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Chemical/Straightening and Other Hair Product Usage during Childhood, Adolescence, and Adulthood among African-American Women: Potential Implications for Health

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Abstract

Few studies have characterized life course hair product usage beyond ever/never. We investigated hair product use from childhood to adulthood, usage patterns in adulthood, and socioeconomic status (SES) correlates among African-American (AA) women. Using self-reported data from 1,555 AA women enrolled in the Study of Environment, Lifestyle, and Fibroids (2010–2018), we estimated the usage frequency of chemical relaxer/straightener (twice/year, once/year, rarely/never) and leave-in/leave-on conditioner (once/week, 1–3 times/month, rarely/never) during

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childhood, adolescence, and adulthood. Latent class analysis was used to identify patterns of adulthood usage of multiple hair products. SES was compared across latent classes. With a mean age of 33 ± 3.4 years, most women reported ever using chemical relaxers/straighteners (89%), and use twice/year increased from childhood (9%) to adolescence (73%) but decreased in adulthood (29%). Leave-in/leave-on conditioner use followed the same pattern. Each of three identified latent classes reported frequent styling product use and similarly low frequency of relaxer/straightener use. Class One was unlikely to use any other products, Class Two moderately used shampoo and conditioner, and Class Three frequently used multiple product types (e.g., moisturizers, conditioners). Participants in the latter two classes reported higher SES. Ever/never characterization may miss important and distinctive patterns of hair product use, which may vary by SES.

Keywords

Hair preparations; cosmetics; African Americans; child; women; latent class analysis

INTRODUCTION

African-American women and children are more likely than their White counterparts to use hair products that are advertised to moisturize hair (e.g., hair lotions, conditioners), promote hair growth (e.g., root stimulators, hair food), and chemically straighten or relax naturally curly hair (e.g., hair relaxers).¹⁻⁷ Historically, these hair products have been used by many African-Americans to attain cultural norms and standards of beauty that favored long, straight hair.^{8,9} Because of these hair product usage behaviors, African-American women and children may be differentially exposed to exogenous hormones and chemicals.¹ As demonstrated in prior studies, hair products used more often by African-American women and children likely contain exogenous hormones, placenta, and endocrine-disrupting chemicals (EDCs) (e.g. certain parabens, phenols, phthalates).¹⁻⁶ Exposure to such hormone- and chemical-containing compounds may adversely alter several biological processes including steroid hormone action, which could explain how hair product usage may contribute to disparities among African-American compared to White women for health outcomes like earlier age of menarche and higher incidence of uterine fibroids.^{1, 8, 10-14}

Prior studies have found associations between hair oils, hair relaxers, hair dyes, hair maintenance practices and poor health behaviors/outcomes. For instance, hair growth products were associated with premature development of secondary sex characteristics (e.g., breasts, pubic hair) among pre-adolescents.¹⁵ Self-reported ever usage of any hair products, including hair oils and hair relaxers during childhood, was associated with earlier age of menarche in cohorts of African-American women.^{10, 11} Among African-American women, ever use of dark shades of hair dyes was associated with increased risk of breast cancer.¹⁶ In a separate study, ever use of dark hair dyes during pregnancy was associated with higher odds of delivering a low-birth weight infant among 315 Chinese mother-infant pairs.¹⁷

Observed associations between hair products and health outcomes may also be due to behavior change related to hair product use. For instance, products only result in temporary

hair maintenance and styling; the altered hair can readily revert to an undesired style or state due to environmental humidity or natural biological processes like sweating from physical activity. As such, certain hair maintenance techniques could influence health behavior patterns. A recent systematic review and several descriptive, as well as qualitative studies found that costly, time-consuming hair maintenance was a barrier to physical activity among African-American adolescents and women.^{18–31} Thus, hair maintenance practices can lead to issues related to weight gain and weight loss maintenance among African-American adolescents and women who have a high prevalence of overweight and obesity.^{32–34}

Although studies have identified unfavorable health behaviors and outcomes related to hair product usage among African-American women, these studies often characterized usage during childhood and adulthood as ever versus never, which likely missed changes in use behaviors over time. Furthermore, despite the high likelihood of simultaneous usage of several hair products, few performed a robust quantification and characterization of concurrent usage of multiple hair products. In prior literature, personal care product usage was characterized by using latent class analysis (LCA), a data reduction approach that clusters participants based on their probabilities of simultaneously using several products.^{35, 36} In these robust studies, the usage behaviors of African-American and White women were combined when determining clusters. However, in addition to varying chemical compositions of products,⁶ there are potential important behavioral differences related to hair product use between African-Americans and Whites, with clusters of hair product usage likely differing if the LCA was stratified by race.^{2–7, 37} Furthermore, studies have shown significantly higher levels of usage of hair products by African-Americans compared to other racial/ethnic groups,^{1–7} suggesting that this may be a particularly vulnerable population.

To address these gaps in the literature, our first objective was to investigate the usage prevalence of two common types of hair products, leave-in/leave-on conditioner and chemical relaxer/straightening products, during childhood, adolescence, and adulthood among a cohort of African-American women. Our second and third objectives were to use LCA to characterize participants based on usage of a variety of hair products (e.g., hair moisturizing products, hair styling products) and to determine whether latent class membership was associated with sociodemographic characteristics. Results of this descriptive study can inform exposure assessment in future analytic studies of associations between hair products and health behaviors/outcomes.

MATERIALS, SUBJECTS, AND METHODS

Study of Environment, Lifestyle, and Fibroids

The Study of Environment, Lifestyle, and Fibroids (SELF) is a prospective cohort study designed to identify risk factors for uterine fibroid incidence and growth among young African-American women. The SELF protocol and a detailed list of inclusion and exclusion criteria are described in detail elsewhere.³⁸ Briefly, from November 2010 to December 2012, self-identified African-American women aged 23–34 years who lived in the Detroit, Michigan area were recruited for study participation. Women had to have no prior clinical diagnosis of fibroids. A total of 1,693 eligible women completed computer-assisted

telephone interviews (CATI), computer-assisted web interviews (CAWI), and clinical examinations at baseline. During the CATI and CAWI interviews, participants self-reported childhood, adolescent, and current sociodemographic and lifestyle/health behavior characteristics. Follow-up of participants continued at approximately 20-month intervals over five years. At each follow-up, a core set of baseline data was updated and special modules were administered to collect data on additional exposures, including a module with detailed questions about hair product use. Participants provided written informed consent. The current investigation included CATI and CAWI data collected at enrollment (2010-2012) and at the second (2013-2014) or third follow-up (2016-2018). Participants who missed the second follow-up completed the hair product usage module during the third follow-up. The SELF protocol was approved by the National Institute of Environmental Health Sciences and the Henry Ford Health System Institutional Review Boards.

Study Participants

Participants were excluded (n=138) if they did not complete the hair product usage module (n=130) or had missing data for either leave-in/leave-on conditioner or chemical relaxer/straightening products during childhood, adolescence, or adulthood (n=8). Participants included and excluded from this study had comparable childhood and baseline socioeconomic characteristics (Supplemental Table 1). Among the 1,555 African-American women in the final analytic sample, the mean age at the time of reporting hair product usage behaviors in the prior 12 months was 33±3.4 years.

Sociodemographic Characteristics

Childhood sociodemographic characteristics self-reported during the baseline CAWI (2010-2012) included highest educational attainment of the participants' primary caregiver (high school or General Education Diploma (GED), some college/associate's or technical degree, or bachelor's degree); household income during most of childhood (well-off, middle income, low income/poor); and parents' marital cohabitating status (two-parent household when participant was 10 years old [yes, no]).

Adulthood sociodemographic characteristics in the 12 months prior were reported during a follow-up CAWI (either 2013-2014 or 2016-2018). These characteristics included age (years); educational attainment (high school or General Education Diploma (GED), some college/associate's or technical degree, or >bachelor's degree); total annual household income (<\$20,000; \$20,000-\$50,000; >\$50,000); current full- or part-time employment (yes, no); and marital/cohabitating status (married/living with partner, divorced/separated/widowed, never married).

Hair Product Usage Behaviors

Childhood and adulthood hair product usage behaviors were collected by CAWI. Details including categorical response options for all childhood and adulthood usage behaviors are provided in Supplemental Table 2.

Leave-in/Leave-on Conditioner Usage during Childhood, Adolescence, and Adulthood.—To assess frequency of leave-in/leave-on conditioner use during childhood

and adolescence, participants responded to the question, ‘How often was your hair treated with leave-in conditioners or other products that remained on your hair rather than being rinsed out when you were around [5 years old; 10 years old; 15 years old]?’ Response options included: ‘*about everyday*’, ‘*3 to 5 times a week*’, ‘*1 to 2 times a week*’, ‘*1 to 3 times a month*’, and ‘*rarely or never*’. To assess leave-in/leave-on conditioner use during adulthood, participants reported how often they used conditioners, crème rinses, or detanglers. Response options included: ‘*2 times a day or more*’, ‘*once a day*’, ‘*2 to 5 times a week*’, ‘*once a week*’, ‘*1-3 times a month*’, ‘*less than once a month*’, and ‘*did not use in past 12 months*’. If participants reported using conditioners, creme rinses or detanglers at least ‘*1-3 times a month*’ in the prior 12 months, they were subsequently asked whether they used leave-in or rinse-off conditioner (yes, no for each). If participants responded ‘yes’ to leave-in conditioner, they were categorized as using leave-in conditioner in the past 12 months. To standardize categorical responses across childhood, adolescence, and adulthood, leave-in conditioner usage was categorized as high (>once/week), medium (1-3 times/month), and low (rarely/never), which included ‘*less than once a month*’ and ‘*did not use*’.

Use of Chemical Products to Change Texture of Hair during Childhood, Adolescence, and Adulthood.—Participants were asked, “How often was your hair treated with chemical products that change the texture of your hair such as Jheri curl, relaxer, or perm when you were around [5 years old; 10 years old; 15 years old]?” During adulthood, participants were asked questions about these products using a skip pattern. First, they were asked if they ever had relaxers, straighteners, or perms applied to their hair during their lifetime. Participants who reported ‘yes’ were then asked at which categorical age relaxers, straighteners, or perms were first applied and how often they were applied to the hair during the past 12 months. Chemical relaxers or straighteners can be applied as often of every 6 weeks, depending on hair texture and desired hairstyles. Frequency of relaxer/straightener/perm use was categorized as high (>twice/year), medium (once/year), or low (never or no use) for childhood, adolescent, and adulthood/past 12 months. Participants also reported the types of chemical relaxers/straightening products used during their lifetime. Categories included: permanent (subcategories: lye, low-lye, other/unknown composition) and temporary (subcategories: keratin, non-keratin, unknown composition). Types of chemical straightening products were not mutually exclusive.

Use of Hair Cleansing, Growth/Moisturizing, Styling, and Coloring Products during Adulthood.—In addition to leave-in/leave-on conditioner and chemical relaxers/straighteners, other adult hair-product usage behaviors were collected. Reported usage was related to shampoo, hair growth/moisturizing, hair styling, and coloring products in the past 12 months. We created trichotomous categories of high (once per week), medium (1-3 times/month), and low/no (rarely/never) for the following products: shampoo, petroleum jelly, shea butter, natural plant-based oils (e.g., coconut oil), hair food, moisturizing creams and lotions, conditioner (e.g., deep conditioner; which were included because of their use as hair moisturizers), and hair styling products (i.e., hair spray or styling spritz, styling gel, mousse, pomade, hair grease, oil sheen, setting lotion). Individual hair styling products were combined because it was not possible to determine the three levels of use for each individual styling product. (Supplemental Table 2). However, use at least weekly (yes vs. no) of each

individual hair styling product was assessed for participants reporting any use of the combined hair styling products. Lastly, participants reported the categorical frequency of hair coloring or hair-gloss products (i.e., henna, rinses, semi-permanent hair color, permanent hair color, bleach, and hair gloss treatment) in the past 12 months, which we recategorized as high (≥ 4 times/year), medium (1-3 times/year), or low (did not use in the past 12 months).

Statistical Analysis

For product use from childhood to adulthood, we separately calculated the usage prevalence of leave-in/leave-on conditioner and relaxers/straighteners at ages 5, 10, 15 (years), and during adulthood (within the past 12 months). Categorical age at first use and types of relaxers used were also calculated. Univariate multinomial logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) associated with childhood socioeconomic characteristics among participants who reported either medium or high versus low use of leave-in/leave-on conditioner and chemical relaxer/straightener at age 5, 10, and 15 years, separately. Separate univariate multinomial logistic regressions were also performed to compare adulthood socioeconomic characteristics for participants who reported either medium or high compared to low use of leave-in/leave-on conditioner and chemical relaxer/straightener in the past 12 months.

Latent class analysis of hair product use in the prior 12 months in adulthood was performed using high, medium, and low categories of chemical relaxers/straighteners, shampoo, hair growth/moisturizing, hair styling, and hair coloring/gloss products. Latent class models are data reduction tools that group individuals together in mutually-exclusive categories based on probabilities of individual indicators; therefore, individuals with similar probabilities of indicators are grouped together.³⁹ In LCA, individuals with missing values for indicators (<0.5% in this study) are included in models (versus listwise deletion) because LCA uses full information maximum likelihood estimation, which incorporates missing data patterns in estimation procedures.⁴⁰ When all products were included as indicators, models failed to converge likely due to infrequent use of several product types (e.g., hair coloring/gloss). To address non-convergence in models with all products, products with low probability of use (i.e., petroleum jelly, hair coloring/gloss products) and little variability were excluded from the model. As a result, models included chemical relaxers/straighteners, shampoo, hair growth/moisturizing products (except petroleum jelly), and hair styling products. We fit a sequence of latent class models starting with one class and increasing up to five classes. To determine the best-fitting model, we used Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), the likelihood ratio, and the size of the smallest class. Criteria for the best fitting model were: the lowest AIC and BIC, a non-significant p-value for the likelihood ratio test for comparisons of the estimated model to the saturated model, and a smallest class containing at least approximately 5% of participants.^{41, 42} After model estimation, posterior probabilities of latent class membership were determined for each individual. Posterior probabilities are estimated after identifying the characteristics of latent classes (e.g., distributions of probabilities of use across products) and are the subsequently estimated probabilities that an individual belongs to a latent class.⁴³ We assigned individuals to the latent class in which their posterior probability of membership was the highest.⁴⁴

After model selection and latent class assignment, prevalence and mean/standard deviation estimates of both childhood and adulthood sociodemographic characteristics were compared overall and across classes using chi square tests and ANOVAs. Analyses were performed using StataSE 15 (StataCorp LLC, College Station, TX). Statistical significance was determined using a two-sided p-value of 0.05. The authors' statistical code is available upon request, pending review.

RESULTS

Use of Leave-in Conditioner and Chemical Hair Products to Change Hair Texture during Childhood, Adolescence, and Adulthood (Prior 12 Months)

The prevalence of leave-in conditioner use once/week increased from ages 5 (20%) to 15 years (28%) but decreased during adulthood (24%; Figure 1a). Similarly, use of leave-in conditioner 1-3 times/month increased from ages 5 (24%) to 15 years (47%); but, prevalence decreased from age 15 years to adulthood (19%). Overall, 1,384 participants (89%) reported ever using chemical relaxers or straightening products in their lifetime; 96% of ever users reported that first use occurred at age 19 years (Supplemental Table 3). Most participants (71%) reported using permanent chemical relaxers/straightening products and prevalence of twice/year use increased from 9% to 34% to 73% from age 5 to 10 to 15 years, respectively (Figure 1b). During adulthood, twice/year prevalence decreased to 29%.

Childhood socioeconomic status was not associated with leave-in conditioner use during childhood nor adolescence (Supplemental Table 4). However, lower parental educational attainment and lower household income were positively associated with medium and high chemical/relaxer use at age 15 years. During adulthood, participants with lower educational attainment or lower total annual household income were less likely to report medium or high versus low use leave-in/-on conditioner but were more likely to report medium or high use of chemical/relaxer or straightener (Supplemental Table 5). Participants who were currently unemployed had lower odds of medium leave-in/-on conditioner use (OR=0.53 [95% CI: 0.37-0.76]) but higher odds of medium chemical relaxer/straightener use (OR=2.16 [95% CI: 1.52-3.05]).

Hair Product Usage in Prior 12 Months

The frequency of hair product usage in the prior 12 months varied by product type (Table 1). Only 29% of participants reported shampoo use once/week, 51% reported shampoo use 1-3 times/month, and the remaining 20% reported shampoo use once/month. The most prevalent hair growth/moisturizing products that were used once/week, were natural plant-based oils (23%), moisturizing creams/lotions (32%), and leave-in or rinse-off conditioners/detanglers (32%). Overall, hair styling products were the most prevalently used products, which were used once/week by 79% of participants. The three most prevalent individual styling products used at least weekly were oil sheen (52%), hair grease (45%), and styling gel (36%) (Supplemental Table 6). Although infrequently used overall, the most commonly used hair coloring products that were used at least once per year were rinse (14%), semi-permanent color (16%), and permanent color (22%, Table 1).

Latent Classes of Hair Product Usage in Prior 12 Months

In the latent class analysis, which included chemical relaxer/straightener, shampoo, hair growth/moisturizing products (except petroleum jelly), and hair styling products, the model fit statistics suggested that the three-class model was the best fit (Supplemental Table 7; Supplemental Figure 1).; Although the fit continued to improve between the three-class and four-class models, the improvement was negligible compared to the sequential improvement until the estimation of the three-class model. Further, in other class solutions, either (1) participants with high probabilities of high and low use for the same product appeared in the same class (two-class model: Class 2, Supplemental Figure 1a) or (2) participants did not clearly distinguish into classes (e.g., 95 participants [four-class model] had a posterior probability of <51% for their assigned latent class vs. 25 participants [three-class model]). Therefore, we chose the less complex, but well-fitting three-class model (Figure 2) as the best model.

We assigned individuals to one of the three classes based on the highest posterior probabilities of class membership.^{43, 44} We labeled the three classes as Class One: high styling product use/low use of other products (36% of participants); Class Two: medium use of shampoo and conditioners along with high styling product use (33%), and Class Three: high use of shampoos, certain growth/moisturizing products (i.e., oils, moisturizing creams/lotions, conditioners), and styling products (31%) (Table 2). Although participants in all three classes were likely to report high (weekly) use of styling products that stay in the hair, only Class Three also reported high (weekly) use of shampoos versus medium to low (<3 times/month) use reported by Classes One and Two. Therefore, participants in Classes One and Two were more likely than those in Class Three to have more exposure to other products (i.e., growth/moisturizing or styling products) because the participants in Class Three were more frequently using shampoos that wash away such products. Chemical relaxer/straightener use was generally low and did not vary across all three classes.

Across classes, participants were of similar age, but socioeconomic status (SES) differed. Compared to the class that reported only high styling product use (and low use of other products; Class One), participants in Classes Two and Three, who reported medium-to-high use of multiple products, were more likely to report higher childhood SES (i.e., higher educational attainment of primary caregiver, middle-to-well-off household income), have attained at least some college/associate/technical degree and report an annual household income of >\$20,000 (two-sided $p < 0.05$ for each). Compared to the other two classes, participants who reported medium use of shampoo and conditioners along with high styling product (Class Two) use, were the most likely (83%) to report current full-time or part-time employment (vs. Class One [74%] and Class Three [76%], $p < 0.05$).

DISCUSSION

Among a large cohort of young adult African-American women, the usage prevalence of both leave-in/leave-on conditioner and chemical relaxer/straightening hair products that change hair texture increased from childhood to adolescence but decreased during adulthood. Because of different windows of biologic vulnerability to EDCs during different life stages, the change in prevalence across life stages highlights the importance of going

beyond capturing lifetime (or ever/never) use of products. Based on prevalence, our findings indicate that adolescence may be a particularly prevalent period of hair product use, which has health implications for exposure to EDCs during critical periods of development.⁶ These results can help guide hair product usage measurement in future life course research of hormonally-mediated health outcomes like obesity and breast cancer that have a higher prevalence or worse prognosis among African-American women.

Furthermore, women's hair product use during the 12 months prior to questionnaire completion was categorized into distinct patterns of hair product usage that ranged from high use of only hair styling products to high use of multiple products that remain on the hair and scalp for extended time periods (e.g., leave-in/leave-on conditioners, hair grease, and styling gels). Participants who reported more frequently using multiple products were more likely to have higher SES, which may relate to lifestyle differences, differences in economic resources related to purchasing and ultimately using products, or workplace expectations related to hair presentation for African-American women. Furthermore, although it is counterintuitive, it is not surprising that higher SES participants were more likely to use multiple products despite the presumption that individuals with higher educational attainment would be more knowledgeable of the potentially harmful health effects related to product use. A recent qualitative study that consisted of focus groups of 91 women in California (93% African-American and 92% who completed at least some college) showed that despite knowledge of potential harmful effects of hair product usage, participants' hair was strongly tied to their identity and self-worth.⁴⁵ As a result, participants reported continued use of potentially harmful hair products, which allowed them to achieve styles associated with their self-identity and acceptance in society. Cultural, sociodemographic, and lifestyle factors should also be collected and analyzed in hair product usage behavior assessments among African-American women.

Our results for chemical relaxer or straightening product usage had noteworthy similarities and differences with prior studies. Similar to our study, prior studies reported a high lifetime prevalence of ever usage of chemical relaxers or straighteners among African-American women, ranging from 60% to 97%.^{12, 16, 46, 47} However, two cohort studies of African-American women in New York prior to 2010 reported a lower prevalence of ever use of chemical relaxers and leave-in conditioners during childhood than observed in this study of African-American women in Detroit, Michigan.^{10, 11} In adulthood, reported ever use since age 20 of chemical relaxers/straighteners was 62% among 248 African American women in New York (mean age 47 years)¹¹ compared to reported use of 42% in the prior 12 months among SELF participants (mean age 33 years) in this study. The lower prevalence of hair relaxer usage in the SELF may reflect differences in assessment time periods (since age 20 years vs. prior 12 months) or the cultural shift/'natural hair movement' that began in the early 2000's. This movement marked the embracing of hair in its naturally-curly state by many women in the African-American community.^{9, 48} By 2010, results of a market survey showed 36% of black women reported eliminating relaxer usage.⁹ Therefore, the present study results may reflect cultural shifts in hair product usage norms unique to age cohorts. For instance, in a cohort of women who became adolescents after the 'natural hair movement', chemical relaxer/straightener usage may be low at all ages and similar to the adulthood prevalence observed in SELF. Future studies should continue to investigate cohort

effects related to hair product usage and beauty norms over the life course and across generations of African-American children and women.

Weekly styling product use was highly prevalent (79%) among African-American women in the SELF cohort. These products often remain on the hair and scalp for extended periods of time. Of note, for most participants (71%), shampoo usage frequency was <once/week; therefore, styling products would remain until washed out. Furthermore, oils, moisturizing creams and lotions, conditioners, and styling products were used by at least one in five participants on a weekly basis. These products – used for a wide range of purposes related to caring for and styling hair – can contain high levels of certain parabens, phenols, and fragrances.⁶ These product combinations may result in complex mixtures of EDCs that may damage health due to the potential cumulative effect of these chemical exposures. Our results of frequent usage of multiple products likely to contain EDCs from childhood to adulthood, which are consistent with other studies, could explain why higher concentrations of certain EDC metabolites are found in African-American compared to white women across the life span.^{49–51} Further investigations of chemical compositions of hair products included in the current study are needed to supplement our epidemiological findings.

The identified distinct latent classes of hair product usage illustrate the complexity of considering hair product usage as an exposure in studies. In addition to the potential EDC exposure that can occur from concurrent usage of multiple products, SES may add to the complexity of investigating personal care product usage and health. Women who reported the most frequent usage were most likely to report higher SES, including higher educational attainment and higher income. In addition to having different hair product usage behaviors, women of varying SES, likely differ in other behaviors, lifestyle factors, and exposure to physical (e.g., neighborhood) and social (e.g., workplace stressors) environments, which can have negative health implications.^{52–55} Future research must consider the combination of multiple environmental (both physical and social), socioeconomic, cultural, and behavioral factors that may result in escalated risk of adverse health consequences among African-American women.

This study has noteworthy limitations. For instance, the cross-sectional study design limited our ability to determine temporality of associations between hair product usage and participant characteristics. Due to the use of self-reported data, hair product usage may have been misclassified, particularly with respect to childhood and adolescent usage. Potential misclassification of leave-in/leave-on conditioner usage during adulthood was more likely because of the assessment's skip pattern, which first asked about frequency of any conditioner use prior to differentiating between rinse-out and leave-in/leave-on conditioner. Related to potential misclassification, the LCA approach used by assigning individuals to classes may also have resulted in non-differential misclassification and therefore attenuated associations between latent class membership and participant characteristics.⁵⁶ Future studies may benefit from including participant characteristics in latent class models when determining latent class membership to reduce potential misclassification.⁵⁶ We were unable to capture the actual products used or the chemical composition of the products. We also did not have data on use of natural hair preparations or explicitly ask if participants wore their hair naturally; however, wearing hair naturally can be inferred from lack of use of chemical

relaxing/straightening products. Nonetheless, future studies should measure and include this information. Lastly, results may not be generalizable to other African-American women as our study participants are from the Detroit, Michigan area and represent women born between 1976 and 1989. Hair product usage behaviors may vary by age cohorts, so women born before or after this cohort may have different usage patterns. More studies describing usage of these products among African-American women are necessary.

Despite these limitations, our descriptive study has important strengths and extends the prior literature. We captured childhood, adolescent, and adulthood usage of commonly used hair products that have been positively associated with EDCs and poor health outcomes among a particularly vulnerable population.^{10–13, 16} Furthermore, to our knowledge, this is the first study to describe leave-in/leave-on conditioner and chemical relaxer/straightener use beyond ever and never categorizations across childhood and adulthood. In future studies, it will be important to determine whether usage during certain life stages and usage trajectories are associated with specific health outcomes. Furthermore, we measured multiple hair product usage behaviors during adulthood. With these comprehensive measures and a relatively large sample of African-American women who are understudied, data were sufficient to robustly perform an LCA. To our knowledge, this is also the first study to perform an LCA of hair product usage behaviors specifically among African-American women. We have identified meaningful latent classes of hair product usage. Latent classes should be explored in future studies to identify whether consistent patterns emerge across other populations of African-American women. Furthermore, health behaviors/outcomes associated with hair product usage in prior literature (i.e., physical activity, early menarche, and fibroids^{10–12, 57}) could be investigated across the classes. Classes may better capture the full range of exposure beyond ever/never use.

Ultimately, hair product usage behaviors – in terms of type and frequency of use – appear to vary across the investigated life stages among African-American women. In this study, the prevalence of leave-in/leave-on and chemical relaxer/straightening product usage increased markedly from childhood to adolescence but decreased during adulthood, which illustrates the importance of measuring usage beyond lifetime or ever/never use. During adulthood, there were distinct groups of participants who engaged in differential hair product usage behaviors; and two groups frequently used multiple product types at least weekly. Women of higher SES reported higher use. Since prior studies have identified exogenous hormones and potentially-health damaging chemicals in these products,⁶ future studies should consider the complexities of hair product usage, their variability by SES, and the impact of these products on chemical exposures in investigations of adverse health outcomes among African-American women who represent a particularly vulnerable population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

AIC	Akaike information criteria
ANOVA	Analysis of variance
BIC	Bayesian information criteria
CATI	Computer-assisted telephone interview
CAWI	Computer-assisted web interview
EDC	Endocrine-disrupting chemical
LCA	Latent class analysis
SELF	Study of Environment, Lifestyle, and Fibroids
SES	Socioeconomic status

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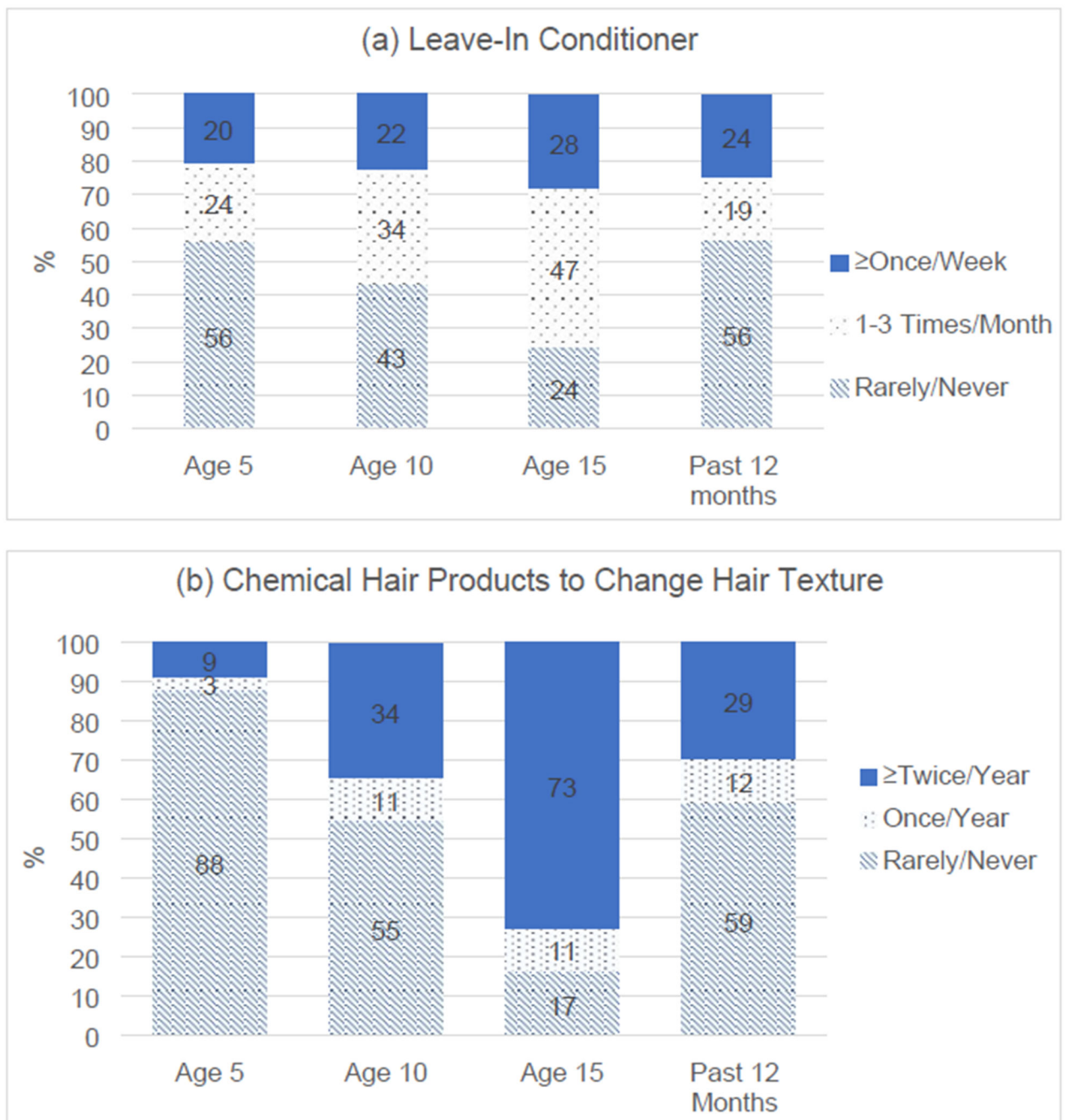


Figure 1. Prevalence of (a) Leave-in/Leave-on Conditioner Usage and (b) Chemical Hair Product Usage during Childhood, Adolescence, and Adulthood among Included Participants, Study of Environment, Lifestyle, and Fibroids (2010-2018), N=1,555

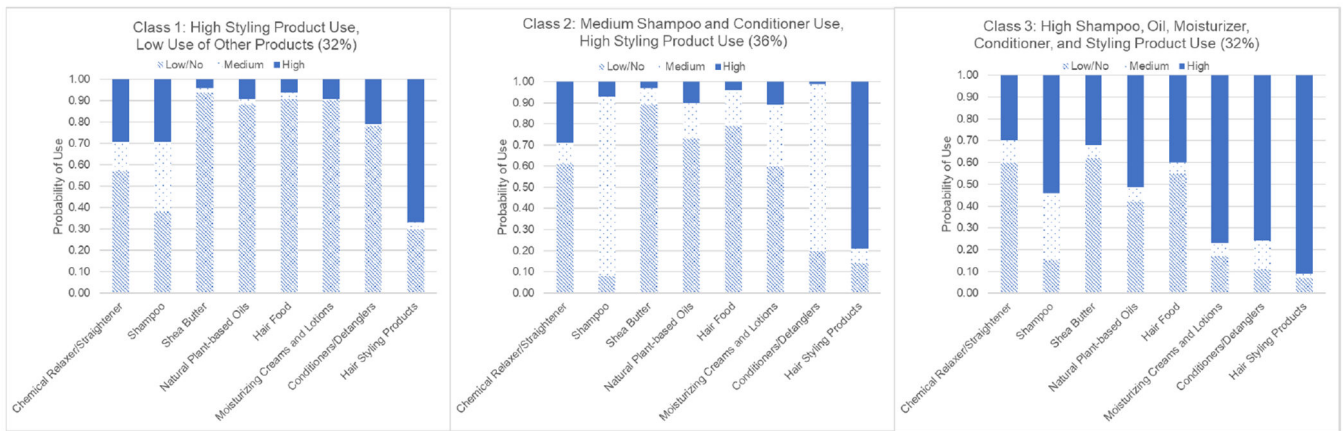


Figure 2. Results of Latent Class Analysis: Three Class Solution Based on Marginal Probabilities of Hair Product Usage during Adulthood (12 Months Prior to Interview), Study of Environment, Lifestyle, and Fibroids (2013-2018), N=1,555

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Frequency of Hair Product Use in the Past 12 Months, Study of Environment, Lifestyle, and Fibroids (2013–2018), N=1,555

Table 1.

Hair Product	Usage Categories ^a			n (%)
	High	Medium	Low/No	
Chemical Relaxer/Straightener	456 (29)	180 (12)	919 (59)	
Hair Cleansing Product				
Shampoo	452 (29)	796 (51)	307 (20)	
Hair Growth/Moisturizing Products				
Petroleum Jelly	125 (8)	33 (2)	1397 (90)	
Shea Butter	200 (13)	85 (5)	1270 (82)	
Natural Plant-based Oils	355 (23)	139 (9)	1056 (68)	
Hair Food	246 (16)	137 (9)	1171 (75)	
Moisturizing Creams and Lotions	491 (32)	193 (12)	870 (56)	
Rinse-off or Leave-in/-on Conditioners/Detanglers	493 (32)	507 (33)	555 (36)	
Hair Styling Products^b	1228 (79)	65 (4)	262 (17)	
Coloring or Gloss Product Use				
Henna	19 (1)	44 (3)	1492 (96)	
Rinse	81 (5)	144 (9)	1330 (86)	
Semi-permanent Hair Color	72 (5)	164 (11)	1318 (85)	
Permanent Hair Color	57 (4)	281 (18)	1216 (78)	
Bleach	34 (2)	175 (11)	1345 (87)	
Hair Gloss Treatment	53 (3)	106 (7)	1395 (90)	

Row percentages are presented. Percentages may not sum to 100 due to rounding.

^aHigh corresponds to use >twice/year for chemical relaxer/straightener; >once/week for hair cleansing, growth/moisturizing, or styling products; and >4 times/year for coloring or gloss products. Medium corresponds to use once/year for chemical relaxer/straightener; 1–3 times/month for hair cleansing, growth/moisturizing, or styling products; and 1–3 times/year for coloring or gloss products. Low/no corresponds to never/no use of chemical relaxer/straightener; rarely/never use of hair cleansing (<once/month), growth/moisturizing, or styling products; and did not use coloring or gloss products.

^bHair styling products include hair spray or styling spritz, styling gel, mousse, pomade, hair grease, oil sheen, and setting lotion. <0.5% missing for natural plant-based oils, hair food, moisturizing creams and lotions, semi-permanent hair color, bleach, and hair gloss treatment.

Table 2.

Self-reported Sociodemographic Characteristics of Participants in Each Latent Class of Hair Product Usage during Adulthood, SELF (2013–2018), N=1,555

Sociodemographic Characteristics	Classes of Hair Product Usage ^a			
	Overall	Class 1 n=558 (36%)	Class 2 n=513 (33%)	Class 3 n=484 (31%)
Mean age ±SD, years	33±3.4	33±3.5	33±3.5	33±3.3
Childhood				
Highest Educational Attainment of Primary Caregiver *				
High School or GED	47	54	43	42
Some College/Associate or Technical Degree	42	37	45	44
Bachelor's Degree	11	9	12	14
Household Income during Most of Childhood *				
Well-off	7	9	6	7
Middle Income	53	46	60	53
Low Income/Poor	40	45	34	40
Two-parent Household *				
Yes	52	50	58	48
No	47	50	42	52
Adulthood				
Educational Attainment *				
High School or GED	47	22	10	13
Some College/Associate or Technical Degree	42	52	52	51
Bachelor's, Master's, or Doctoral Degree	11	26	37	36
Total Annual Household Income *				
<\$20,000	36	43	28	35
\$20,000-\$50,000	39	36	44	37
>\$50,000	25	21	28	28
Current full- or part-time employment (yes) *	78	74	83	76
Marital Status				
Married/Living with Partner	41	41	42	41
Divorced/Separated/Widowed	20	18	20	21
Never Married	39	41	38	38

Abbreviations: SELF=Study of Environment, Lifestyle, and Fibroids; SD=standard deviation; GED=General Education Diploma

^aClass 1 consisted of participants who reported high use of styling products and low use of other products. Class 2 consisted of participants who reported medium use of shampoo and conditioner as well as high use of styling products. Class 3 consisted of participants who reported high use of shampoo, certain growth/moisturizing products (i.e., oil, moisturizers, conditioners), and styling products. Percentages of participants in each class differ from Figure 2 because class assignment was based on the highest posterior probabilities of membership, which are determined post-model selection. Posterior probabilities may differ from marginal probabilities estimated during model estimation because posterior probabilities of membership are generated based on assumptions regarding the compositions of the estimated latent classes.

Note: Percentages are column percentages, which may not sum to 100 due to rounding. 1% missing for educational attainment and annual household income

* two-sided $p < 0.05$ for chi-square test for differences between classes. Percentages that differed between classes are bolded.

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