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Authors
Berger, Kimberly P
Kogut, Katherine R
Bradman, Asa
et al.

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Personal care product use as a predictor of urinary concentrations of certain phthalates, parabens, and phenols in the HERMOSA study

Kimberly P. Berger, MPH[1], **Katherine R. Kogut, MPH**[1], **Asa Bradman, PhD**[1], **Jianwen She, PhD**[2], **Qi Gavin**[2], **Rana Zahedi, PhD**[2], **Kimberly L. Parra**[3], and **Kim G. Harley, PhD**[1,*]

[1]Center for Environmental Research and Children's Health (CERCH), School of Public Health, University of California, Berkeley, CA, USA

[2]Environmental Health Laboratory, California Department of Public Heath, Richmond, California, USA

[3]Clinica de Salud del Valle de Salinas, Salinas, California, USA

Abstract

Use of personal care products, such as makeup, soaps, and sunscreen, may expose adolescent girls to potential endocrine disruptors, including phthalates, parabens, and other phenols. We evaluated the relationship between recent self-reported personal care product use and concentrations for urinary metabolites of phthalates, parabens, triclosan, and benzophenone-3 (BP-3) in 100 Latina adolescents. Girls who reported using makeup every day vs. rarely/never had higher urinary concentrations of monoethyl phthalate (MEP) (102.2 ng/mL vs 52.4 ng/mL, P-value: 0.04), methyl paraben (MP) (120.5 ng/mL vs. 13.4 ng/mL, P-value <0.01), and propyl paraben (PP) (60.4 ng/mL vs. 2.9 ng/mL, P-value <0.01). Girls who reported recent use of specific makeup products, including foundation, blush, and mascara, had higher urinary concentrations of MEP, mono-n-butyl phthalate (MBP), MP, and PP. Use of Colgate Total toothpaste was associated with 86.7% higher urinary triclosan concentrations. Use of sunscreen was associated with 57.8% higher urinary concentrations of BP-3. Our findings suggest that personal care product use is associated with higher exposure to certain phthalates, parabens, and other phenols in urine. This may be especially relevant in adolescent girls who have high use of personal care products during a period of important reproductive development.

Keywords

Personal care products; product use; phthalates; parabens; triclosan; benzophenone-3

Corresponding author: Kim Harley, PhD, Center for Environmental Research and Children's Health (CERCH), School of Public Health University of California, Berkeley, 1995 University Ave Suite 265, Berkeley, CA USA, Phone: (510) 643-1310, kharley@berkeley.edu.

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Introduction

Synthetic chemicals are regularly used in personal care products. Phthalates such as diethyl phthalate (DEP), di-n-butyl phthalate (DBP), and di-isobutyl phthalate (DiBP) are used in fragrance, deodorants, soap, shampoo, nail polish, and cosmetics. (1–4) Parabens, including methyl paraben (MP), propyl paraben (PP), butyl paraben (BP), and ethyl paraben (EP), are used as bactericides, fungicides, and preservatives in cosmetics and pharmaceuticals. (4, 5) Triclosan is an anti-microbial agent that was widely used in antibacterial hand soaps until it was banned by the FDA in 2016 (6) and continues to be used in some toothpaste, mouthwash, acne cream, and deodorant. (7) Benzophenone- 3 (BP-3; also known as oxybenzone) absorbs ultraviolet A and B rays and is found in sunscreens and sun-protectant lip balm and foundation. (8, 9) BP-3 has also been used to prolong durability of lipstick, shampoo, and lotion. (10)

Most of these personal care product chemicals have been associated with endocrine disrupting effects *in vitro*, (11, 12) in animals, (13–19) and in humans, (13–15, 20–25) including in a longitudinal study of 1,239 girls that showed later puberty was associated with higher prepubertal levels of phthalates. (26) Phthalates, parabens, triclosan, and BP-3 have also been associated with immunotoxic effects *in vitro*, (27, 28) in animals, (27, 29–33) and in humans, (34–40) including in a longitudinal study of 171 children followed from birth until age nine who showed increased risk for asthma and higher serum levels of IgE associated with prenatal phthalate exposure. (41) In addition, *in vitro* and mouse studies suggest that triclosan and some parabens play a role in cancer progression, (13, 42, 43) but the literature is not conclusive. Triclosan has also been associated with thyroid dysfunction *in vitro*, (14) mice, (14, 44) and in a longitudinal study of 194 participants. (45)

These personal care product chemicals are ubiquitous environmental contaminants and have been detected globally in aquatic environments, wastewater treatment plants, drinking water, indoor dust, and wildlife. (46–50) Evidence suggests that phthalates, parabens, triclosan, and BP-3 readily enter the body through dermal absorption, inhalation, or ingestion. (1, 2, 51, 52) Exposure in the United States population is widespread, with the majority of Americans having detectable metabolites of these chemicals in their urine. (53–55) Women, who use higher amounts of personal care products than men, tend to have higher urinary concentrations of these chemicals. (56) Adolescent girls may be particularly exposed; according to one small study, the average teenage girl uses 17 products daily, compared to 12 daily products for the average adult woman. (57) Adolescence may be a particularly critical window of exposure to endocrine disruptors as girls are undergoing reproductive and pubertal development. Additionally, there is evidence from the National Health and Nutrition Examination Survey (NHANES) that levels of some phthalates and parabens are higher in minority women, including Mexican Americans, than in white women. (58)

Some studies have found associations between personal care product use and higher urinary concentrations of these chemicals. A study of 337 U.S. pregnant women conducted between 2002 and 2005 found that use of perfume, deodorant, hairspray, conditioner, other hair products, and bar soap in the previous 24 hours was associated with higher urinary concentrations of mono-ethyl phthalate (MEP), a metabolite of DEP. (59) Use in the previous 48 hours of eye makeup, scented products, nail polish or remover, and sunscreen was associated with higher concentrations of mono-butyl phthalate (MBP), a metabolite of DBP, in 50 U.S. pregnant women from 2000 to 2004. (60) Use of lotion, perfume/cologne, cosmetics, nail polish, sunscreen, and hair gel in the previous 24 hours was associated with higher paraben concentrations in a U.S. study of 177 pregnant women from 2005 to 2011. (61) Studies have found that concentrations of phthalates and parabens in urine increased with the number of products used. (59, 61–65) The current study may reflect recent changes in product ingredients, such as declines in DEP and DBP in the mid and late 2000s. (66) We have previously published results of an intervention study of this population showing that using personal care products labelled free of phthalates, parabens, triclosan, and BP-3 for three days was associated with significantly reduced urinary metabolite concentrations of these compounds. (67)

To further assess the relationship between use of specific personal care products and exposure to these chemicals, we collected detailed information about recent product use of the teenage girls participating in the intervention study and measured their urinary concentrations of several phthalates, parabens, and phenols. Based on known ingredient classifications, we hypothesized that we would observe associations between phthalate concentrations and scented product use, (1–4) paraben concentrations and makeup use, (4, 5) triclosan concentrations and use of antibacterial hand soap, specific toothpastes, and other anti-microbial products, (7) and benzophenone-3 concentrations and use of sunscreens. (8, 9) This is the first study to-date examining these exposure in Mexican-American adolescents.

Materials and Methods

Study population

The Health and Environmental Research on Makeup of Salinas Adolescents (HERMOSA) Study was a youth-led intervention study to reduce endocrine disruptor exposure from personal care product use among adolescent girls. Information on this youth participatory action research study has been previously published. (67, 68) Study participants were 100 Latina adolescent girls living in Salinas, California, a small city in an agricultural region with a predominantly Latino population. Participants were recruited in May-July 2013 through social media, word of mouth, and personal contacts of the collaborating youth research assistants. Eligible participants were girls between 14 and 18 years of age who had lived in the United States for at least 1 year and spoke English or Spanish. Informed consent was obtained for all 18-year-old participants and parental permission and informed assent was obtained for 14- to 17-year-old participants. The study was approved by the Committee for the Protection of Human Subjects at the University of California, Berkeley.

Data collection

Study participants were interviewed three times: during a home visit, and at pre- and post-intervention office visits. The current analysis uses data collected only at the home visit and pre-intervention visit. At the home visit, we obtained parental permission and gathered information about family income and use of scented items and cleaning products in the home. We also took photographs of all the participant's cosmetics and personal care products (divided into hair, face, body, and teeth items) to document types and brands and to help with recall during the pre-intervention office visits. At the pre-intervention office visit, the participant completed a structured questionnaire that inventoried all the personal care products she had used on her hair, face, body, and teeth that day and the previous day, including the time of day each was used. At the same office visit, the participant then provided a urine sample in a sterile polypropylene cup for analysis of phthalate, paraben, triclosan, and BP-3 analytes. For the intervention segment of the study, participants were asked to refrain from using any regular personal care products for three days until returning to provide a follow-up urine sample at the post-intervention visit. Data from the intervention visit was not included in the present analysis results of the intervention study have been published previously. (67)

Laboratory analysis

Urine specific gravity was measured in the field at the time of collection using a handheld refractometer (PAL-10S, Atago USA Inc). All urine samples were then aliquoted and frozen at −80°C until shipment on dry ice to the Environmental Health Laboratory of the California Department of Public Health in Richmond, California for analysis. Laboratory methods for phthalates (69) (DEP, DnBP, and DiBP) and phenols (70) (MP, PP, EP, BP, triclosan, and BP3) have been previously described. Detection frequencies were below 49% for BP and 55% for EP, so these two analytes were not included in final statistical analyses presented here.

Chemical analyte concentrations were reported in ng/mL of urine. Concentrations below the limit of detection were assigned the value of LOD/(square root 2). (71) The median specific gravity for our population was 1.018. To account for urinary dilution, we corrected analyte concentrations for specific gravity using the equation: (analyte concentration * 1 – 1.018)/(sample specific gravity – 1). (64) Concentrations of urinary personal care product chemical analytes (MEP, MBP, MiBP, MP, PP, triclosan, and BP-3) tended to be log-normally distributed and were thus log2-transformed for analysis.

Personal care product use

The current analysis focused on use of a comprehensive list of personal care products, including makeup (foundation, blush, eyeliner, mascara, eyeshadow, lip gloss, lipstick, lip balm, etc.), other face products (acne medication, facial cleanser or soap, makeup remover wipes, etc.), oral hygiene (Colgate Total toothpaste [the only toothpaste used by participants that lists triclosan as an ingredient], any toothpaste, mouthwash, teeth whitener, etc.), sunscreen, lotion/moisturizer, deodorants/perfumes (stick or roll-on deodorant, spray on deodorant, perfume), soaps (bar soap, liquid soap, antibacterial soap, any handwashing), nail products (nail polish, nail polish remover, etc.), hair products (shampoo, conditioner, leave in conditioner, hair heat protector, hair gel, hair oil, hair spray, etc.), and feminine care products (tampons or pads; feminine sprays, wipes, or douches). Because phthalates can be found in some scented household products, we also examined use of scented cleaning products, scented laundry detergent, and air freshener in the home. We gathered information separately about whether the girls had used products on the day of urine collection or on the day before urine collection. We chose to categorize products as "used today or yesterday (yes/no)" for the final analysis because this represented all use in the previous 24-36 hours and was more strongly correlated with almost all urinary analyte concentrations than use today or yesterday alone. The exception was toothpaste which had been used by all participants in the previous two days and was instead assessed as "used today (yes/no)". In sensitivity analyses, we looked at product use only on the day of urine collection ("today only") and only on the day before urine collection ("yesterday only").

Additionally, we asked about typical personal care product use, including how often the participant typically used make-up, fragrance, and moisturizer (every day, 2-6 times a week, once a week, rarely/never). Scented laundry detergent was assessed as whether or not the participant's family usually used it, and air freshener was assessed as "Did Use/Did Not Use" in the last week. We additionally aggregated several similar products into broader categories. For example, lipstick, lip gloss, and lip balm were examined both individually and together as 'any lip product'.

Statistical analysis

We compared geometric mean concentrations of each urinary analyte among participants who used vs. did not use each product (today and/or yesterday) using t-tests. For variables that measured categories of product use (for example, how many times a week a participant used makeup), we compared geometric means across categories and calculated a P value for trend using one-way ANOVA and linear regression.

We controlled for age, BMI, and time of urine collection (calculated as the number of hours between waking up and providing the urine sample). These potential confounders were determined *a priori* using directed acyclic graphs and were treated as continuous variables. Fourteen participants were missing information on household income relative to the federal poverty thresholds. Although poverty status could affect the choice and number of products used, inclusion in the models did not substantively change the findings in sensitivity analyses and all participants were relatively low income, so we did not include this variable in final models.

Use of some products was interrelated (for example, blush was rarely used without foundation). To assess joint product use, we conducted Bayesian Profile Regression (BPR), which clusters participants into groups based on their personal care product use.(72, 73) We included in the analysis use of all individual products found in Table 4 (excluding redundant aggregate variables such as "any eye makeup"). Using the four clusters of individuals identified in the BPR analysis, we then determined the geometric mean and geometric standard deviations of chemical concentrations for each cluster and ran ANOVAs to determine if clusters were significantly different from each other.

Results

All participants were Latinas between the ages of 14 and 18. Most participants were from Spanish-speaking households (86%), had parents with less than a high school education (57%), and were of normal BMI (56%) (Table 1). All girls were English-speaking and were interviewed in English. Most girls reported using moisturizer (84%) and fragrance (65%) at least four days per week and 50% of girls wore make-up at least four days per week.

Urinary concentrations of MEP, MBP, MiBP, MP, PP, triclosan, and BP-3 were detected in over 90% of participants. Geometric means and percentiles can be found in Table 2. Urinary concentrations of phthalate, paraben, and BP-3, but not triclosan metabolites, were slightly higher than among a nationally representative sample of 14-18 year old females participating in the 2011-2012 wave of NHANES. (56, 67)

We observed differences in geometric mean concentrations of several urinary metabolites by frequency of use of make-up, fragrance, and moisturizer (Table 3), comparing girls who used products every day, 2-6 times per week, once a week, and rarely/never. Concentrations were higher among participants who reported that they wore make-up every day vs. rarely/never for MEP (102.2 ng/mL vs 52.4 ng/mL, P_{trend} <0.01), MP (120.5 ng/mL vs. 13.4 ng/mL, P_{trend}<0.01), PP (60.4 ng/mL vs. 2.9 ng/mL, P_{trend} <0.01), and BP-3 (282.7 ng/mL vs. 70.0 ng/mL, P_{trend}=0.03). Concentrations also varied by frequency of fragrance use for MP (112.1 ng/mL vs. 23.7 ng/mL, P_{trend}=0.04); and by frequency of moisturizer use for MEP (90.4 ng/mL vs. 26.3 ng/mL, P_{trend}<0.01) and MP (123.8 ng/mL vs. 69.4 ng/mL, P_{trend}=0.01). Girls who used 20 or more products today and yesterday had higher levels of the PP compared to girls who used fewer than nine products today or yesterday (33.4 ng/mL vs. 6.1 ng/mL, P_{trend}=0.04).

Urinary concentrations of phthalate metabolites were also associated with use of specific products today or yesterday (Table 4 and Figure 1). As shown in Table 4, we observed higher MEP concentrations, on average, among girls reporting use of several make-up items today or yesterday, including foundation (21.3% higher MEP concentrations), blush (22.4%), eyeliner (24.2%), mascara (26.4%), and any eye makeup (29.9%). MEP concentrations were also positively associated with recent moisturizer (41.2%) and stick/roll-on deodorant use (44.0%). Contrary to our hypothesis, MEP concentrations were not associated with recent use of perfume and were negatively associated with recent use of spray-on deodorant (−30.9%). MEP concentrations were also negatively associated with recent use of bar soap (−22.6%) and hair gel (−21.9%). MBP concentrations were positively associated with certain make-up products, specifically foundation (11.5%), eyeshadow (13.4%), lip balm (16.8%), and use of any lip products (19.4%). MiBP was negatively associated with recent use of bar soap (−17.1%). We observed no associations of any phthalate metabolites with use of scented products such as liquid soaps/body wash, shampoo, conditioner, air fresheners, and cleaning products in the home, although we had limited power to examine shampoo since use was almost universal. We also found no association of urinary concentrations of phthalates with nail polish. Figure 1 shows the geometric mean concentrations of MEP and MBP metabolites by use of select personal care products.

We observed several associations of product use with paraben concentrations. Both MP and PP urinary concentrations were positively associated with use of foundation (MP: 52.1%, PP: 69.3%), blush (MP: 34.0%, PP: 44.9%), mascara (MP: 64.3%, PP: 76.3%), any eye makeup (MP: 58.0%, PP: 84.3%), and any makeup (MP: 77.9%, PP: 75.7%). Geometric mean concentrations of MP among users and non-users of foundation, blush, and mascara are shown in Figure 1. Additionally, PP urinary concentrations were negatively associated with lip gloss use (−51.1%).

We observed 86.7% higher triclosan concentrations, on average, among girls reporting use of Colgate Total toothpaste today or yesterday than those who did not (Table 4 and Figure 1). Triclosan was not associated with reported use of antibacterial hand soap but was associated with use of liquid hand soap (48.3%), although this association was of borderline significance. Concentrations of BP-3 were positively associated with recent use of sunscreen (57.8%) as well as with use of any eye makeup (42.5%), and hair oil (50.2%) (Table 4 and Figure 1).

In sensitivity analyses, weaker associations were observed between urinary analyte concentrations and product use "today only" and "yesterday only" than use "today and yesterday," although overall patterns persisted. (Supplemental Tables 1 and 2)

The BPR analysis yielded 4 clusters of girls, influenced mainly by use of foundation, blush, eyeliner, mascara, perfume, and perfume/spray-on deodorant (Supplemental Figure 1). Cluster 1 (n=46) was characterized by high makeup use and high scent use. Cluster 2 (n=14) was characterized by high makeup use and low scent use. Cluster 3 (n=22) was characterized by low makeup use and high scent use. Cluster 4 (n=18) was characterized by low use of both makeup and scent. Clusters varied significantly on urinary chemical concentrations of MEP (P-value for ANOVA=0.02), MP (P=0.01), PP (P<0.01), and BP3 (P=0.04). As shown in Figure 2, cluster 1 (high makeup/high scent) was characterized by high levels of MEP, MP, and PP. Cluster 2 (high makeup/low scent) was characterized by high levels of MEP, MP, PP, and BP3. Cluster 3 (low makeup/high scent) and cluster 4 (low makeup/low scent) were characterized by lower levels of all chemicals.

Discussion

We found that recent use of certain personal care products was associated with higher concentrations of urinary metabolites of phthalates, parabens, benzophenone-3, and triclosan. Specifically, we observed higher urinary concentrations of the phthalate metabolite MEP with use of lotion and roll-on/stick deodorant and higher concentrations of MEP and MBP with several types of makeup. We observed higher urinary concentrations of methyl and propyl paraben with recent use of makeup, including foundation, blush, mascara, and any eye makeup, and higher triclosan with use of Colgate Total toothpaste. We also observed higher BP-3 levels with sunscreen use and with use of lip balm, hair oil, and eye makeup which may be due to inclusion of this ingredient for sun protection. (74, 75) We found that girls clustered into four groups characterized by high or low makeup and scent use, and that girls in clusters with higher makeup use had higher urinary chemical concentrations.

These findings are consistent with other studies. A study of 105 pregnant Puerto Rican women found that self-reported use of cosmetics or lotion in the previous 48 hours was associated with higher urinary concentrations of methyl, propyl, and butyl parabens. (76) The same study also found that self-reported sunscreen use in the previous 48 hours was associated with higher urinary concentrations of BP-3. Cosmetic use in the previous 24 hours was also associated with higher urinary concentrations of methyl, propyl, and butyl parabens, and MBP concentrations in a study of 177 pregnant women in Boston. (61) This study also found lotion use in the past 24 hours was associated with higher urinary concentrations of MEP and MBP. In addition, a study of 108 Mexican children aged 8-13 found that use of cosmetics in general in the previous 24 hours was associated with higher urinary MBP concentrations in girls. (64)

Some findings were not as expected. We hypothesized *a priori* that phthalates, specifically MEP, would be associated with use of scented products since DEP is a known fragrance additive. (2) However, none of the phthalates we examined were associated with use of perfume and, surprisingly, MEP was inversely associated with use of spray-on deodorant and bar soap. Of the potentially scented products examined, only use of stick/roll-on deodorant and lotion were positively associated with MEP concentrations. This finding is contrary to several studies that have found urinary MEP concentrations to be positively associated with scented products. A study of 337 women in the U.S. (59) and a study of 108 children aged 8-13 in Mexico (64) found higher urinary concentrations of MEP were associated with recent use of both perfume and deodorant. Three U.S. studies, one of 177 pregnant women, (61) one of 186 pregnant women, (77) and one of 406 men, (62) found recent use of perfume or cologne was associated with higher urinary MEP concentrations. Additionally, a study of 50 pregnant women in the U.S. found higher urinary MiBP concentrations were associated with recent perfume use. (60) However, there is some evidence that use of DEP in personal care products has decreased in recent years. (66, 78) A study of NHANES participants from 2001-2010 showed a 42% decrease in urinary concentration of MEP over the 10 year period. (53) The data for the present study were collected in 2013, more recently than the studies referenced above, and may reflect the recent decrease in MEP use. Additionally, the findings of positive associations of use of foundation, blush, and eye make-up with MEP and, to a lesser extent, MBP was unexpected and has not be shown in other studies.

We also expected to find an association between triclosan and liquid hand soaps, particularly antibacterial hand soaps, as triclosan was still widely used in antibacterial soaps at the time of the data collection in 2013. A previous study conducted in 2010-2012 found higher triclosan levels associated with use of liquid soap in the last 48 hours in 105 Puerto Rican pregnant women. (76) We did not observe an association of triclosan concentrations with reported use of antibacterial soap and we observed only a borderline significant association with use of liquid hand soap in general. This may have been due to misclassification of type of soap, which would bias towards the null. Misclassification of soap use is a possibility since people often wash their hands in public locations where they have no knowledge of the type of soap. By comparison, we feel that misclassification of other personal care products is less likely because of the in depth nature of the interview and the use of photographs of their usual products to aid recall.

We did not find an association between MBP and recent nail polish use, in contrast to previous studies. (2) A 2005-2011 study of 177 pregnant women found that use of nail polish in the previous 24 hours was associated with increased MBP urinary concentrations, (61) and a 2004-2005 study of 40 manicurists found higher urinary levels of MBP after a work shift compared to before a shift. (79) Several major nail polish brands removed DBP from their products in the mid-2000s which may be reflected in our study. (66)

This analysis examines multiple cosmetic products and chemical biomarkers, resulting in multiple comparisons and suggesting that the results be interpreted with caution. However, the associations between products and chemical analytes follow expected patterns, such as the consistent associations of methyl paraben with multiple make-up products. Some of our expected null findings serve as negative controls. For example, the null association between triclosan and makeup was expected, as was the null association between BP-3 and non-sunscreen lotions, and the null association between phthalates, parabens, and tooth products.

People often do not use personal care products in isolation, and it is important to take into account joint exposure to many products at once. We addressed the issue of correlated product use and exposure to mixtures of multiple chemicals by examining associations of urinary metabolites with frequency of make-up use in general and by clustering girls by their patterns of product use. Clusters varied on chemical concentrations in expected ways, with higher urinary chemical concentrations generally found in clusters characterized by higher product use. Although sunscreen use did not vary across clusters, BP3 levels were markedly higher in cluster 2. This may be from use of foundation or blush that includes sunscreen.

One limitation of this study is we did not look at explicit information on ingredients in the products used by the participants. Although similar products have been tested for chemical ingredients, (4, 80, 81) we did not test the products used by the girls in our study, and exposures to the chemicals examined in this study could have originated from sources other than personal care products. (82) DBP and DiBP have been found in adhesives in paper and board food packaging, and have been found to migrate into the packaging contents. (83) DEP was associated with meat, tomato, and potato consumption in an NHANES dietary recall study. (84) DEP and DBP are both found in medication coatings. (85) Although DBP was banned from children’s toys in 2008, it may be present in older items. (86) Parabens are found in many paper products, including currency, newspapers, and food cartons, as well as in foods and medications. (87, 88) Triclosan is also found in sportswear, toys and plastic kitchenware. (89) We did not analyze participants’ exposure outside of personal care products and scented household cleaning products, so our results may be affected by these other sources.

An additional limitation of this study is that we were unable to differentiate sources of exposure among highly correlated products that are commonly used together. We did not have enough participants who, for example, used only foundation or only blush so we could not determine whether risk associated with one of these products was confounded by use of the other.

The chemicals in the current study have short half-lives and are metabolized within 24-48 hours. (90–92) While one urine measurement adequately captures exposures within the previous day or two days, it does not capture regular, longer-term exposure. Our measurements may be less reflective of participants’ chronic exposure if their recent product use was atypical. However, it should be a good reflection of their exposure from personal care products used today and yesterday.

We have previously reported that HERMOSA participants have higher levels of personal care product chemicals than adolescent NHANES participants. (67) HERMOSA participants are tended to be of lower income and all identified as Latina. These differences may affect the generalizability of our findings.

Our findings suggest that use of certain personal care products is associated with higher exposure to phthalates, parabens, triclosan, and benzophenone-3. Major predictors of urinary chemical concentrations appear to be makeup, lotion, Colgate Total toothpaste, and sunscreens. This is especially important in adolescent girls because they are in a critical age in hormonal development and have high use of personal care products. (57)

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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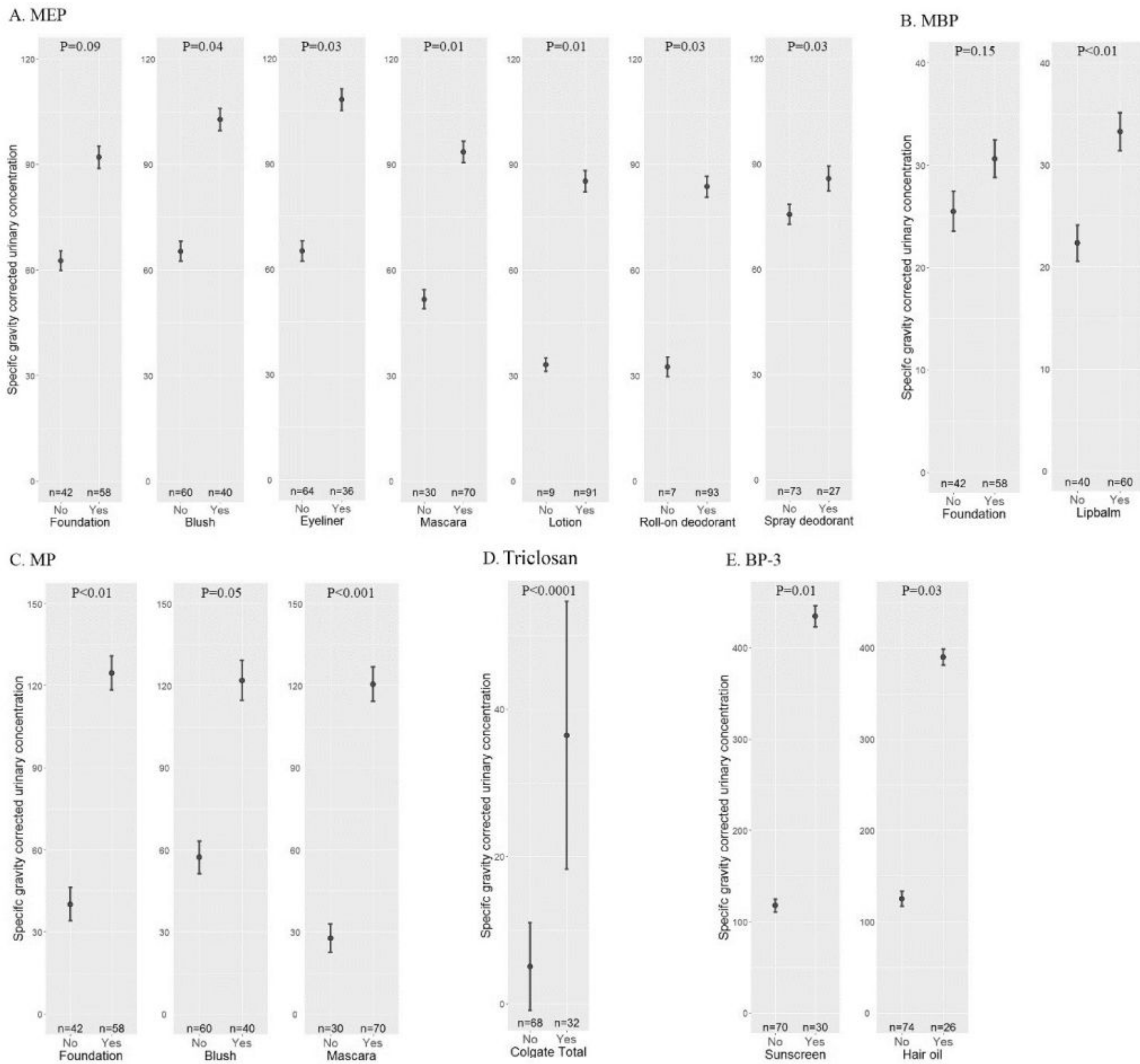

Figure 1.

Geometric means and geometric standard errors of urinary chemical concentrations among HERMOSA participants (N=100) who recently used or did not use certain personal care products, with p-values for T-tests comparing geometric means

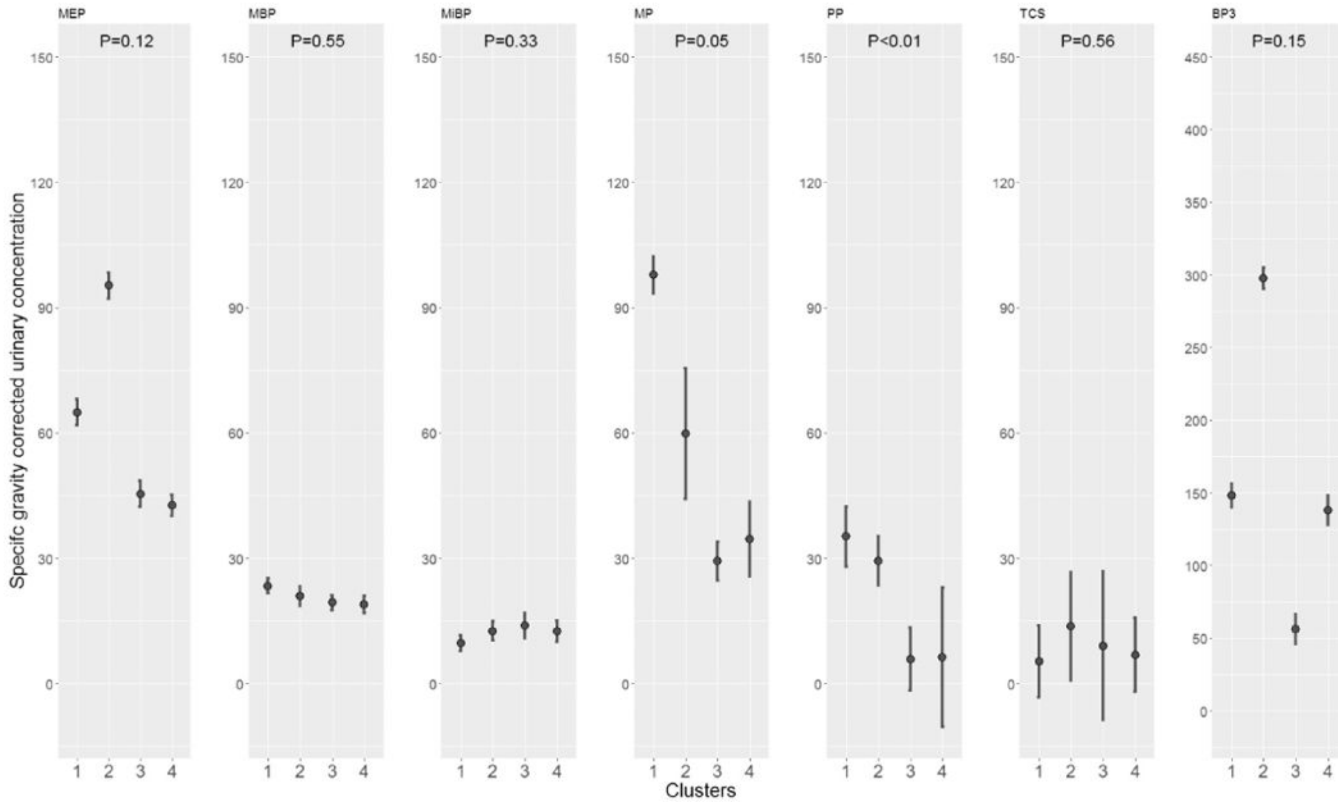

Figure 2.

Geometric means and geometric standard deviations of urinary chemical concentrations of personal care product chemicals by clusters as determined using Bayesian Profile Regression

Cluster 1 (n=46) is characterized by high makeup use and high scent use. Cluster 2 (n=14) is characterized by high makeup use and low scent use. Cluster 3 (n=22) is characterized by low makeup use and high scent use. Cluster 4 (n=18) is characterized by low makeup use and low scent use.

Table 1

Demographic characteristics of HERMOSA study participants (N=100)

Characteristic	***n***	**(%)**
Age (years)		
14	11	(11)
15	22	(22)
16	29	(29)
17	30	(30)
18	8	(8)
BMI		
Underweight	4	(4)
Normal weight	56	(56)
Overweight	26	(26)
Obese	14	(14)
Country of Birth		
United States	81	(81)
Mexico	19	(19)
Language spoken at home		
Mostly Spanish	57	(57)
Spanish and English equally	29	(29)
Mostly English	14	(14)
Highest parental education		
Less high school	57	(57)
High school graduate	33	(33)
Unknown	10	(10)
Annual household income[1]		
≤ $24,000	38	(38)
$24,001 - $36,000	29	(29)
> $36,000	25	(25)
Unknown/refused	8	(8)
Frequency of makeup use		
Every day	27	(27)
4-6 times per week	23	(23)
2-3 times per week	20	(20)
Once a week or less	30	(30)
Frequency of moisturizer use		
Every day	65	(65)
4-6 times per week	19	(19)
2-3 times per week	8	(8)
Once a week or less	8	(8)
Frequency of fragrance use		

Characteristic	*n*	(%)
Every day	47	(47)
4-6 times per week	18	(18)
2-3 times per week	17	(17)
Once a week or less	18	(18)

[1]Information provided by parent

Table 2

Distribution of uncorrected and specific gravity-corrected (italics) urinary analyte concentrations (ug analyte/mL urine) in HERMOSA participants (N=100)

				Percentiles (ug/g)			
	LOD (ug/L)	>LOD (%)	GM (ug/g)	25%	50%	75%	95%
MEP	0.5	100	40.3	14.7	45.0	94.9	427.5
			78.3	*32.9*	*73.9*	*161.0*	*388.3*
MBP	0.9	97	14.6	7.4	19.4	29.4	60.9
			28.3	*19.5*	*27.9*	*43.3*	*84.1*
MiBP	0.4	99	7.8	3.1	7.3	19.7	51.0
			15.2	*8.8*	*13.2*	*26.9*	*67.4*
MP	0.5	93	39.9	11.5	37.9	123.5	2340.0
			77.4	*21.3*	*82.3*	*206.1*	*2106.2*
PP	0.5	90	11.6	2.2	16.9	67.4	386.0
			22.6	*4.7*	*24.8*	*143.5*	*556.0*
TCS	0.2	93	4.9	0.9	3.6	21.1	389.0
			9.5	*1.7*	*6.0*	*28.3*	*1018.6*
BP3	0.5	97	89.6	20.9	76.0	445.5	4090.0
			173.8	*48.8*	*214.7*	*648.0*	*6155.1*

Abbreviations: LOD = Limit of Detection, DF = Detection Frequency, GM = Geometric Mean

Table 3

Geometric means (ng/mL) of specific-gravity-corrected urinary analyte concentrations by frequency of product use

		MEP	MBP	MiBP	MP	PP	TCS	BP3
	n	GM (GSD)	GM (GSD)	GM (GSD)	GM (GSD)	GM (GSD)	GM (GSD)	GM (GSD)
Frequency of makeup use								
Everyday	27	102.24 (1.72)	23.58 (1.27)	14.74 (1.44)	120.45 (2.25)	60.41 (2.15)	12.14 (2.61)	282.72 (2.19)
2-6 times per week	43	88.86 (1.52)	33.54 (1.27)	15.01 (1.38)	107.52 (2.17)	32.67 (2.62)	10.88 (3.12)	199.16 (2.46)
Once a week	13	49.85 (1.42)	34.86 (1.40)	15.75 (1.36)	103.89 (2.03)	12.80 (2.41)	5.50 (2.54)	132.22 (3.08)
Rarely/never	17	52.37 (1.74)	21.10 (1.34)	15.81 (1.64)	13.36 (1.93)	2.87 (2.37)	6.97 (2.66)	69.99 (3.11)
		P_{trend}<0.01	P_{trend}=0.54	P_{trend}=0.84	P_{trend}<0.00	P_{trend}<0.00	P_{trend}=0.35	P_{trend}=0.02
Frequency of fragrance use								
Everyday	47	80.35 (1.64)	31.41 (1.32)	14.32 (1.36)	112.13 (2.22)	32.30 (2.69)	9.64 (3.04)	190.96 (2.60)
2-6 times per week	35	91.20 (1.63)	25.45 (1.31)	15.72 (1.52)	65.75 (2.26)	19.92 (2.51)	12.86 (2.87)	196.98 (2.62)
Once a week	9	53.99 (1.46)	29.61 (1.17)	18.43 (1.45)	69.12 (2.57)	8.80 (3.35)	5.86 (2.59)	43.92 (3.07)
Rarely/never	9	54.43 (1.60)	24.00 (1.49)	14.57 (1.53)	23.67 (2.12)	14.75 (2.57)	4.43 (1.56)	257.76 (1.77)
		P_{trend} =0.38	P_{trend}=0.51	P_{trend}=0.53	P_{trend}=0.03	P_{trend}=0.05	P_{trend}=0.35	P_{trend}=0.71
Frequency of moisturizer use								
Everyday	65	90.35 (1.64)	29.57 (1.34)	15.42 (1.41)	123.78 (2.22)	33.67 (2.67)	9.97 (2.98)	174.15 (2.68)
2-6 times per week	27	74.33 (1.54)	26.61 (1.25)	13.90 (1.50)	28.04 (2.16)	8.61 (2.65)	7.06 (2.07)	181.12 (2.63)
Once a week	4	31.79 (1.36)	22.96 (1.41)	13.91 (1.15)	40.09 (1.44)	11.08 (1.54)	41.71 (5.47)	96.38 (2.54)
Rarely/never	4	26.32 (1.40)	26.66 (1.47)	22.54 (1.67)	69.37 (2.42)	46.47 (1.80)	7.42 (3.40)	228.15 (1.54)
		P_{trend}<0.00	P_{trend}=0.36	P_{trend}=0.96	P_{trend}=0.00	P_{trend}=0.08	P_{trend}=0.98	P_{trend}=0.96
Total number of products used today and yesterday								
0-8	15	41.44 (1.47)	23.09 (1.30)	15.61 (1.42)	38.72 (1.66)	6.14 (2.47)	9.36 (2.86)	112.18 (2.21)
9-19	71	89.62 (1.63)	29.83 (1.32)	14.71 (1.44)	88.94 (2.35)	27.52 (2.76)	10.85 (2.89)	187.97 (2.79)
20-35	14	77.70 (1.58)	27.15 (1.30)	17.15 (1.46)	80.51 (2.50)	33.36 (2.01)	4.95 (2.38)	186.37 (2.08)
		P_{trend} =0.11	P_{trend}=0.49	P_{trend}=0.89	P_{trend}=0.31	P_{trend}=0.044	P_{trend}=0.47	P_{trend}=0.53

Table 4

Percent change with usage of product on the day of or day before the office visit (unless otherwise noted), adjusted for age, BMI, and time between waking up and urine collection

	Did Not Use	Used	% Change in Urinary Metabolites						
	N	N	MEP	MBP	MiBP	MP	PP	TCS	BP3
Makeup									
Foundation	42	58	21.3	11.5	−11.0	52.1	69.3	−2.4	12.4
Blush	60	40	22.4	6.8	−0.6	34.0	44.9	2.1	16.1
Eyeliner	64	36	24.2	2.6	8.7	20.4	35.5	15.8	1.9
Mascara	30	70	26.4	9.0	−3.3	64.3	76.3	10.1	35.9
Eyeshadow	79	21	19.5	13.4	5.6	6.8	4.6	−45.3	11.6
Any eye makeup	28	72	29.9	10.2	−2.8	58.0	84.3	8.7	42.5
Lipgloss	80	20	11.4	7.5	6.1	−2.2	−51.1	−7.8	−40.4
Lipstick	77	23	19.5	5.9	−6.1	−5.8	20.7	−0.9	−9.2
Lipbalm	40	60	−2.1	16.8	7.6	32.5	32.3	19.1	24.2
Any lip product	24	76	16.2	19.4	15.2	25.6	8.4	−3.7	−19.0
Any makeup	10	90	28.6	12.8	15.0	77.9	75.7	2.5	−4.0
Other facial products									
Acne Medication	79	21	4.2	−1.3	3.6	10.5	1.2	−25.5	22.0
Facial cleanser or soap	31	69	−18.3	−2.2	6.0	−14.2	−4.5	−5.5	−3.3
Makeup remover wipes	90	10	−1.6	−3.3	−9.6	21.5	71.4	29.9	20.2
Oral hygiene									
Toothpaste today	2	98	−28.8	5.6	−37.4	−51.2	−32.4	7.0	71.0
Colgate Total toothpaste	68	32	10.5	4.3	−2.2	10.8	−3.7	86.7	−9.9
Mouthwash	57	43	1.7	0.4	−2.9	9.0	27.2	−4.9	−1.0
Sunscreen									
Sunscreen/moisturizer with sunscreen	70	30	2.0	−10.5	−14.9	8.5	−7.9	−7.6	57.8
Lotion/moisturizer									
Lotion/moisturizer (face)	45	55	20.4	−0.8	2.5	13.5	9.5	22.1	−11.3
Lotion/moisturizer (hands or body)	11	89	36.8	−12.9	−16.1	30.9	−1.2	−47.8	−32.3
Any lotion or moisturizer	9	91	41.2	−10.5	−15.7	12.8	2.0	−25.8	−35.1

	Did Not Use	Used	% Change in Urinary Metabolites						
	N	N	MEP	MBP	MiBP	MP	PP	TCS	BP3
Deodorants/perfumes									
Stick/roll-on deodorant	7	93	44.0	9.1	16.8	16.5	−0.6	−75.4	−39.0
Spray deodorant	87	13	−30.9	2.2	−13.2	28.6	34.0	−5.0	26.0
Perfume	37	63	3.3	1.4	−2.8	10.9	7.7	−16.1	−31.3
Perfume or spray deodorant	31	69	−3.8	6.3	−6.5	24.4	28.0	−20.8	−30.5
Soaps									
Bar soap	25	75	−22.6	2.2	−17.1	19.0	−9.4	−3.2	−9.1
Liquid hand soap	19	81	−2.8	3.5	−8.6	−22.2	−5.0	48.3	16.3
Antibacterial hand soap	26	60	10.2	1.0	−6.2	28.1	9.0	22.4	−0.5
Any handwashing	4	96	−49.7	22.2	−4.2	12.4	−6.3	18.2	−1.5
Nail products									
Nail polish	47	53	5.3	3.2	−1.4	2.6	32.1	36.7	23.9
Nail polish remover	87	13	−7.0	2.9	7.6	−2.5	4.0	−14.4	0.7
Hair products									
Shampoo	2	98	−8.1	31.8	−0.1	87.2	64.6	93.4	47.4
Conditioner	22	78	8.9	6.7	−1.7	5.8	0.6	−3.7	−1.5
Leave in conditioner	93	7	18.7	2.2	12.9	9.3	19.6	−16.6	8.6
Hair heat protector	93	7	−0.7	−2.2	4.5	19.0	14.7	−29.5	−28.6
Hair gel	81	19	−21.9	−3.7	1.4	−5.3	−4.9	−3.2	15.1
Hair oil	74	26	18.9	7.5	9.6	21.1	19.3	14.7	50.2
Hair spray	87	13	−20.2	0.4	−6.4	2.5	17.0	6.0	3.2
Scented household products									
Scented cleaning products	61	39	−0.7	−8.7	−8.8	−9.6	4.0	−9.7	15.6
Scented laundry detergent usually used	18	82	−10.8	−6.1	−15.4	−18.9	−31.7	17.6	−10.8
Air freshener in the last week	15	85	15.0	−8.0	0.7	26.1	28.6	−40.5	−10.0
Feminine products									
Tampons or pads	80	20	9.5	3.4	−3.9	9.0	−12.2	10.6	−7.9
Sprays or wipes	86	14	−11.8	−14.4	14.5	−18.3	−6.1	−6.1	−20.6

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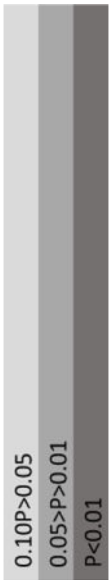
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