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Highly Processed and Ready-to-Eat Packaged Food and Beverage Purchases Differ by Race/Ethnicity among US Households[1–3]

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Abstract

Background: Racial/ethnic disparities in dietary quality persist among Americans, but it is unclear whether highly processed foods or convenience foods contribute to these inequalities.

Objective: We examined the independent associations of race/ethnicity with highly processed and ready-to-eat (RTE) food purchases among US households. We determined whether controlling for between-group differences in purchases of these products attenuated associations between race/ethnicity and the nutritional quality of purchases.

Methods: The 2000–2012 Homescan Panel followed US households (n = 157,142) that scanned their consumer packaged goods (CPG) food and beverage purchases. By using repeated-measures regression models adjusted for sociodemographic characteristics, we examined time-varying associations of race/ethnicity with processed and convenience food purchases, expressed as a percentage of calories purchased. We estimated associations between race/ethnicity and saturated fat, sugar, or energy density of total purchases with and without adjustment for processed and convenience food purchases.

Results: Compared with white households, black households had significantly lower purchases of highly processed foods (–4.1% kcal) and RTE convenience foods (–4.9% kcal) and had higher purchases of basic processed foods, particularly cooking oils and sugar (+5.4% kcal), foods requiring cooking/preparation (+4.5% kcal), and highly processed beverages (+7.1% kcal). Hispanics also had lower purchases of highly processed and RTE foods than whites. Blacks had CPG purchases with significantly higher median sugar (+2.2% kcal) and energy density (+72 kcal/1000 g), whereas Hispanics had purchases with lower saturated fat (–0.6% kcal) and energy density (–25 kcal/1000 g) than whites. Racial/ethnic differences remained significant after adjustment for processed and convenience food purchases.

Conclusions: In our study, compared with white households, both black and Hispanic households had lower purchases of highly processed and RTE foods, yet had total CPG purchases with differing nutritional quality. Our findings suggest that highly processed convenience foods are associated with, but cannot fully explain, racial/ethnic disparities in the nutritional quality of CPG purchases. *J Nutr* 2016;146:1722–30.

Keywords: processed food, food processing, convenience, race, ethnicity, disparities

Introduction

Racial and ethnic disparities in obesity and nutrition-related chronic diseases among Americans have been well documented (1–3). Differences in dietary intake across racial/ethnic groups may mediate these health inequalities (4, 5). Previous studies found that black children and adults had less favorable nutrient intakes, lower adherence to dietary guidelines, and poorer dietary quality than their white counterparts (6–12). To reduce these disparities, a better understanding of the types of foods purchased and consumed by each population group is needed to inform dietary guidance, interventions, or policy efforts (6–8). Scholars have proposed that future efforts may thus need a new focus on novel metrics, such as food processing (13–16).

Foods can be classified along a spectrum ranging from minimally processed to highly processed on the basis of the extent to which the food was altered from its natural state as a result of industrial food processing (16–18). Highly processed foods are defined as multi-ingredient, industrially formulated mixtures

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[3] Supplemental Materials 1 and 2, Supplemental Tables 1–3, and Supplemental Figures 1–15 are available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http:// jn.nutrition.org.

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(17). Some, but not all, processed foods are manufactured to be ready-to-eat (RTE)[4] and may independently promote overconsumption; thus, researchers may distinguish processing from convenience (19–22). The highly processed and RTE foods purchased by US households were found to have substantially higher saturated fat, sugar, and sodium content than less processed foods or foods requiring cooking, respectively (17). Greater consumption of highly processed foods has been associated with higher energy intake, poorer dietary quality, and higher obesity prevalence (23, 24). In a recent study, highly processed foods and beverages provided 61.0% of calories in consumer packaged goods (CPG) purchased by US households, and the majority of products (68.1%) were purchased in RTE form (17); furthermore, 57.3% of energy intake came from processed foods among NHANES participants (18).

However, it is unknown whether highly processed and convenience food purchases differ across racial/ethnic populations and whether these differences have widened or narrowed across time. Studies of racial/ethnic variation in diet have been hindered by differential bias in self-reported intake and lack of culturally appropriate questionnaires or food-composition databases (25–29); therefore, food-purchasing data recorded by barcode scanning may provide valuable insight (30). Disparities in dietary quality have worsened in the past decade, which suggests that changes in highly processed or RTE foods may have occurred (10–12).

In addition, although previous studies suggest that racial/ethnic disparities exist in the overall nutritional quality of dietary intake and CPG purchases (8, 31), a lack of understanding of how highly processed and convenience foods contribute to these differences is a major gap in the literature. Scholars hypothesize that excess consumption of highly processed or convenience foods may promote poor dietary quality because of their less healthful nutritional profile as well as their potential ability to trigger addictive-like eating behaviors (24, 32–34). Yet, other scholars concluded that processed foods are not major determinants of the nutrient content of dietary intake (18). Thus, examining whether racial/ethnic differences in processed and convenience food purchases are associated with disparities in the nutrient content of CPG purchases is essential to help guide future intervention or policy work that might target highly processed RTE foods. To address these gaps in the research literature, we aimed *1*) to examine multivariable-adjusted associations of race/ethnicity with highly processed and RTE food and beverage CPG purchases among a large nationwide sample of US households and *2*) to determine whether controlling for subpopulation differences in processed and convenience food purchases could attenuate the associations between race/ethnicity and the nutritional quality of total CPG purchases.

Methods

Study population

This analysis used data from the 2000–2012 Nielsen Homescan Panel, a nationwide study of CPG food and beverage purchases by US households (35–38). Household members are given barcode scanners and are instructed to scan the barcodes on all foods and beverages purchased from grocery, drug, mass-merchandise, supercenter, and convenience stores and supermarkets. Homescan uses an open-cohort study design, in which households are required to scan purchases continuously for ≥10 mo and then may exit the study at any time. As households exit the study, new households are enrolled to rebalance the sociodemographic characteristics of the sample. Households scan their purchases continuously throughout the year; to best capture usual shopping habits, all purchases during a calendar year were summed to create year-level purchase totals. The majority of those surveyed between 2000 and 2012 remained in the study for multiple years of observation (70%) and had multiple year-level observations. The mean time in the study was 4.2 y (range: 1–13 y). Households were sampled from 76 geographic markets. Race/ethnicity and educational level of the male and female heads of household, household income, and each household member's age and sex were assessed by questionnaire. Multiracial households were categorized on the basis of the race/ethnicity of the head of household. To capture usual shopping, this analysis excluded purchases during annual quarters deemed unreliable by study investigators (CPG purchases <$135 for multimember households and <$45 for single-member households in any 4-wk period) and year-level observations for households reporting >1 unreliable quarter during a given year (2.2%) (39). The final analytic sample included 656,184 household year-level observations (157,142 unique households) from 2000 through 2012. As secondary analysis, this study was exempt from institutional review board approval.

Food and beverage purchase data

Households scanned the barcode of each purchased item. Each barcode was linked to a corresponding Nutrition Facts Panel with the product's nutrient content, weight (g), ingredients, and description (39). Product attributes and ingredient lists were used to categorize products at the barcode level into food groups reflecting nutrient content and consumption patterns (17).

Processing and convenience classification

Previous work developed a classification system for categorizing foods and beverages by degree of processing and level of convenience; a detailed description of this system is available elsewhere (17) and is described in brief below and in **Supplemental Material 1**. Each of 1,230,536 barcoded products was classified into a single category for processing and separately into a single category for convenience. Classification was conducted programmatically by using the Perl-based pattern matching syntax "regular expressions" to perform keyword searches of ingredient lists, product attributes, and package information (17).

Processing. Each barcoded item was assigned to 1 of 4 categories of food processing on the basis of the extent to which the food was altered from its natural state by industrial food processing and the purpose of these processing steps (**Supplemental Table 1**) (17). "Unprocessed or minimally processed" products are single-ingredient foods that have undergone no or slight modifications, such as milk, fresh or frozen fruit and vegetables, or unseasoned meats. "Basic processed" products have undergone physical or chemical processing but remain as single foods (17). This category includes basic processed ingredients, such as oil or granulated sugar, and foods processed for basic preservation, such as vegetables canned with no added salt or refined-grain flour. "Moderately processed" products are single foods with the addition of flavor additives, such as salted nuts or fruit canned in syrup; these products remain recognizable as their original plant or animal source (17). "Highly processed" products are multi-ingredient, industrially formulated mixtures that have been processed to an extent that they are no longer recognizable as their original plant or animal source (17). Examples are refined breads, grain-based desserts, sugar-sweetened beverages (SSBs), pre-prepared mixed dishes, margarine, or ketchup.

Convenience. To separately classify foods and beverages by convenience, each product was assigned to 1 of 3 categories on the basis of the amount of food preparation required by the consumer before the product can be eaten (**Supplemental Table 2**) (17). Products requiring "cooking and/or preparation" (hereafter "requiring cooking") require input of the consumer's time, culinary skill, energy, or attention to cook or prepare before consumption (17). Examples include raw meat, fresh potatoes, cooking oil, flour, or dry pasta. Products "ready-to-heat or requiring minimal preparation" (hereafter "ready-to-heat") require only a small amount of the consumer's time or effort and no culinary skill or attention, such as

[4] Abbreviations used: CPG, consumer packaged goods; RTE, ready-to-eat; SSB, sugar-sweetened beverage.

frozen dinners or canned soup (17). RTE products can be consumed immediately with no preparation (17) and include bread, salty snacks, cookies, fruit, and some raw vegetables (e.g., precut salad or baby carrots).

Statistical analyses

All of the statistical analyses were performed using Stata 14 (Stata Corp). To examine the association of highly processed or RTE food and beverage purchases with race/ethnicity, we used multivariable-adjusted, repeated-measures, random-effects regression models; these models were used to account for correlation between repeated measures within households across time. To estimate time-varying associations with race/ethnicity independent of income or education, models regressed the percentage of calories purchased from a given category of processed food on year (dummy variables) and race/ethnicity [non-Hispanic white (white), non-Hispanic black (black), Hispanic, and all other races/ethnicities] while adjusting for education (less than high school, high school, and college degree or higher), household income [<$25,000 (low income), $25,000–$49,999, $50,000–$74,999, and ≥$75,000 (high-income)], and other covariates (described below). Because of heterogeneity among those classified as other races/ethnicities, results for these households are not shown. Separate models were used for each category of processing and convenience, separately for foods (as a percentage of food calories purchased) and beverages (as a percentage of beverage calories purchased). Outcomes were expressed as percentages to control for differences in absolute calories purchased across racial/ethnic groups.

To determine whether associations between purchases and race/ethnicity varied across time, Wald tests for the joint significance of interaction product terms were used. Significant interactions ($P < 0.001$) were detected between time (y) and race/ethnicity for all outcomes, so interaction terms were retained in the final models. Coefficients from the full model were used to determine the adjusted outcome value (%kcal from processed or convenience foods) for each racial/ethnic group in each year. Results focus on 2000 and 2012 only because differences were minimal across time. Associations between purchases and race/ethnicity were assessed as conditional marginal effects in 2000 and 2012. Time trends from 2000 through 2012 were assessed as the marginal effect of year (2012 compared with 2000) for each racial/ethnic group. Time trends and purchases were compared across subpopulations by using postestimation Wald tests.

To determine whether associations between purchases and race/ethnicity differed by household income, 2-way and 3-way interactions of race, income, and time were tested for each outcome. Tests were not significant, except for models with the outcomes basic processed foods and foods requiring cooking; although these were significant, differences were small. Because associations of purchases and race/ethnicity showed similar patterns for all income groups, results stratified by income are presented as **Supplemental Figures 1–12**. Additional analyses to identify key processed or convenience foods that varied across racial/ethnic groups are described in detail in **Supplemental Material 2**.

To examine how these differences in processed and convenience food purchases across racial/ethnic subpopulations may be related to the nutritional quality of purchases, associations between the nutrient content of total purchases and race/ethnicity were estimated with and without adjustment for processed and convenience food purchases. This analysis used multivariable-adjusted quantile regression with saturated fat (% kcal), sugar (% kcal), or energy density (kcal/1000 g; food only) of total CPG purchases as continuous outcomes, race/ethnicity as the main independent variable, and clustering on the household to account for correlation of repeated measures. Quantile regression was used to appropriately model the skewed distribution of nutrient content outcomes and to remove undue influence of outliers (40). β-Coefficients provided the difference in nutrient content of CPG purchases at the 50th (median) and 90th percentiles for each racial/ethnic group compared with the referent group (white); this approach was used to reveal heterogeneity in racial/ethnic differentials among households with the poorest nutritional quality of purchases that are potentially associated with greater health risk. Models were additionally adjusted for purchases from each category jointly defined by processing and convenience. Estimates with and without adjustment were compared, with a 10% change-in-estimate used as an a priori criterion that indicated that processed and convenience food purchases partially explained racial/ethnic variation in the nutrient content of purchases.

All models were adjusted for year; household income; education; household composition (single adult with no children, single adult with children, multiple adults with no children, and multiple adults with children); interactions of income, education, and household composition with year; the number of male and female household members within age groups (children aged 2–5 y, 6–11 y, and 12–18 y and adults aged ≥19 y); geographic market; and market-level unemployment rate. For all analyses, significant differences were tested by using a 2-sided P value of 0.001 to account for multiple comparisons and the large sample size.

Results

Characteristics of the study population by race/ethnicity are presented in **Supplemental Table 3**. Black and Hispanic households in our study have higher incomes than in the general US population; our sample is not nationally representative, so we

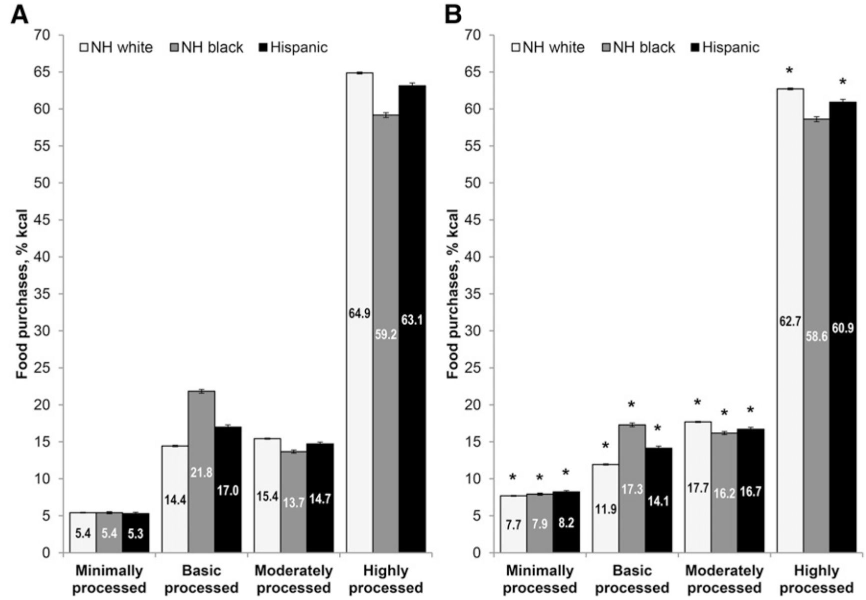

FIGURE 1 Multivariable-adjusted associations between race/ethnicity and the contribution of minimally processed, basic processed, moderately processed, and highly processed foods to total calories in all CPG food purchases in 2000 (A) and 2012 (B) among US households in the Homescan Panel. Values are adjusted means (95% CIs) from longitudinal random-effects linear regression models that regress percentage of kilocalories (% kcal) from each processing category on year (dummy variables), household race/ethnicity, and the interaction of year and race/ethnicity with adjustment for educational level, household income, household composition, the number of household members in each age and sex group, geographic market, and market-level unemployment rate; n = 656,172 household year-level observations from n = 127,871 NH white, n = 14,539 NH black, and n = 11,133 Hispanic households (results for ''other races/ethnicities'' not shown). *Significant within-group change in % kcal from processed foods between 2000 and 2012, $P < 0.001$ (Wald test). CPG, consumer packaged goods; NH, non-Hispanic.

cannot estimate racial/ethnic differences that reflect the distribution of income across racial/ethnic groups in the United States. Instead, racial/ethnic differentials are presented after adjustment for income and sociodemographic factors to show these differences holding constant socioeconomic status. Race/ethnicity was significantly associated with the proportion of calories purchased from basic processed and highly processed CPG foods (**Figure 1**). Both black and Hispanic households had higher purchases of basic processed foods and lower purchases of highly processed foods, as a percentage of total calories purchased, than white households in all years between 2000 and 2012. In 2012, the calorie contribution of highly processed foods to purchases was 4.1% kcal lower ($P < 0.001$) among black than among white households, despite small but significant declines in the calorie contribution of these products between 2000 and 2012 among white but not black households. The black-white difference was significantly larger among low-income households ($\beta = -4.9\%$ kcal) than among high-income households ($\beta = -3.7\%$ kcal) (Supplemental Figures 1–4). In contrast, the proportion of calories purchased from basic processed foods was 5.4% kcal higher ($P < 0.001$) among black households than among white households. Again, the black-white difference was significantly greater among low-income households ($\beta = 6.1\%$ kcal) than among high-income households ($\beta = 4.8\%$ kcal) (Supplemental Figures 1–4).

In terms of calories purchased per person, highly processed food purchases were 95 kcal/d lower among blacks and 82 kcal/d lower among Hispanics than among whites in 2012 (**Table 1**). Lower purchases of grain-based desserts, candy, salty snacks, and dairy-based desserts among black and Hispanic households contributed to these differences. Differences in basic processed food purchases included greater purchases of cooking oil and rice among blacks and Hispanics and higher purchases of granulated sugar among blacks than among whites.

TABLE 1 Daily per capita CPG purchases of top food groups contributing to racial/ethnic differentials in processed food purchases among US households by race/ethnicity: Homescan Panel 2012[1]

	Daily per capita purchases, kcal/d			Racial/ethnic differential (kcal/d),[2] β (95% CI)		
	NH white	NH black	Hispanic	NH white	NH black	Hispanic
Total (foods + beverages)	1297 ± 3.2	1230 ± 9.8*	1205 ± 13.1*	Ref	−67 (−88, −47)	−92 (−119, −66)
Foods	1128 ± 3.0	1064 ± 9.0*	1046 ± 12.0*	Ref	−64 (−83, −45)	−82 (−107, −58)
Minimally processed	88 ± 0.4	86 ± 1.2	89 ± 1.6	Ref	−2 (−5, 0)	1 (−2, 4)
Eggs	18 ± 0.1	20 ± 0.3*	20 ± 0.4*	Ref	2 (1, 2)	2 (1, 3)
Basic processed	139 ± 0.7	202 ± 2.2*	163 ± 2.9*	Ref	63 (58, 68)	24 (18, 30)
Fats and oils (oil, unsalted butter)	46 ± 0.3	85 ± 1.1*	60 ± 1.4*	Ref	39 (37, 42)	14 (11, 17)
Sweeteners (granulated sugar)	43 ± 0.3	60 ± 1.1*	42 ± 1.3	Ref	17 (15, 19)	−1 (−4, 2)
Rice (white or instant)	7 ± 0.1	13 ± 0.4*	20 ± 0.6*	Ref	7 (6, 7)	13 (12, 15)
Moderately processed	200 ± 0.7	170 ± 2.0*	174 ± 2.7*	Ref	−30 (−34, −25)	−26 (−31, −20)
Nuts (salted nuts, nut butters)	43 ± 0.2	31 ± 0.7*	34 ± 1.0*	Ref	−12 (−14, −11)	−9 (−11, −7)
Cheese	36 ± 0.2	22 ± 0.5*	32 ± 0.6*	Ref	−14 (−15, −13)	−5 (−6, −4)
Highly processed	701 ± 2.1	606 ± 6.4*	619 ± 8.6*	Ref	−95 (−108, −82)	−82 (−99, −64)
Grain-based desserts	101 ± 0.4	84 ± 1.3*	88 ± 1.7*	Ref	−17 (−20, −15)	−13 (−16, −9)
Breads and quick breads	98 ± 0.4	94 ± 1.1*	100 ± 1.5	Ref	−4 (−7, −2)	2 (−1, 5)
Candy and sweet snacks	75 ± 0.4	58 ± 1.2*	61 ± 1.6*	Ref	−17 (−20, −15)	−14 (−17, −11)
Salty snacks	74 ± 0.3	59 ± 0.9*	67 ± 1.1*	Ref	−15 (−17, −13)	−7 (−9, −5)
Dairy-based desserts	38 ± 0.2	29 ± 0.6*	30 ± 0.9*	Ref	−9 (−10, −8)	−9 (−10, −7)
Pasta dishes	28 ± 0.5	18 ± 1.5*	21 ± 2.0*	Ref	−10 (−13, −7)	−7 (−11, −3)
Processed meat	27 ± 0.1	34 ± 0.4*	26 ± 0.6	Ref	7 (6, 8)	−1 (−2, 0)
Beverages	169 ± 0.7	166 ± 2.2	159 ± 3.0	Ref	−3 (−8, 1)	−10 (−16, −4)
Minimally processed	52 ± 0.3	30 ± 0.8*	48 ± 1.1*	Ref	−23 (−24, −21)	−4 (−7, −2)
Milk	52 ± 0.3	29 ± 0.8*	48 ± 1.1*	Ref	−23 (−24, −21)	−4 (−7, −2)
Basic processed	13 ± 0.1	15 ± 0.3*	13 ± 0.4	Ref	2 (2, 3)	0 (0, 1)
Fruit juice (unsweetened)	11 ± 0.1	14 ± 0.3*	12 ± 0.4	Ref	3 (2, 3)	1 (0, 1)
Moderately processed	16 ± 0.1	22 ± 0.4*	19 ± 0.6*	Ref	6 (5, 7)	3 (2, 4)
Tea (sweetened or flavored)	4 ± 0.1	8 ± 0.3*	6 ± 0.3*	Ref	4 (3, 4)	2 (1, 3)
Highly processed	88 ± 0.6	99 ± 1.9*	79 ± 2.5*	Ref	11 (7, 15)	−9 (−14, −4)
SSBs	48 ± 0.4	67 ± 1.3*	51 ± 1.7	Ref	19 (16, 22)	3 (−1, 6)
Beer	12 ± 0.3	10 ± 0.8	12 ± 1.1	Ref	−2 (−3, 0)	0 (−2, 3)
Wine	11 ± 0.2	6 ± 0.6*	6 ± 0.8*	Ref	−5 (−6, −4)	−5 (−7, -3)
Liquor	9 ± 0.2	8 ± 0.7	6 ± 0.8*	Ref	−1 (−2, 1)	−3 (−5, −2)

[1] Values are adjusted mean ± SE daily per capita household purchases of selected food groups within categories of processing unless otherwise indicated; n = 59,286 households (n = 47,833 NH white, n = 5485 NH black, and n = 3069 Hispanic households; results for ''other races/ethnicities'' not shown). *Different from NH white, $P < 0.001$ (Wald test). For food groups with <15% nonconsumers, values were determined from linear regression models, regressing purchases (kcal/d) on race/ethnicity; for food groups with >15% nonconsumers, values were determined from a 2-part model including *1*) a probit model of the probability of purchasing and *2*) linear regression of the amount purchased. All models were adjusted for education, income, household composition, number of household members in each age and sex category, and geographic market. CPG, consumer packaged goods; NH, non-Hispanic; Ref, reference group; SSB, sugar-sweetened beverage.

[2] Values are the difference in per capita household purchases between specified racial/ethnic group and NH white households.

By level of convenience, both black and Hispanic households had higher CPG purchases of foods requiring cooking and lower purchases of RTE foods, as a percentage of calories purchased, than white households (**Figure 2**). In 2012, the contribution to food purchases from products requiring cooking was 4.5% kcal higher ($P < 0.001$) and the contribution from RTE food purchases was 4.9% kcal lower ($P < 0.001$) among black than among white households.

Purchases of foods requiring cooking were 46 kcal/d and 23 kcal/d higher and purchases of RTE foods were 97 kcal/d and 81 kcal/d lower among blacks and Hispanics, respectively, than among whites in 2012 (**Table 2**). For both blacks and Hispanics, lower purchases of candy, nuts, salty snacks, and grain-based desserts contributed to differences in RTE food purchases. For foods requiring cooking, blacks and Hispanics had greater purchases of cooking oil and shortening, uncooked processed meat (among blacks), and rice (among Hispanics) than whites.

For beverages, black households had a significantly higher mean contribution of highly processed drinks to beverage calories (7.1% kcal in 2012; $P < 0.001$) than whites, although a significant decrease occurred between 2000 and 2012 for black but not for white households (**Figure 3**). Furthermore, the caloric share of minimally processed beverages was 11.3% kcal lower ($P < 0.001$) among black than among white households. Higher SSB and lower plain milk purchases among blacks were the primary contributors to caloric differences in beverage purchases across racial/ethnic subpopulations (Table 1). In supplemental analyses that used purchases measured in grams rather than calories, associations between race/ethnicity and processed food, convenience food, and processed beverage purchases exhibited similar patterns and directionality (**Supplemental Figures 13–15**).

The adjusted median saturated fat content of total CPG food and beverage purchases was significantly lower among black ($\beta = -1.0\%$; 95% CI: -1.0%, -0.9%) and Hispanic households ($\beta = -0.6\%$; 95% CI: -0.6%, -0.5%) than among white households (**Figure 4**); racial/ethnic differences were greater at the 90th percentile ($\beta = -1.4\%$ for blacks and $\beta = -0.8\%$ for Hispanics). Hispanics also had a significantly lower median energy density of food purchases than whites ($\beta = -25$ kcal/1000 g; 95% CI: -33, -17 kcal/1000 g). Conversely, compared with whites, blacks had CPG purchases with significantly higher sugar content at the median ($\beta = 2.2\%$; 95% CI: 2.0%, 2.3%) and 90th percentile ($\beta = 3.0\%$; 95% CI: 2.8%, 3.3%) and higher energy density at the median ($\beta = 72$ kcal/1000 g; 95% CI: 64, 79 kcal/1000 g) and 90th percentile ($\beta = 83$ kcal/1000 g; 95% CI: 72, 94 kcal/1000 g). After additional adjustment for processed and convenience food purchases, these associations between race/ethnicity and the nutrient content of CPG purchases were attenuated (>10% change-in-estimate) for saturated fat and sugar but not for energy density; however, all associations remained significant.

Discussion

By using data from a large panel of US households and product-specific nutrient information for >1.2 million items, this study provides evidence that black and Hispanic households had significantly lower CPG purchases of highly processed and RTE foods and higher purchases of basic processed foods (e.g., cooking oil and sugar) and foods requiring cooking than white households in multivariable models adjusted for income and education. Racial/ethnic differentials in processed and convenience food purchases were observed when measured as a percentage of calories purchased or as absolute calories purchased per person per day. Differences were stable over time. Despite these similarities in purchases among minority households, when compared with white households, Hispanic households had CPG purchases with lower saturated fat and energy density, whereas black households had purchases with higher sugar and energy density. Adjustment for differences in the degree of processing and convenience of purchases attenuated associations between race/ethnicity and the nutritional quality of CPG food and beverage purchases, but these inequalities remained significant.

In our sample, black and Hispanic households had the lowest purchases of highly processed and RTE foods, including grain-based desserts, candy, and salty snacks, consistently from 2000 to 2012. Only one previous US study has investigated

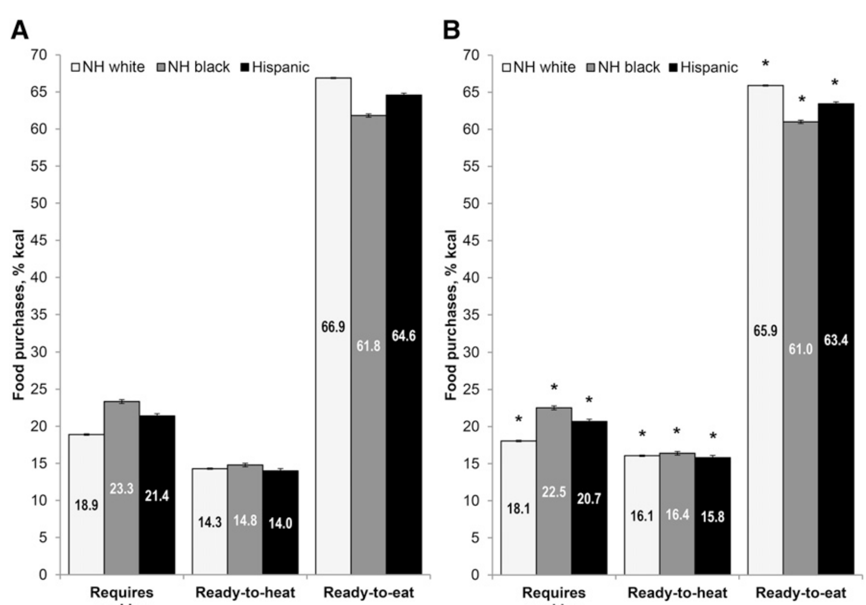

FIGURE 2 Multivariable-adjusted associations between race/ethnicity and the contribution of foods requiring cooking and/or preparation, ready-to-heat or requiring minimal preparation, and ready-to-eat to total calories in all CPG food purchases in 2000 (A) and 2012 (B) among US households in the Homescan Panel. Values are adjusted means (95% CIs) from longitudinal random-effects linear regression models that regress percentage of kilocalories (% kcal) from each convenience category on year (dummy variables), household race/ethnicity, and the interaction of year and race/ethnicity with adjustment for educational level, household income, household composition, the number of household members in each age and sex group, geographic market, and market-level unemployment rate; n = 656,172 household year-level observations from n = 127,871 NH white, n = 14,539 NH black, and n = 11,133 Hispanic households (results for "other races/ethnicities" not shown). *Significant within-group change in % kcal from convenience foods between 2000 and 2012, $P < 0.001$ (Wald test). CPG, consumer packaged goods; NH, non-Hispanic.

TABLE 2 Daily per capita CPG purchases of top food groups contributing to racial/ethnic differentials in convenience food purchases among US households by race/ethnicity: Homescan Panel 2012[1]

	Daily per capita purchases, kcal/d			Racial/ethnic differential (kcal/d),[2] β (95% CI)		
	NH white	NH black	Hispanic	NH white	NH black	Hispanic
Total (foods + beverages)	1297 ± 3.2	1230 ± 9.8*	1205 ± 13.1*	Ref	−67 (−88, −47)	−92 (−119, −66)
Foods	1128 ± 3.0	1064 ± 9.0*	1046 ± 12.0*	Ref	−64 (−83, −45)	−82 (−107, −58)
Requires cooking or preparation	208 ± 0.8	254 ± 2.5*	230 ± 3.4*	Ref	46 (41, 52)	23 (16, 29)
Fats and oils (oil, shortening)	45 ± 0.3	84 ± 1.1*	59 ± 1.4*	Ref	39 (37, 41)	14 (11, 17)
Processed meat (uncooked bacon and sausage)	12 ± 0.1	20 ± 0.3*	12 ± 0.3	Ref	8 (7, 8)	−1 (−1, 0)
Dried rice, uncooked	6 ± 0.1	13 ± 0.5*	20 ± 0.7*	Ref	7 (6, 8)	14 (13, 16)
RTH or minimal preparation	180 ± 1.4	167 ± 4.1	156 ± 5.5*	Ref	−13 (−22, −5)	−24 (−35, −13)
RTH grain-based mixed dishes	26 ± 0.2	20 ± 0.5*	23 ± 0.7*	Ref	−6 (−7, −5)	−3 (−5, −2)
RTE	740 ± 1.8	644 ± 5.4*	660 ± 7.2*	Ref	−97 (−108, −86)	−81 (−95, −66)
RTE salty snacks	98 ± 0.4	85 ± 1.1*	89 ± 1.5*	Ref	−13 (−15, −11)	−9 (−12, −6)
RTE breads and quick breads	75 ± 0.3	70 ± 0.9*	80 ± 1.2*	Ref	−6 (−8, −4)	5 (2, 7)
RTE grain-based desserts	75 ± 0.4	64 ± 1.1*	67 ± 1.4*	Ref	−11 (−13, −9)	−8 (−11, −5)
Candy and sweet snacks	68 ± 0.4	55 ± 1.2*	56 ± 1.6*	Ref	−13 (−15, −10)	−12 (−15, −9)
Sweeteners (sugar, syrups, jam, jelly)	50 ± 0.3	69 ± 1.0*	49 ± 1.4	Ref	18 (16, 20)	−1 (−4, 1)
RTE fats and oils (butter, margarine)	49 ± 0.2	45 ± 0.7*	39 ± 0.9*	Ref	−4 (−5, −3)	−10 (−12, −9)
Nuts or nut butters	55 ± 0.3	41 ± 0.9*	44 ± 1.3*	Ref	−14 (−16, −12)	−11 (−13, −8)
Cheese	51 ± 0.2	33 ± 0.6*	44 ± 0.8*	Ref	−19 (−20, −17)	−7 (−9, −5)
RTE dairy-based desserts (ice cream, pudding)	37 ± 0.2	28 ± 0.6*	29 ± 0.8*	Ref	−9 (−10, −7)	−8 (−10, −6)

[1] Values are adjusted mean ± SE daily per capita household purchases of selected food groups within categories of convenience unless otherwise indicated; n = 59,286 households (n = 47,833 NH white, n = 5485 NH black, and n = 3069 Hispanic households; results for ''other races/ethnicities'' not shown). Beverages are not shown because >90% kcal are RTE. *Different from NH white, $P < 0.001$ (Wald test). For food groups with <15% nonconsumers, values were determined from linear regression models, regressing purchases (kcal/d) on race/ethnicity; for food groups with >15% nonconsumers, values were determined from a 2-part model including *1*) a probit model of the probability of purchasing and *2*) linear regression of the amount purchased. All models were adjusted for education, income, household composition, number of household members in each age and sex category, and geographic market. CPG, consumer packaged goods; NH, non-Hispanic; Ref, reference group; RTE, ready-to-eat; RTH, ready-to-heat.

[2] Values are the difference in per capita household purchases between specified racial/ethnic group and NH white households.

racial/ethnic differences in highly processed food intakes (41). Similar to our results, Eicher-Miller et al. (41) found that blacks and Hispanics had lower intakes of highly processed foods than whites in cross-sectional analysis of NHANES 2003–2008 data. To the best of our knowledge, no previous US studies have examined racial/ethnic differences in purchases or intake of convenience foods.

Black households had a striking contrast in purchasing patterns of foods compared with beverages: these households had the highest purchases of highly processed beverages but the lowest purchases of highly processed foods as percentages of calories purchased. Our findings are consistent with the higher consumption of SSBs previously reported among blacks than among whites (42, 43). We also found lower relative purchases of minimally

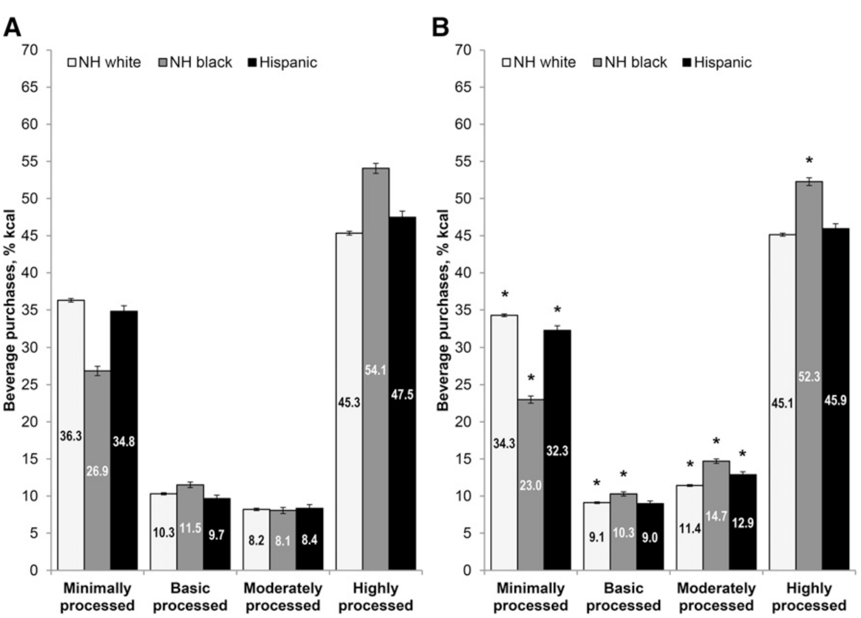

FIGURE 3 Multivariable-adjusted associations between race/ethnicity and the contribution of minimally processed, basic processed, moderately processed, and highly processed beverages to total calories in all CPG beverage purchases in 2000 (A) and 2012 (B) among US households in the Homescan Panel. Values are adjusted means (95% CIs) from longitudinal random-effects linear regression models that regress percentage of kilocalories (% kcal) from each processing category on year (dummy variables), household race/ethnicity, and the interaction of year and race/ethnicity with adjustment for educational level, household income, household composition, the number of household members in each age and sex group, geographic market, and market-level unemployment rate; n = 655,833 household year-level observations from n = 127,845 NH white, n = 14,537 NH black, and n = 11,133 Hispanic households (results for ''other races/ethnicities'' not shown). *Significant within-group change in % kcal from processed beverages between 2000 and 2012, $P < 0.001$ (Wald test). CPG, consumer packaged goods; NH, non-Hispanic.

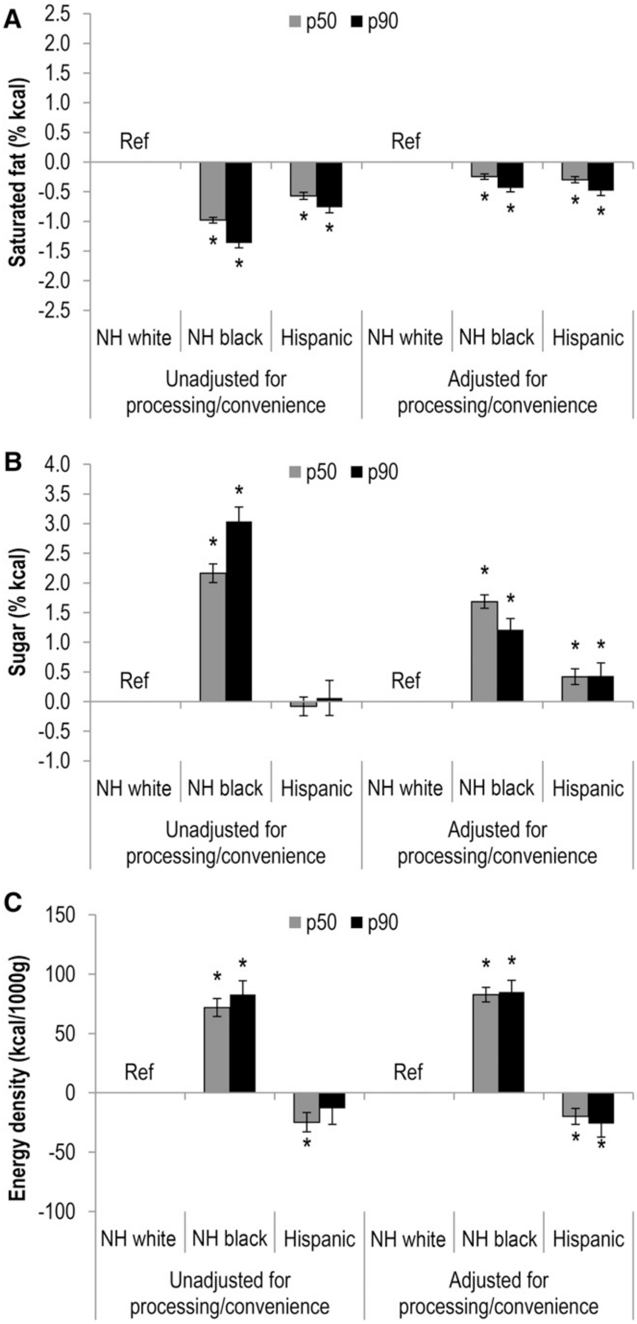

FIGURE 4 Multivariable-adjusted differences in saturated fat (A), total sugar (B), and energy density (C) of total CPG food and beverage purchases at the 50th and 90th percentiles across racial/ethnic groups among US households in the 2000–2012 Homescan Panel; n = 655,821 household year-level observations from n = 127,843 NH white, n = 14,537 NH black, and n = 11,133 Hispanic households (results for ''other races/ethnicities'' not shown). Values are β-coefficients (95% CIs) from quantile regression models that regress nutrient content on year (dummy variables), household race/ethnicity, educational level, income, household composition, number of household members in each age and sex group, geographic market, and market-level unemployment rate. *Different from NH white households, $P < 0.001$ (Wald test). CPG, consumer packaged goods; NH, non-Hispanic; p50, 50th percentile; p90, 90th percentile; Ref, reference group.

processed beverages, primarily plain milk, among black than among white households. In agreement, nationally representative studies reported lower calcium intake and prevalence of meeting milk recommendations among blacks than among whites (6, 7, 11).

After adjustment for differences in the processing and convenience level of purchases, associations with race/ethnicity were attenuated only for saturated fat and sugar but not for energy density; associations with race/ethnicity for saturated fat, sugar, and energy density of purchases all remained significant. This finding suggests that differences in purchasing of highly processed and RTE foods and beverages are associated with, but do not fully explain, racial/ethnic variation in the nutritional quality of purchases. Although highly processed and RTE foods have higher saturated fat, sugar, and sodium content, on average, compared with less-processed foods or foods requiring cooking, substantial variation exists in the nutrient content of foods within all categories of processing and convenience (17). For example, RTE foods include both precut bagged salad and cookies. Thus, traditional and cultural variations in preferences for certain foods, food combinations, and preparation methods may have also contributed to the racial/ethnic differentials in CPG purchases in our study, in beneficial or adverse ways (5, 44). For example, for both black and Hispanic households, a higher proportion of CPG food purchases required cooking or preparation than for white households. However, Hispanic households in our study had total CPG purchases with the most favorable nutrient content, whereas black households had purchases with the highest sugar and energy density among racial/ethnic groups. Differences in the quality of home-prepared meals or cooking methods across populations have been suggested as explanations of why foods cooked at home may not necessarily be more healthful than convenience foods (45–48). Future efforts to improve disparities in the nutritional quality of CPG purchases may need to consider factors other than processing or convenience.

A key limitation of this study is that households do not report whether all purchases were consumed, and the amount of food waste may vary across races/ethnicities (49). Foods without barcodes could not be scanned and linked to calories purchased, so these non-CPG items were excluded from analyses. However, in 2007–2011, a small subsample of households (~7500/y) self-reported their expenditures on CPG and non-CPG purchases in broad food categories. Non-CPG purchases contributed ~22% of dollars spent on store purchases (results not shown); however, differences across racial/ethnic groups were small ($2–$4/mo) and included differences in purchases of both minimally processed items (random-weight fresh poultry) and highly processed items (bakery products and store-prepared RTE or ready-to-heat foods). Expenditures on non-CPG fruit and vegetables were not significantly different among black households and were not meaningfully higher among Hispanic households (1%) than among white households. Because of likely variations across racial/ethnic groups in the types and the kilocalories per dollar of items purchased within these broad non-CPG food categories, future studies are needed to determine how non-CPGs add to the racial/ethnic differences we observed for CPG purchases. In addition, households did not report foods purchased away-from-home, which differs by race/ethnicity and may also contribute to disparities (50). Therefore, our findings apply only to purchases of packaged goods and may not be generalizable to total diet. However, as noted above, our results are consistent with the previous study of intake (41). The black-white difference in highly processed food was ~100 kcal/d in that study of dietary intake and in our study of purchases (41). Although misreporting is possible, the accuracy of

the Homescan data is comparable to other commonly used economic data sets (36).

Findings from our sample may not be generalizable to the US population because of potential selection bias or nonresponse related to participant burden (37). Because our sample of relatively high-income households is not nationally representative and the distribution of income across racial/ethnic groups does not match that of the US population, all models were adjusted for income; results were interpreted with caution as associations between purchases and race/ethnicity independent of income, which potentially might reflect differences in food preferences, time constraints, or cultural traditions. Despite underrepresentation in the total sample of ~34,000–60,000 households/y, low-income households were included in our sample in sufficient numbers (≥275 Hispanic and ≥530 black household/y) to ensure valid statistical estimates. Furthermore, we examined interactions of race/ethnicity and income in supplemental analyses and found similar associations between race/ethnicity and purchases in all income groups. We were unable to subdivide racial/ethnic groups by cultural heritage; combining heterogeneous populations into a single category may obscure dietary differences (4). We had insufficient information to identify Asian, American Indian, Alaska Native, Native Hawaiian, or Pacific Islander households and could not examine purchases for these understudied populations. We examined if processing and convenience were statistical explanatory correlates of associations between race/ethnicity and the nutritional profile of purchases, but causality cannot be inferred from this observational study.

A major strength of our study is the use of objective scanning of product barcodes, which may be advantageous for monitoring racial/ethnic differences in the diet because of differential underreporting among subpopulations (25–27, 30). The use of item-specific nutrition information may improve accuracy by capturing ethnic variation in preferred products (28–30). Strengths and weaknesses of this and other classification systems for food processing and convenience have been discussed previously; our categorization is based on the top-rated NOVA system (16, 17).

In conclusion, our findings suggest that highly processed and RTE food and beverage purchases as well as purchases of basic processed foods requiring home cooking vary greatly across racial/ethnic groups in the United States. Our results suggest that processing and convenience cannot fully explain racial/ethnic differences in the nutritional quality of CPG food and beverage purchases. Our findings have major implications for the foods and behaviors that future interventions or policy might target to improve racial/ethnic disparities. Further investigation is warranted to examine how purchasing patterns of basic processed foods used in cooking among vulnerable populations may contribute to disparities in diet and health.

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