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Letter

Formaldehyde and Formaldehyde Releasing Preservatives in Personal Care Products Used by Black Women and Latinas

Robin E. Dodson,* Elissia T. Franklin, Ami R. Zota, René LaPointe Jameson, Janette Robinson Flint, Lariah Edwards, Emily B. Weaver, and Bhavna Shamasunder

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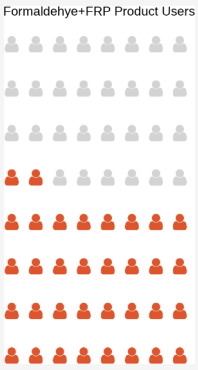
ABSTRACT: Formaldehyde and formaldehyde releasing preservatives (FRPs) are used in personal care products (PCPs) to prevent microbial growth and extend the shelf life. Several countries and U.S. states have banned or restricted the use of these chemicals due to carcinogenicity and other health concerns. However, the prevalence of these chemicals in PCPs used by the public, particularly by Black women and Latinas, remains poorly documented. We examined the prevalence of formaldehyde and FRPs listed as ingredients on PCPs from the Taking Stock Study (TSS), a community-engaged study in which 70 Black women and Latinas in South Los Angeles logged their PCP use with a smartphone application. We contextualized our results using EPA's Chemical and Products Database (CPDat), a public ingredient database. More than half of the TSS participants (53%) reported using at least one PCP with formaldehyde or FRPs despite only 4% of TSS PCPs and 8% of CPDat PCPs listing formaldehyde and/or FRPs as ingredients. We found formaldehyde and FRPs listed in frequently used products such as lotions and cleansers. The most common FRP was 1,3-dimethylol-5,5-dimethylhydantoin (DMDM) hydantoin. These results could inform the types of regulations needed to protect the U.S. population from adverse health risks due to formaldehyde exposure from PCP use.



KEYWORDS: *beauty justice, Taking Stock Study, EPA CPDat, DMDM hydantoin, formaldehyde releasers, personal care product chemicals, chemical exposures, community-engaged research*

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INTRODUCTION

Formaldehyde and chemicals that release formaldehyde, known as formaldehyde releasing preservatives (FRPs), are used in personal care products (PCPs) to prevent microbial growth and extend product shelf life and sometimes as a functional ingredient (e.g., hair straightener). Formaldehyde can be absorbed through the skin or inhaled during product use. Formaldehyde is highly toxic and classified as a known human carcinogen based on sufficient evidence of carcinogenicity from human studies and mechanistic data.[1,2] Epidemiologic studies report consistent findings of increased risks of nasopharyngeal, sinonasal, and lymphohematopoietic cancer among individuals with a higher exposure to formaldehyde. Formaldehyde and FRPs can cause allergic contact dermatitis; contact allergy rates to these chemicals are estimated to be 8% in the U.S.[3]

The prevalence of formaldehyde and FRPs in PCPs has not been well established. A recent ingredient analysis of 546 products found that 13% listed FRPs as ingredients, with the highest prevalence in hair and skin products.[4] Two studies that directly measured formaldehyde in PCPs found maximum concentrations greater than the level to elicit contact dermatitis (200 ppm) in PCPs labeled with FRPs.[5,6] Both studies also measured formaldehyde in products not labeled with FRPs, raising concerns about unknown chemical sources of formaldehyde in products.

Formaldehyde exposure from hair products is a growing concern. In 2011, the Occupational Safety and Health Administration issued a hazard alert and subsequent citations to workplaces, including salons, for failing to protect workers from formaldehyde exposure.[7] In 2015, the U.S. Food and Drug Administration (FDA) began a safety assessment of formaldehyde in hair-straightening products. In 2021, they issued a health alert advising against Brazilian blowouts, a formaldehyde-intensive hair-straightening treatment.[8] In 2023, the FDA proposed a rule to ban formaldehyde as an ingredient in hair straightening products.[9] However, no rule has been promulgated to date.

Some countries and U.S. states have banned or restricted the use of formaldehyde and FRPs in PCPs. The European Union (EU) banned formaldehyde as a cosmetic ingredient in 2009. Additionally, any cosmetics sold in the EU containing FRPs resulting in a formaldehyde concentration above 0.001% in the product must include the warning, "releases formaldehyde".[10] Effective in 2025, California bans formaldehyde, paraformaldehyde (polymeric formaldehyde), methylene glycol (form-

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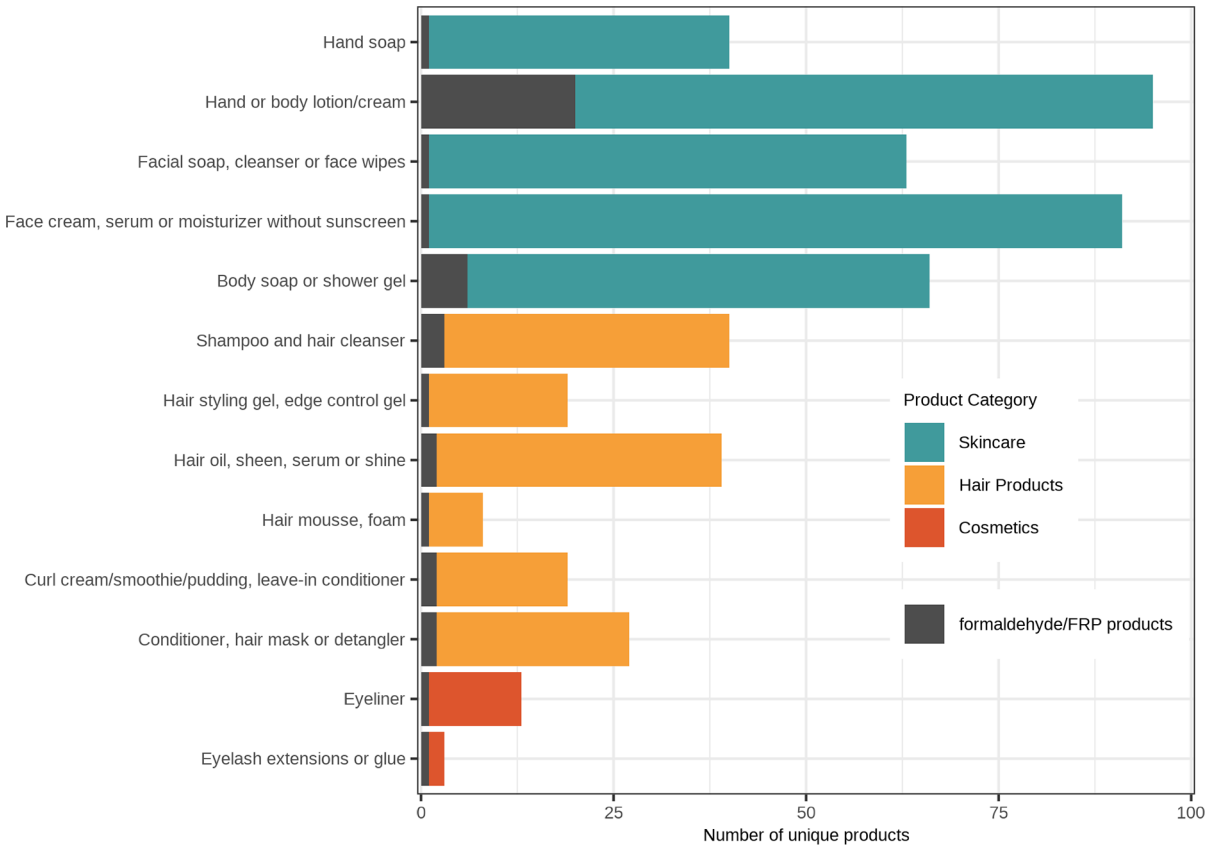

Figure 1. Number of unique products in each subcategory used by the TSS participants. Dark gray bars indicate the number of products in each subcategory that list formaldehyde (n = 1 product) or FRPs (n = 41 products) as ingredients. Product subcategories grouped by category (skincare, hair products, and cosmetics).

aldehyde equivalent), and quaternium-15 (FRP), from cosmetics sold in California.[11] Washington State has a similar ban of formaldehyde or methylene glycol in cosmetics effective in 2025, with additional consideration of FRPs.[12] At least 10 other U.S. states have issued health advisories or introduced policies to ban formaldehyde and FRPs in PCPs.[13]

Formaldehyde has been a long-standing focus of beauty justice, which is both an emerging area of research that recognizes racial and ethnic inequalities in exposure to potentially toxic chemicals in PCPs as an environmental justice concern[14,15] and an area of advocacy focused on equitable access to safer products to address exposure and health inequities. Previous studies have characterized the disproportionate burden of PCP-related exposures among Black women and Latinas.[16−19] Hair straighteners are used more often by Black women compared to White women: hair discrimination and racialized beauty standards often drive use of hair-straightening products to better ensure social and economic opportunity.[15,20] Studies have measured formaldehyde exposures from nail products,[21,22] which are used more often by Black women and Latinas compared to White women.[18] However, the resulting formaldehyde exposures from FRPs used in PCPs have not been well characterized in a beauty justice context.

We aimed to evaluate the presence of formaldehyde and FRPs as listed ingredients in PCPs. We leveraged data from the Taking Stock Study (TSS), a community-academic collaboration documenting product use among Black women and Latinas living in South Los Angeles. We analyzed over 1,100 products collected through a smartphone application developed for the study used by TSS participants. We then queried the U.S. Environmental Protection Agency's (EPA) Chemical and Products Database (CPDat) to compare our results with national data. Our objective of this work is to increase our understanding of the presence of formaldehyde and FRPs in PCPs, particularly PCPs used by diverse populations who are often overburdened with environmental exposures and less likely to be represented in research studies. Given the rapidly evolving policy landscape, these results could inform the types of regulations needed to protect the U.S. population from adverse health risks due to formaldehyde exposure from PCP use.

METHODS AND MATERIALS

Identifying Formaldehyde and FRPs in Products from TSS. Through TSS, a community-academic collaborative, we collected consumer product use data from 70 women living in South Los Angeles in the early 2021. Black Women for Wellness, a nonprofit education, empowerment, and advocacy organization, recruited half of the participants who identified as Black women. A local community health worker (*promotora*) recruited the other half of the participants, who identified as Latinas. Occidental College Institutional Review Board reviewed and approved all study protocols.

After we obtained informed consent, we asked participants to download a smartphone app. Using the app, participants created their product inventory and logged each product use with a date and time stamp over 1 week. Participants provided the product name and category (e.g., skincare) and answered

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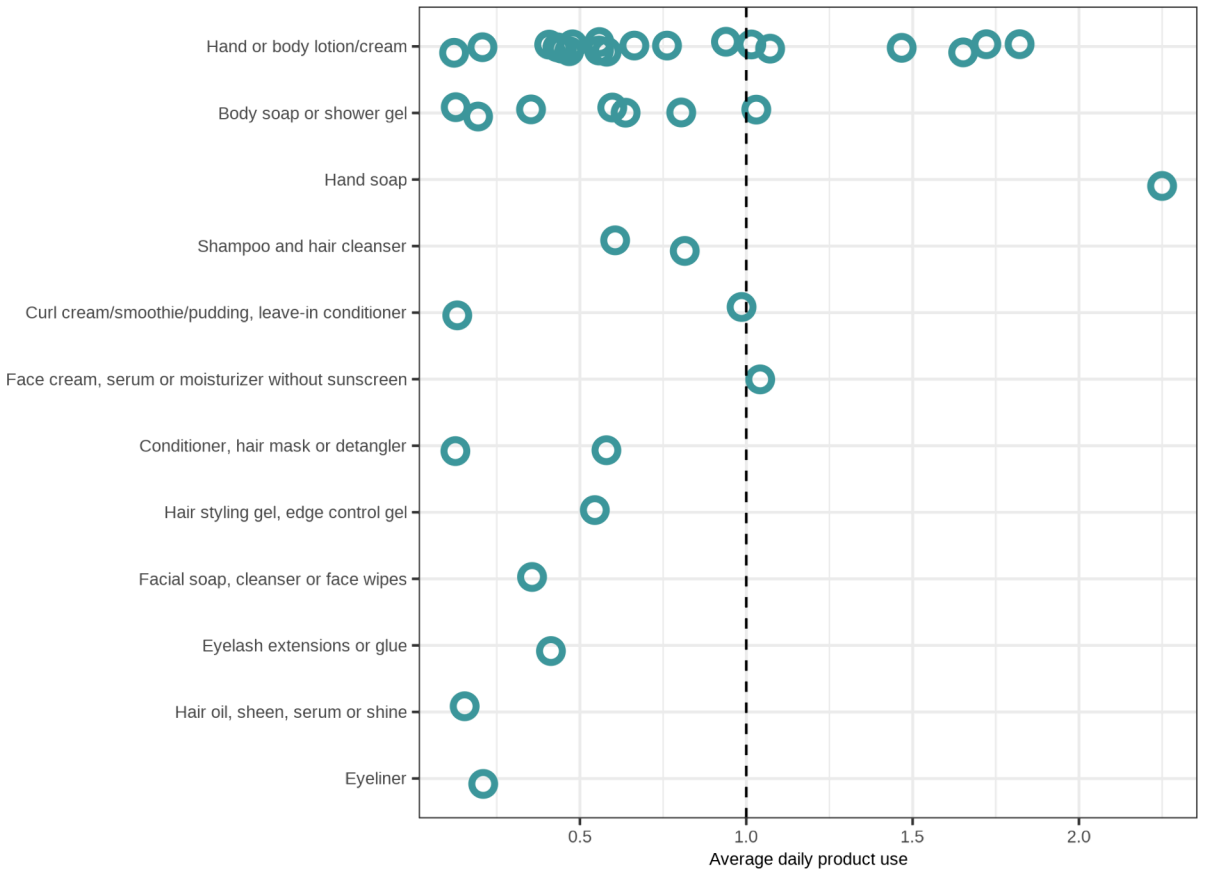

Figure 2. Average daily use of PCPs with formaldehyde and FRPs listed as ingredients by TSS participants. PCP subcategories are sorted by total number of logged uses by all study participants. Each dot represents a participant's product use. Dashed vertical line indicates use on average once per day.

questions about how they obtained products. The app prompted users to take photos of the front label and the ingredient list of products. Six TSS participants did not take photos of their products; therefore, we dropped their products from further analysis, and a photo of the ingredient list was not taken for 8% of products used by the 64 TSS participants. We used two separate optical character recognition (OCR) tools to extract the ingredient text for each product. Silent Spring developed the first OCR tool that was deployed in Python. We manually reviewed all product photos and OCR-extracted ingredients on a custom-built interface. We reviewed the ingredient database to harmonize ingredient names and assigned each ingredient a CAS Registry Number. We then shared product photos with Clearya, a digital product ingredient screening platform, for a second OCR ingredient extraction so that we could assess the accuracy of the OCR tools (see Supporting Information). Approximately 10% of the products had photos of insufficient quality to extract ingredients. Finally, we estimated a false negative rate (missing individual ingredients due to photo issues) of 4%.

We reviewed the TSS ingredient databases for formaldehyde and a list of 35 substances identified by de Groot et al. 2009 as FRPs based on scientific literature (see Table S1).[23] Only products with formaldehyde and FRPs captured by both the OCR methods are included in our analysis. We summarized the results by product subcategory (e.g., facial soaps) and by broader categories (e.g., skincare). We also compared the presence of FRPs in products logged by Black women and Latinas and tested differences by group using Fisher's exact tests (for proportions) and Wilcoxon rank sum tests (for right-skewed integer data). We provide a complete list of product categories and subcategories in Table S2.

Publicly Available Ingredient Database. To provide context and a comparison to the data collected by TSS, we also examined a publicly available ingredient data set for formaldehyde and FRPs. EPA's CPDat is a curated data set of nearly 50,000 chemicals reported and/or predicted to be present in over 200,000 consumer products mapped to hierarchical Product Use Categories (PUCs).[24,25] PUCs are organized into three levels: General Categories, Product Families, and Product Type. EPA's CPDat information is generated voluntarily (i.e., there are no mandatory reporting requirements by manufacturers) and includes some data from several years ago. We accessed CPDat using the ctxR package.[26] We identified all products in the PUC General Category "Personal care" that list formaldehyde and FRPs as ingredients using CAS numbers. We conducted all analyses in R (version 4.3.1).

RESULTS

Products with Formaldehyde and FRPs Listed in TSS. TSS participants used a total of 1,143 unique PCPs, with an average of 17 PCPs (range 5−43) used by each participant. One product, an eyelash glue, listed formaldehyde as an ingredient, and 41 products (3.6%) listed FRPs as an ingredient. FRPs were found in products within skincare, hair, and cosmetic categories (Figure 1). Some of these may be used daily including: 20 body lotions, six body soaps or shower

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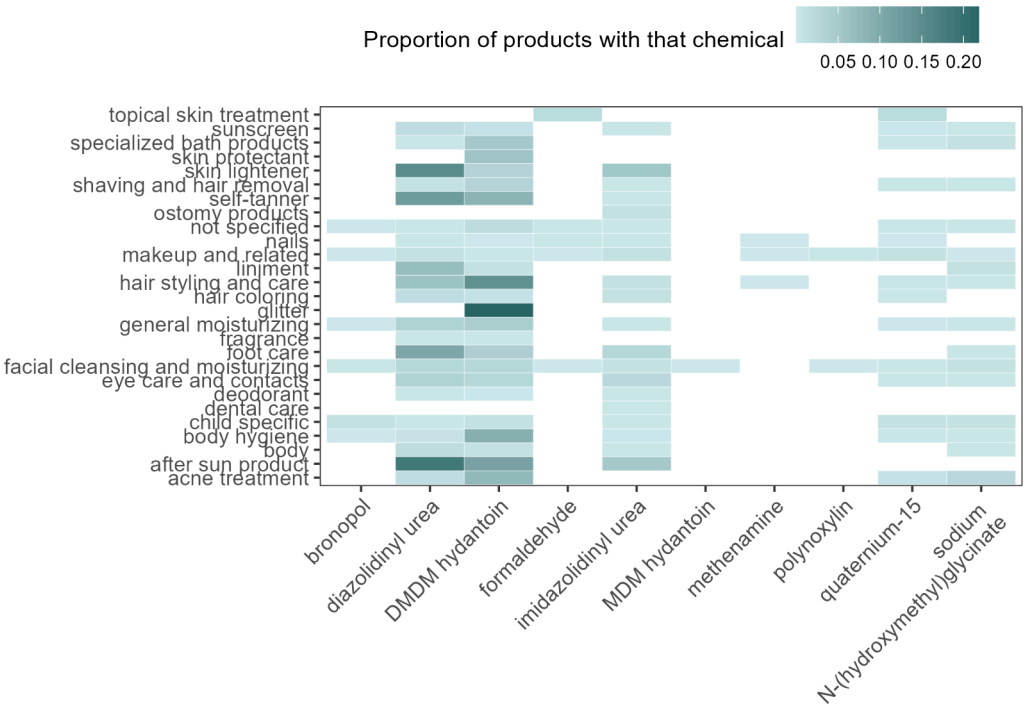

Figure 3. Proportion of products in a category (Product Family) listing formaldehyde and FRPs in PCPs in EPA's CPDat. The color intensity indicates the proportion of products within the category that lists that chemical.

gels, and three shampoos. Twelve of the FRP-containing lotions were from the same brand, Bath & Body Works.

We compared products with formaldehyde and FRPs by racial/ethnic groups (Table S3). A Black woman logged the formaldehyde-containing eyelash glue. The total number of formaldehyde- and FRP-listing products inventoried was not significantly different between Black women and Latinas (p = 0.31). The percent of products logged by Latinas that listed FRPs was higher than the percent of products logged by Black women (4.1% vs 2.7%; p = 0.21), although the difference was not statistically significant.

More than half (53%) of the TSS participants reported using PCPs with FRPs listed as ingredients (Figure S1). One participant used three products with FRPs (a leave-in conditioner, rinse-off conditioner, and a body wash). Seven participants used two products with FRPs, and 26 participants used one product with FRPs. Of the 34 participants using PCPs with FRPs, 16 identified as Black and 18 identified as Latina, which did not vary significantly (Fisher's exact test, p-value = 0.62; Table S3).

Some participants used PCPs with FRPs multiple times per day (Figure 2). One participant used hand soap with FRPs more than two times per day, on average. Some participants used lotions with FRPs multiple times per day. Over a five-day period, 20 participants used lotions with FRPs a total of 76 times; over 70% of products with FRPs were used at least twice by participants over the study period.

Of the 35 FRPs examined, we found five on ingredient lists in products used by participants. The most common FRP listed was DMDM hydantoin, which occurred in 19 products (Figure S2). Approximately 47% of skincare and 58% of hair products with FRPs contained DMDM hydantoin. The second most common FRP was diazolidinyl urea, which occurred in 17 products; all but three were skincare products. Another FRP, imidazolidinyl urea, was listed in two skincare products, one hair product, and one cosmetic. Two products—a body lotion and a shampoo—listed multiple FRPs as ingredients; each of these products listed DMDM hydantoin plus an additional FRP.

Products with Formaldehyde and FRPs in EPA's CPDat. In CPDat, 5,929 PCPs listed formaldehyde and FRPs as ingredients (7.6% of all PCPs in the database). Formaldehyde was listed in several PUCs including facial cleansers, eye makeup, and nail products. We found FRPs in an even greater number of PUCs than formaldehyde (Figure 3). Nearly a third of after sun products had a FRP listed as an ingredient. Approximately 20% of hair styling and care products, skin lighteners, self-tanners, and glitter listed FRPs. DMDM hydantoin, the most prevalent FRP, was found in 3.6% of all PCPs while all other FRPs combined were also in 4% of the products.

DISCUSSION

We analyzed ingredient data for products used by participants in TSS, providing some of the first data on formaldehyde and FRPs in products used by Black women and Latinas. Over half of the TSS participants used products that listed FRPs as ingredients. Most of the FRP-containing products were used daily or multiple times per week. Within the EPA's CPDat database, 5,929 PCPs listed formaldehyde and FRPs as ingredients. While we estimated that 3.6% of TSS PCPs and 7.6% of CPDat PCPs list formaldehyde and FRPs as ingredients, previous national estimates were as high as 20%.[27] This difference may be a result of temporal changes in product formulation as previous national estimates are based on 2008 data from the FDA's Voluntary Cosmetic Registration Program. Our prevalence estimates are also lower than those reported in another community-engaged study by Johnson et al., which reported 13% prevalence of FRPs in PCPs.[4] Importantly, some PCP subcategories in our study had a

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higher proportion of products with FRPs; for example, 21% of TSS body lotions listed FRPs.

We found that DMDM hydantoin was the most common FRP found in the ingredient lists. DMDM hydantoin was also the most common FRP reported in Johnson et al.[4] Each molecule of DMDM hydantoin can release two equivalents of formaldehyde.[28] Separate from the health effects of the formaldehyde it releases, DMDM hydantoin may elicit contact dermatitis in approximately 8−9% of the U.S. public.[29]

We relied on a well-established list of 35 FRPs used in consumer products;[23] however, there may be other chemicals that release formaldehyde. As part of Washington's recent cosmetic safety law, an expert panel is convening to identify substances considered FRPs and restrict their use by 2026.[12] Many FRPs have complex names that do not include "formaldehyde," which poses a challenge for consumers trying to avoid them.[30] Market-based initiatives and regulations, such as those in the EU that require labeling of FRPs may support consumers.

Formaldehyde and FRPs are found as ingredients in products used frequently (e.g., lotions and soaps) as well as in products used intermittently (e.g., hair-straightening products). While regulatory attention has focused largely on intermittently used products, our analysis suggests that frequently used products also deserve attention. Additionally, many of these products are leave-on products and applied to large fractions of the body's surface area, raising concerns for increased exposure potential.[31] Some TSS participants used multiple products with FRPs, raising concerns about aggregate exposures, which are typically ignored in product risk assessments.

Formaldehyde and FRPs were listed as ingredients in products used by Black women and Latinas. Within TSS, the proportion of products with FRPs used was higher for Latinas than Black women, although the difference was not statistically significant, consistent with Johnson et al.[4] In both TSS and CPDat, formaldehyde and FRPs were found in various hair products, including gels, edge controls, oils, and curl creams. Black women report using more hair products than other women.[16] Formaldehyde and FRPs were also found in cosmetics such as eyeliner and eyelash glues. We previously found that Latinas use more cosmetics compared to other women.[16] Future research should examine sociodemographic differences in FRP-containing products among more diverse racial/ethnic and socioeconomic populations in a wider range of locations. Additionally, products marketed to children, who may have higher susceptibility, should be examined for the presence of formaldehyde and FRPs. Lastly, future research should examine the health impacts of chronic use of FRP-containing PCPs.

We present data on formaldehyde and FRPs listed as ingredients in PCPs used by Black women and Latinas collected through a community-academic study. Potential limitations of this analysis include technological issues with the OCR, including inaccuracies in text extraction due to photo quality (e.g., blurriness) and ingredient list orientation (e.g., round products) leading to false negatives (4%), limited study period (5−7 days of PCP use), and the results may not be widely generalizable due to the small community sample and because the study was conducted during the COVID pandemic.

As various state and federal agencies consider regulations to limit formaldehyde exposures, these data can help to inform exposure estimates among diverse populations, who are often overburdened by and underprotected from environmental exposures in PCPs.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.estlett.5c00242.

> Description of the accuracy of ingredient extraction; list of FRPs used in this analysis; PCP categories and subcategories used in the TSS; product use by recruitment group; number of products containing formaldehyde and FRPs used by TSS participants; number of products with each FRP by product category (PDF)

■ AUTHOR INFORMATION

Corresponding Author

Robin E. Dodson − *Silent Spring Institute, Newton, Massachusetts 02460, United States;* orcid.org/0000-0001-7356-9511; Email: dodson@silentspring.org

Authors

Elissia T. Franklin − *Silent Spring Institute, Newton, Massachusetts 02460, United States;* orcid.org/0000-0002-1017-9927

Ami R. Zota − *Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, New York 10032, United States*

René LaPointe Jameson − *Silent Spring Institute, Newton, Massachusetts 02460, United States*

Janette Robinson Flint − *Black Women for Wellness, Los Angeles, California 90008, United States*

Lariah Edwards − *Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, New York 10032, United States*

Emily B. Weaver − *Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, New York 10032, United States*

Bhavna Shamasunder − *Department of Urban and Environmental Policy, Occidental College, Los Angeles, California 90041, United States; Environmental Studies Program, University of California, Santa Barbara, California 93106, United States*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.estlett.5c00242

Notes

The authors declare no competing financial interest.

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