of personal care products varied by socio-demographic factors. Females were more likely to use many of the products used by both sexes than males, and also use them more frequently than males. Younger adults were heavier users of

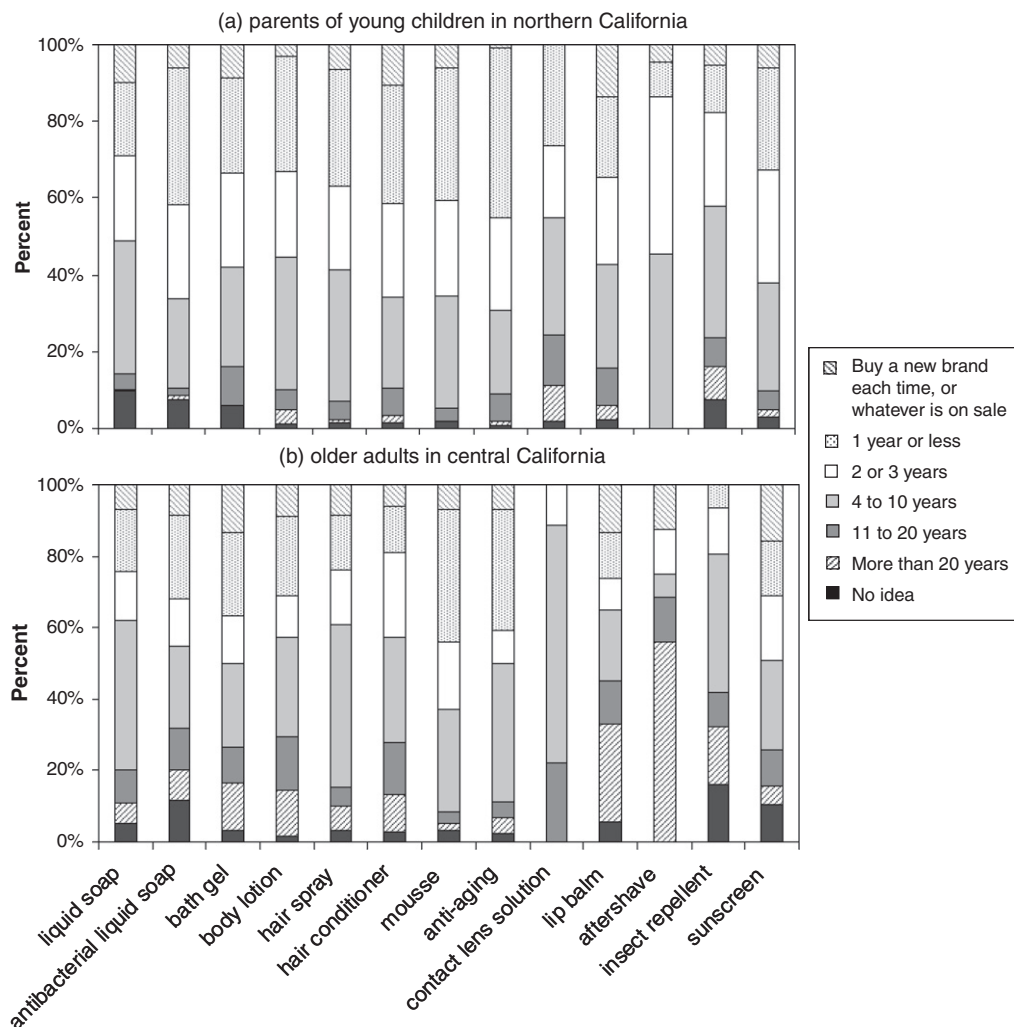


Fig. 5. Brand loyalty of using personal care products among northern (a) and central (b) California cohorts.

many personal care products, with exceptions for health related products (e.g., nasal spray), and some products may not be popular with younger populations (e.g., hair spray and aftershave products). According to the results for younger women, race is an important factor determining the usage of personal care products for a range of product categories. Educational attainment also influences choices of some products where health awareness may be a factor (e.g., more frequent use of sunscreen) or where higher income might play a role (e.g., more use professional services for nails). We found the product use of parents and children in the same household to be somewhat correlated, suggesting that either parents use the products on their children with similar patterns as they use them on themselves, or for older children, that parental use patterns influence their children's use and thus their exposure to chemicals in the products. For example, a surprisingly high percentage of young children used nail polish (45% of girls ages 5 or under) and hair mousse (30%). This might be explained by 81% of female parents reporting professional nail polish treatment and 63% using hair mousse.

One aim of investigating use frequency is to contribute information for the purpose of estimating aggregate and cumulative exposure to chemicals with potential health risks in personal care products. Since co-use of personal care products containing the same ingredients would result in aggregate exposure (Cowan-Ellsberry and Robison, 2009), it is relevant that we observed the use of personal care products from the same class (i.e., hygiene products/

makeup/skincare/hair products) to be moderately correlated, while use of products in different classes was not necessarily correlated. Considering that products in the same class can contain similar ingredients, this information can assist in the estimation of exposure to chemicals from multiple products.

In our study, we also examined correlations between purchase frequency and use frequency of selected personal care products, which is important for exposure modeling given limited usage data. Correlations between purchase and use frequency were low to moderate for the products we examined, and did not change when we distinguished between participants who bought regular size or bulk (wholesale) products. This observation suggests additional complexity for purchase frequency and individuals' use frequency, e.g., study participants may share products with family members, or may not necessarily use all of each product bought. Given these considerations, we would advise against employing purchase frequency as a proxy for use frequency.

There are very limited published data available about use patterns of personal care products in the US. The US EPA Exposure Factors Handbook (in short, Handbook) (EPA, 1997) included data from three studies conducted by the Cosmetic, Toiletry, and Fragrance Association, Inc. (CTFA) (1983): one targeting CTFA employees, one of customers of a cosmetic manufacturer, and one conducted in the general female population reflecting the socio-demographic characteristics of the entire US female population (US EPA, 1997). To enhance comparability, we calculated the use

Table 4
Comparison of the use frequency (per month) of personal care products between the US EPA Exposure Factors Handbook and the female population in SUPERB.

US EPA Exposure Factor Handbook Category	EPA Exposure Factors Handbook ^a						SUPERB ^b (N = 473)				SUPERB Category
	CTFA (N = 47)		Cosmetic Co. (N = 1129)		Market Research Bureau (N = 9684)		Female users only		All Females		
	Mean	P90	Mean	P90	Mean	P90	Mean	P90	Mean	P90	
Wrinkle smoothers	0.63	30	4.5	30	–	–	27.2	60	10.9	30	Anti-aging or overnight cream
Night skin care products	5.4	30	15	30	–	–	–	–	–	–	–
Baby oil - baby use ^c	4.2	4.2	36	90	–	–	10.2	30	–	–	Baby oil baby use
Underarm Deodorants	30.3	38.7	24	38.7	33	60	30.6	30	28.2	30	Deodorant
Lipstick & lip gloss ^d	51.9	120	36.9	85.8	78.6	180	43	90	40.8	90	Lip Balm/Lipstick
Cleansing product (cold creams, cleaning lotions liquids & pads) ^e	18.9	51.3	24	60	16.2	45	34	60	23.6	60	Facial cleanser
Hair conditioner	12	30	12	30	8.1	25.8	19.5	30	17.2	30	Hair conditioner
Hair dye	0.03	0.12	–	–	0.15	0.42	0.46	1	0.28	0.75	Hair dye
Moisturizers ^f	29.4	60	26.4	51.3	18.9	45	33.3	60	26.5	60	Facial moisturizer
Foundations	13.8	30	23.4	30	14.1	45	17.8	30	11.5	30	Foundation
Colognes & Toilet Water	20.4	51.3	25.5	42.9	16.8	45	14.3	30	10.7	30	Fragrance
Perfumes	8.7	25.8	7.8	30	11.4	45	–	–	–	–	–
Hair sprays	7.5	30	16.5	30	9.6	30	16.9	30	9.9	30	Hair spray
Mascara	23.7	38.7	26.1	30	13.8	45	16.9	30	12.3	30	Mascara
Paste mask (mud packs)	0.81	4.2	6	12.9	–	–	–	4.3	1.4	4.3	Facial mask / Deep cleanser
Nail polish & Enamel ^g	4.8	21.3	6	12.9	2.1	30	1.3	4.3	0.6	2	Nail polish (self)
Permanent Wave	0.09	0.25	–	–	0.03	0.15	0.7	2	0.5	2	Nail polish (professional)
Hair straighteners	0.021	0.15	–	–	–	–	0.36	0.50	0.03	0	Hair perm
Shampoos	24.6	30	17.7	30	14.4	30	20.9	30	20.9	30	Shampoo
Sunscreen	0.09	4.2	–	–	0.06	0.15	24.1	43.4	20.2	30	Sunscreen - hot season
							20.2	30	9.9	30	Sunscreen - cool season

^a Source: Cosmetic, Toiletry, and Fragrance Association, Inc. (CTFA), 1983;

^b Only female subjects 13 years of age and older were included. The average use frequency (per month) was determined for both “users” and “non-users”.

^c The use frequency of baby oil was determined among “users” only, including both sex.

^d Not including lip balm.

^e Not specified facial.

^f Not specified facial or body.

^g Not specified self and professional service.

frequency for SUPERB participants based on all females 13 years of age and older. The product classes used in the CTFA and the SUPERB studies were somewhat different too, but we compared the use frequencies of the products surveyed in both studies nevertheless (Table 4). SUPERB recorded higher use frequency of anti-aging or night cream, hair conditioner, facial cleanser and moisturizer, hair dye and perm, and sunscreen. In contrast, CTFA studies found higher use frequencies for foundation, mascara, fragrance, and nail polish. The CTFA studies were conducted in the early 1980's and thus changes in use patterns might be attributable to market shifts in the cosmetic industry over time, e.g., people have paid more attention to skincare than makeup recently; easy-to-use hair dye products have been developed; and awareness regarding the importance of UV protection has increased.

For the SUPERB data in this report, we used information obtained through phone interviews, a common data collection method in population-based surveys, which may introduce errors of recall. Our data checking method demonstrated consistency and internal validity of the data collected, and interview season was found to be unlikely to have biased the response. A drawback of phone interviews is that one cannot expect participants to be able to accurately report the quantity of product used per application, critical in estimating personal care product exposure level for risk assessments. In addition, owing to our focus on younger children, this study only included a small number of children older than 5 years ($N = 70$).

In summary, this study provides recent information on use patterns for a large number of commonly used personal care products at baseline for two population groups, thus updating the current knowledge on usage of personal care products. Compared to previously collected data, use frequencies reported in this study were

similar for many product types but did show differences for some product classes, which may be due to market shifts in the cosmetic industry and rising health consciousness among the public. The information on percentage of users, variation of use frequency by socio-demographic factors, and correlation between usages of different products, provides some essential input for future exposure and risk assessment modeling.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.fct.2010.08.004](https://doi.org/10.1016/j.fct.2010.08.004).

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