Food insecurity and ultra-processed food consumption: the modifying role of participation in the Supplemental Nutrition Assistance Program (SNAP)

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ABSTRACT

Background: Ultra-processed foods contribute to risks of obesity and cardiometabolic disease, and higher intakes have been observed in low-income populations in the United States. Consumption of ultra-processed foods may be particularly higher among individuals experiencing food insecurity and participating in the Supplemental Nutrition Assistance Program (SNAP).

Objectives: Using data from the 2007–2016 NHANES, we examined the associations between food insecurity, SNAP participation, and ultra-processed food consumption.

Methods: The study population comprised 9190 adults, aged 20–65 y, with incomes ≤300% of the federal poverty level (FPL). Food insecurity was assessed using the Household Food Security Survey Module and SNAP participation over the past 12 mo was self-reported. Dietary intake was measured from two 24-h dietary recalls. Ultra-processed food consumption (percentage of total energy intake) was defined using the NOVA food classification system. Linear regression models were used to examine the associations between food insecurity, SNAP participation, and ultra-processed food consumption, adjusting for sociodemographic and health characteristics.

Results: More severe food insecurity was associated with higher intakes of ultra-processed foods (P-trend = 0.003). The adjusted means of ultra-processed food intake ranged from 52.6% for adults with high food security to 55.7% for adults with very low food security. SNAP participation was also associated with higher intakes of ultra-processed foods (adjusted mean: 54.7%), compared with income-eligible participants (adjusted mean: 53.0%). Furthermore, the association between food insecurity and ultra-processed foods was modified by SNAP participation (P-interaction = 0.02). Among income-eligible nonparticipants and income-ineligible nonparticipants, more severe food insecurity was associated with higher consumption of ultra-processed foods. Among SNAP participants, the association between food insecurity and consumption of ultra-processed foods was nonsignificant.

Conclusion: In a nationally representative sample of adults, food insecurity and SNAP participation were both associated with higher levels of ultra-processed food consumption. *Am J Clin Nutr* 2022;116:197–205.

Introduction

Food insecurity, defined as the "limited or uncertain availability of nutritionally adequate and safe foods or the limited or uncertain ability to acquire acceptable foods in socially acceptable ways," is a critical social determinant of health (1). In 2019, it was estimated that 10.5% (or 13.7 million) US households experienced food insecurity (2). As a result of the ongoing COVID-19 pandemic, estimates of national food insecurity have more than tripled, which will likely result in widening diet and health disparities in marginalized groups (3, 4).

Food insecurity has been adversely associated with dietary intake in low-income adults (5). Across multiple studies, food

insecurity has been associated with lower intakes of fruits and vegetables, higher intakes of red and processed meats and sugar-sweetened beverages, and lower scores on evidence-based diet quality indices, such as the Healthy Eating Index and the Alternate Healthy Eating Index (6–10). These findings suggest that dietary behaviors play an important role in mediating the observed associations between food insecurity and hypertension, diabetes, and other cardiometabolic conditions (11–14). However, the degree to which prior dietary studies have captured the spectrum of typical foods consumed by low-income populations is unclear.

The relation between food insecurity and dietary intake is further complicated by participation in the Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program. SNAP is the largest of 15 federal nutrition assistance programs whose central goal is to alleviate food insecurity. In 2020, SNAP provided benefits to ∼40 million low-income individuals (≤130% of the FPL) at a total cost of $74 billion (15). SNAP benefits are distributed via Electronic Benefit Transfer (EBT) cards, which can be used to purchase most foods and beverages, with the exception of hot or prepared foods, alcohol, and dietary supplements. Despite the well-established effects of SNAP in alleviating food insecurity (16, 17), SNAP participants have poorer diet quality and cardiometabolic health outcomes than both their low- and higher-income nonparticipant counterparts (18, 19). SNAP participation may also positively or negatively modify the relation between household food security and dietary outcomes through its role as a policy intervention to improve food insecurity and poor nutrition, or as a proxy for individuals most vulnerable to poverty, food insecurity, and poor health. To our knowledge, few studies have examined this relation.

In the present study, we focused on the outcome of ultra-processed food consumption. According to NOVA, ultra-processed foods are formulations of ingredients, mostly of exclusive industrial use, that result from a series of industrial processes and typically contain high levels of added refined carbohydrates and/or fats. These foods include frozen and shelf-stable meals, breakfast cereals, sugar-sweetened beverages, baked desserts, and more (20). Ultra-processed foods comprise nearly 60% of total energy intake consumed in the United States, and higher intake rates have been observed in low-income populations (21). The current study of the relation between food insecurity and ultra-processed food consumption is distinct from prior studies of food insecurity and consumption of individual foods, food groups, or diet patterns because it focuses on the degree of food processing. Given that ultra-processed foods are aggressively marketed, widely accessible, more shelf stable than foods with less processing, and touted for their convenience (20), individuals from food-insecure households and those participating in SNAP may increase consumption of ultra-processed foods when monetary resources are low. Furthermore, ultra-processed foods contribute to excessive caloric intake (22) and overweight/obesity (23, 24), providing a plausible mechanism for the positive associations of diet-sensitive cardiometabolic outcomes with food insecurity and SNAP participation.

Our primary objectives were to examine associations of household food security and SNAP participation with ultra-processed food consumption. Our secondary objective was to examine the modifying role of SNAP participation in the

association between household food security and ultra-processed food consumption. Based on prior studies, we hypothesized that food insecurity and SNAP participation would be positively associated with ultra-processed food consumption and that the association between food insecurity and ultra-processed food consumption would be more pronounced among low-income adults participating in SNAP.

Methods

Study population

NHANES is an ongoing, multistage survey representative of the civilian, noninstitutionalized United States population (25). NHANES collects information on demographics, dietary intake, and other health-related characteristics. NHANES study protocols were approved by the National Center for Health Statistics (NCHS) ethics review board and informed consent was obtained from all adult participants. The present study combines data from 2007 to 2016, including information from participants who completed two 24-h diet recalls, with information on household food security and other covariates of interest.

The analytic population comprised 9190 adults, ages 20–65 y, with family incomes ≤300% of the FPL at the time of data collection (**Supplemental Figure 1**). Individuals aged ≥65 y were excluded due to known differences in socioeconomic status, dietary behaviors, and the presence of existing health conditions, which may lead to differential associations between food insecurity and ultra-processed food consumption. Similar to prior studies, in the present study an income threshold was applied to focus on individuals at risk for food insecurity and to reduce the potential for residual confounding by income (8, 11, 26).

Household food security and SNAP participation

Household food security was measured using the 18-item US Household Food Security Survey Module (27). This "core module" is one of the most widely used instruments to measure food security status. Briefly, questions are ordered by severity and ask about experiences or behaviors related to inadequate resources to acquire food over the 12 mo prior to the time of collection of these data. Affirmative responses to the 18 questions are summed to create a score ranging from 0 to 18, with a higher score denoting more severe food insecurity. According to USDA guidelines, 0 affirmative responses indicates high food security, 1–2 affirmative responses indicates marginal food security, 3–5 affirmative responses in households without children or 3–7 affirmative responses in households with children indicates low food security, and 6–10 affirmative responses in households without children or 8–18 affirmative responses in households with children indicates very low food security.

SNAP participation was assessed using the question, "In the last 12 mo, did (you/you or any member of your household) receive Food Stamp benefits?" Beginning in 2013–2014, this question was rephrased to include "SNAP or Food Stamp benefits." Individuals who responded affirmatively to this question and who had family incomes ≤130% FPL were categorized as SNAP participants. Individuals who responded negatively to this question and who had family incomes ≤130% FPL were

categorized as income-eligible nonparticipants. Individuals who responded negatively to this question and had family incomes >130% FPL were considered income-ineligible nonparticipants because they would be financially ineligible to receive SNAP benefits. Individuals who responded affirmatively to receiving SNAP benefits and who had family incomes above the federal eligibility criteria for SNAP (i.e., >130% FPL) were excluded due to potential misclassification ($n = 970$). Information on the duration of SNAP participation was not collected in NHANES.

Ultra-processed food intake

Dietary intake was assessed using two 24-h dietary recalls using the Automated Multiple Pass Method, conducted by trained interviewers. The 24-h recall collects detailed information on all foods and beverages consumed from midnight to midnight of the previous day. The first recall is administered in-person in the Mobile Examination Center (28). The second recall is administered by telephone 3–10 d later (29). The validity of the 24-h recall method has been previously established (30, 31). We included recalls that were categorized as "reliable and met the minimum criteria" according to NCHS staff. Recalls with implausible total energy intakes (<500 or >5000 kcal) were excluded from analyses ($n = 711$) to reduce the potential for measurement error.

In the present analysis, all food and beverage items were categorized according to NOVA, a system that classifies each food item based on the extent and purpose to which the food item is industrially processed (32) into 4 mutually exclusive groups: *1*) unprocessed or minimally processed foods, *2*) processed culinary ingredients, *3*) processed foods, and *4*) ultra-processed foods. Ultra-processed foods are foods that contain the greatest degree of industrial processing, oftentimes containing cosmetic additives (e.g., coloring, flavoring, sweeteners, emulsifiers, etc.) and other substances of no or rare culinary use (e.g., modified starches, hydrogenated oils, protein isolates, etc.).

Foods were classified based on the following NHANES variables: "Main Food Description," "Additional Food Description" (describing food codes), and "SR Code Description" (describing SR codes), as well as "Combination Food Type" and "Source of Food." When foods were judged to be a hand-made recipe, the classification was applied to the underlying ingredients (SR codes) to ensure a more accurate classification. Details about the calculations for energy values are described in detail elsewhere (33). The energy contribution from all ultra-processed foods was summed and divided by the participant's total energy intake. Thus, the primary outcome for this analysis is the % of total energy (in kilocalories) from ultra-processed foods, averaging over 2 d of dietary recalls.

Study covariates

Sociodemographic and health covariates were included in the analyses because they were hypothesized to be common predictors of household food security and dietary intake. Sociodemographic covariates included age (in 5-y increments), sex, self-reported race/ethnicity (Non-Hispanic white, Non-Hispanic black, Hispanic, Other or multi-race/ethnicity), educational attainment (<12 y, high school diploma or equivalent, some

college, college graduate or higher), family income to poverty ratio (as linear and quadratic terms), marital status (married or living with partner, never married, separated/widowed/divorced), and survey year (in 2-y NHANES cycles). Health covariates included smoking status (never smoker, former smoker, current smoker), vigorous physical activity (any, none), moderate physical activity (any, none), and total energy intake (as a linear term). Individuals with missing data on study covariates were also excluded from the analytic population: education ($n = 11$), marital status ($n = 7$), smoking status ($n = 9$), vigorous physical activity ($n = 2$), and moderate physical activity ($n = 2$).

Statistical analysis

Complex sampling weights were used to account for different sampling probabilities, nonresponse, and to make nationally representative estimates. Dietary weights were recalculated to reflect the probability of being sampled in the 10-y period according to NCHS guidelines and applied to all analyses.

First, we examined differences in sociodemographic and health characteristics by household food security status in adults with family incomes ≤300% FPL using χ^2 tests and univariate linear regression models. Second, we evaluated the associations between household food security and ultra-processed food consumption using unadjusted and multivariate linear regression models. Unadjusted and adjusted means of ultra-processed food intake were computed using least squared means in the respective linear regression models. Trend tests were conducted by including household food security as an ordinal variable. Next, we examined the associations between SNAP participation and ultra-processed food consumption using unadjusted and multivariate linear regression models. In sensitivity analyses, we examined the associations between household food security and SNAP participation with individual categories of ultra-processed foods, adjusting for all study covariates. Finally, we examined whether the associations between household food security and ultra-processed food intake were modified by SNAP participation by including a multiplicative interaction term in the multivariate model. Where statistical interaction was found, least squared means of ultra-processed food intake were stratified by subgroups of interest.

All statistical tests were 2-sided and significance was considered at $P < 0.05$. Statistical analyses were performed using SAS 9.4 (SAS Institute Inc.).

Results

In the analytic population of 9190 adults with incomes ≤300% FPL, 56.1% of adults had full food security, 15.1% had marginal food security, 17.5% had low food security, and 11.3% had very low food security. Differences in sociodemographic and health covariates by food security status are shown in **Table 1**. Compared with food-secure adults, adults with marginal, low, or very low food security were more likely to be younger, of minority race/ethnicity, have lower incomes, have lower educational attainment, be a current smoker, be less likely to be married or partnered, and be or engage in any vigorous or moderate physical activity. Adults with more severe food

TABLE 1 Sociodemographic and health characteristics of 9190 adults with family incomes ≤300% of the FPL, NHANES 2007–2016[1]

| | Overall (n = 9190) | Food security | | | | P value |
		Secure (n = 4671)	Marginal (n = 1490)	Low (n = 1859)	Very low (n = 1170)	
Age, y	39.6 ± 0.4	40.1 ± 0.5	39.3 ± 0.6	38.2 ± 0.5	39.8 ± 0.7	0.01
Income to poverty ratio	1.43 ± 0.02	1.65 ± 0.03	1.35 ± 0.04	1.10 ± 0.03	0.99 ± 0.04	<0.0001
Sex						0.12
Male	4199 (46.3)	2205 (47.7)	642 (43.2)	830 (44.9)	522 (46.0)	
Female	4991 (53.7)	2466 (52.3)	848 (56.8)	1029 (55.1)	648 (54.0)	
Race/ethnicity						<0.0001
Non-Hispanic white	3300 (54.2)	1892 (61.7)	426 (43.8)	538 (41.9)	444 (49.9)	
Non-Hispanic black	2052 (15.0)	943 (12.1)	370 (18.4)	443 (18.2)	296 (20.0)	
Hispanic	3024 (22.9)	1356 (17.8)	566 (28.7)	747 (33.7)	355 (24.3)	
Other or multi-race	814 (7.8)	480 (8.5)	128 (9.0)	131 (6.2)	75 (5.9)	
Educational attainment						<0.0001
<12 y	2784 (24.0)	1177 (18.6)	443 (23.4)	738 (36.1)	426 (32.5)	
High school diploma or equivalent	2377 (27.0)	1173 (26.2)	406 (29.0)	492 (26.3)	306 (29.9)	
Some college	2801 (33.2)	1474 (33.8)	462 (34.6)	499 (30.6)	366 (31.9)	
College graduate or higher	1228 (15.9)	847 (21.4)	179 (13.0)	130 (7.1)	72 (5.7)	
Marital status						<0.0001
Married or living with partner	5043 (54.1)	2657 (56.2)	822 (55.2)	1021 (52.9)	543 (43.8)	
Never married	2304 (27.7)	1165 (28.1)	363 (25.8)	471 (27)	305 (29.3)	
Separated, widowed, or divorced	1843 (18.3)	849 (15.7)	305 (19.1)	367 (20.1)	322 (26.9	
Smoking status						<0.0001
Never smoker	4898 (51.9)	2627 (54.8)	832 (52.9)	946 (51.4)	493 (37.4)	
Former smoker	1680 (8.7)	916 (20.7)	268 (19.0)	321 (14.8)	175 (14.4)	
Current smoker	2612 (29.4)	1128 (24.5)	390 (28.1)	592 (33.8)	502 (48.2)	
Vigorous physical activity (any)	1883 (23.9)	1026 (26.2)	313 (23.2)	327 (20.2)	217 (19.3)	0.001
Moderate physical activity (any)	3334 (40.2)	1830 (44.5)	510 (37.8)	610 (33.3)	384 (32.5)	<0.0001
Survey year						<0.0001
2007–08	1851 (19.6)	1086 (22.4)	258 (14.4)	334 (19.5)	173 (12.6)	
2009–10	2063 (19.3)	1020 (19.9)	329 (18.2)	434 (18.6)	280 (19.2)	
2011–12	1805 (20.4)	896 (19.5)	313 (21.3)	350 (19)	246 (25.9)	
2013–14	1790 (20.6)	910 (20.6)	279 (19.3)	363 (21.6)	238 (20.7)	
2015–16	1681 (20.2)	759 (17.7)	311 (26.8)	378 (21.3)	233 (21.6)	
SNAP participation status						<0.0001
Participant	2744 (25.4)	879 (14.5)	473 (27.7)	815 (42.6)	577 (50.0)	
Income-eligible nonparticipant	2585 (25.4)	1264 (23.7)	428 (26.4)	544 (28.0)	349 (28.2)	
Income-ineligible nonparticipant	3861 (49.2)	2528 (61.7)	589 (45.9)	500 (29.5)	244 (21.8)	

[1] Values are presented as mean ± SD or n (%). FPL, Federal Poverty Level; SNAP, Supplemental Nutrition Assistance Program.
[2] From univariate linear regression or chi-squared.

insecurity were also more likely to be financially eligible for SNAP and report receiving SNAP benefits in the past 12 mo. For example, among adults with low food security, 42.6% participated in SNAP over the previous year and 28.0% were income-eligible but did not participate in SNAP. Among adults with very low food security, 50.0% participated in SNAP over the previous year and 28.2% were income-eligible but did not participate.

The associations between household food security and ultra-processed food intake are shown in **Table 2**. Across food security groups, the unadjusted means for percentage energy intake from ultra-processed foods ranged from 56.0% to 60.1%. After adjusting for sociodemographic and health characteristics, adults with very low food security consumed 55.7% energy intake from ultra-processed foods (95% CI: 54.1%, 57.4%), ~3.1% more than adults with high food security (P = 0.002). There was a dose-response relation, such that more severe food insecurity was associated with higher ultra-processed food intake (P-trend = 0.003). Sensitivity analysis of individual ultra-processed food categories showed significant associations

between more severe food insecurity and higher intakes of pizza (P-trend = 0.002) and soft drinks (P-trend = 0.02) (**Supplemental Table 1**).

The associations between SNAP participation and ultra-processed food intake are shown in **Table 3**. Compared with both income-eligible nonparticipants (55.6%) and income-ineligible nonparticipants (56.0%), SNAP participants had higher unadjusted means (59.3%) of energy intake from ultra-processed foods. After adjustment for sociodemographic and health characteristics and household food security, the data indicated that compared with income-eligible nonparticipants, SNAP participants consumed 1.7% more of their energy intake from ultra-processed foods (P = 0.04). The contrast in adjusted means between SNAP participants and income-ineligible nonparticipants was not statistically significant (P > 0.05). Sensitivity analysis of individual ultra-processed food categories showed that the difference in ultra-processed food intake between SNAP participants and income-eligible nonparticipants was driven by higher intakes of salty snacks and soft drinks (**Supplemental Table 2**).

TABLE 2 Associations between household food security and percentage energy intake (in kcal) from ultra-processed foods, NHANES 2007–2016 (n = 9190)[1]

Household food security	n	Unadjusted mean (95% CI)	Adjusted mean (95% CI)
High	4671	56.0 (54.9, 57.2)	52.6 (51.6, 53.7)
Marginal	1490	56.4 (54.9, 57.8)	53.6 (52.2, 55.0)
Low	1859	57.2 (55.6, 58.7)	53.7 (52.3, 55.1)
Very low	1170	60.1[2] (58.5, 61.7)	55.7[2] (54.1, 57.4)
P-trend[3]		0.002	0.003

[1]Least squared means from multivariable linear regression models were used to estimate mean % energy from ultra-processed foods adjusting for age (in 5-y increments), sex, race/ethnicity, educational attainment, family income to poverty ratio (continuous and squared term), marital status, smoking status, vigorous physical activity, moderate physical activity, survey year, and total energy intake.

[2]Significantly different from high food security.

[3]P values for trend were obtained from linear regression models including household food security as an ordinal variable.

Furthermore, SNAP participation status modified the associations between household food security and ultra-processed food consumption (P-interaction = 0.02). The least squared means of ultra-processed food consumption in relation to household food security and SNAP participation status are shown in **Figure 1**. Among income-eligible nonparticipants, adults with very low food security consumed 5.4% more of their energy intake from ultra-processed foods than adults with high food security (P = 0.0002). Similarly, among income-ineligible nonparticipants, compared with adults with high food security adults with very low food security consumed 4.0% more of their energy intake from ultra-processed foods (P = 0.03). Among SNAP participants, the associations were attenuated; there were no significant associations between household food security and ultra-processed food consumption. However, among adults with full food security, SNAP participants had significantly higher intake of ultra-processed foods than income-eligible nonparticipants (P = 0.002). No other comparisons within household food security groups by SNAP participation status were statistically significant.

Discussion

In recent decades, there have been stark increases in the availability and consumption of ultra-processed foods on a global scale (34–40). Ultra-processed foods now comprise over half of all Americans' daily calories (21), and their intake has contributed to increased risks of obesity, type 2 diabetes, cardiovascular disease, and even depression (41, 42). To our knowledge, this is the first study to examine the associations between household food security and SNAP participation with ultra-processed food consumption. We provide evidence of a graded relation between food insecurity and ultra-processed food consumption in a large, national sample of adults with family incomes ≤300% FPL, and this result furthered differed by SNAP participation status. These findings corroborate prior studies of food insecurity and diet quality, and further suggest that higher consumption of ultra-processed foods may contribute to the observed disparities in cardiometabolic health outcomes by food insecurity and SNAP participation status (5, 14).

It has been posited that the high cost of fruits, vegetables, and other healthful and less processed foods and the limited availability of these foods in the surrounding food environment can explain the inverse associations between socioeconomic status and diet quality (43). However, the contribution of economic and environmental factors to the observed disparities has been challenged by additional research (44–46). We hypothesize that psychological, neurological, and behavioral pathways are potentially important mediators of the associations between food insecurity and ultra-processed food consumption (and by association, overall diet quality). Specifically, we elaborate below on the intersecting and compounding roles of psychological distress specific to food insecurity, the addictive potential of

TABLE 3 Associations between SNAP participation status and percentage energy intake (in kcal) from ultra-processed foods, NHANES 2007–2016 (n = 9190)[1]

SNAP participation	n	Unadjusted mean (95% CI)	Adjusted mean (95% CI)
SNAP participants	2744	59.3 (58.1, 60.5)	54.7 (53.0, 56.3)
Income-eligible nonparticipants	2585	55.6[2] (54.2, 57.1)	53.0[2] (51.5, 54.5)
Income-ineligible nonparticipants	3861	56.0[2] (54.8, 57.1)	53.9 (52.4, 55.3)

[1]Least squared means from multivariable linear regression models were used to estimate mean percentage of energy from ultra-processed foods (adjusting for age in 5-y increments), sex, race/ethnicity, educational attainment, family income to poverty ratio (continuous and squared term), marital status, smoking status, vigorous physical activity, moderate physical activity, survey year, total energy intake, and household food security status. SNAP, Supplemental Nutrition Assistance Program.

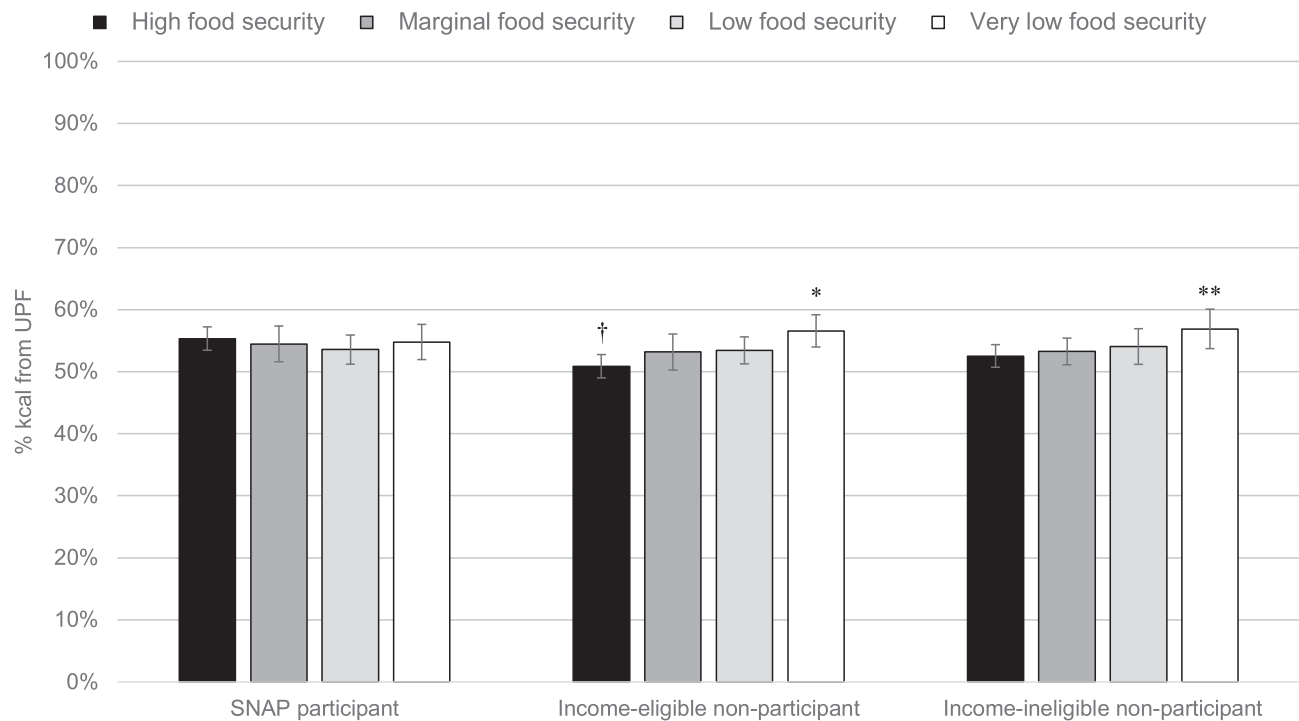[2]Significantly different from SNAP participants.

FIGURE 1 Least squared means from multivariable linear regression models of ultra-processed food intake by household food security status and SNAP participation adjusted for sociodemographic and health characteristics, NHANEs 2007–2016 ($n = 9190$). P-interaction between household food security and SNAP participation was 0.02. *Significant difference from income-eligible nonparticipants with high food security $P = 0.0002$; **significant difference from income-ineligible nonparticipants with high food security $P = 0.03$; †significant difference from SNAP participants with high food security $P = 0.002$. SNAP, Supplemental Nutrition Assistance Program.

ultra-processed foods, and the coping strategies used during periods of food insecurity in the context of the observed associations.

First, food insecurity is an inherently stressful experience. Studies have found that food insecurity is associated with greater perceived stress, trait anxiety, depressive symptoms, and serious psychological distress in low-income adults (47–52). Chronic stress is known to activate the hypothalamus–pituitary–adrenal axis, stimulating the release of cortisol, which alters certain metabolic processes. Chronic stress drives consumption of ultra-processed foods high in fat and sugar, which dampens the stress response in the short term but promotes visceral fat accumulation and increases chronic disease risk in the long term (53, 54). Health psychologists have termed this model "reward-based stress eating" or "comfort eating" (53, 54)—a paradigm that food-insecure populations may be counterintuitively more vulnerable to in response to the chronic stress they experience, as suggested by our findings.

Second, this issue is compounded by the way in which the consumption of ultra-processed foods activates neural reward pathways (55) and is associated with behavioral patterns indicative of addictive disorders, including diminished control over consumption, continued use despite negative consequences, and withdrawal (56). Individuals with low incomes and/or those experiencing food insecurity may be especially vulnerable to the addictive consumption of ultra-processed foods due to the dominance of these foods in their food environment and targeted marketing by the food industry (57). Further, psychological

distress can increase the appeal of addictive substances, which further increases the vulnerability of low-income individuals to the addictive nature of ultra-processed foods (58).

And finally, coping strategies for food insecurity may reinforce consumption of ultra-processed foods. Studies have found that food-insecure families tend to keep ultra-processed microwavable or frozen meals in the home and feed their children more grains, mixed dishes, and processed meats as a strategy to cope with food insecurity (59, 60). These and other studies suggest that low-income adults may selectively seek out ultra-processed foods to ensure sufficient food for their household during food-related hardship. Future research should focus on examining the psychological and neurological mechanisms that reinforce the observed associations (61, 62).

We further found that compared with income-eligible nonparticipants and income-ineligible nonparticipants, SNAP participants had the highest level of ultra-processed food intake. Although this finding is consistent with prior studies of SNAP participation and diet quality (18, 63), the association is likely not causal. Some of this difference may be attributable to selective participation in the program, such that individuals who participate in the program are already at higher risk of food insecurity, poverty, and poor health. However, it is widely known that SNAP benefits are inadequate, leading to difficulties in food procurement and heightened coping strategies toward the end of the month (64–66). According to a recent USDA report, nearly 9 out of 10 SNAP participants reported challenges in eating a healthy diet, with cost, time, and transportation representing key

barriers (67). Compared with income-eligible nonparticipants, the higher levels of ultra-processed food consumption among SNAP participants may be indicative of the coping strategies used to manage food insecurity, further magnified by the constraints of insufficient SNAP benefits and other structural barriers to healthy eating.

Furthermore, SNAP participation modified the association between food insecurity and ultra-processed food consumption. Among both income-eligible and income-ineligible nonparticipants, greater severity of food insecurity was associated with higher consumption of ultra-processed food in a graded fashion. Although this pattern was not observed among SNAP participants, SNAP participants with high food security had higher intakes of ultra-processed foods than their nonparticipant counterparts at the same level of food security. Further research examining the eating patterns of SNAP participants over the monthly benefit cycle and at varying levels of benefit issuance are needed to better understand this nuanced association.

These findings have important policy implications. Given the reality that ultra-processed foods will remain ubiquitous in the food environment and, in the United States, few limits on marketing such products are viable options, policies that increase access to and affordability of less processed and unprocessed products are important to minimize obstacles to accessing alternatives to ultra-processed foods. In the last decade, nutrition-related interventions for SNAP have focused on incentivizing and increasing the purchasing power for fruits and vegetables. Results from these interventions and related projects have demonstrated that financial incentives are successful in increasing fruit and vegetable intake (68). A simulation study estimated that incentivizing fruits and vegetable intake would prevent >300,000 cardiovascular events and save $6.8 billion in healthcare costs (69). Another recent USDA proposed rule would have also strengthened the stocking standards for SNAP-authorized food stores, mandating a greater array of fresh and shelf-stable foods (70). However, this rule was relaxed prior to being finalized (71). Changing SNAP stocking standards could be another important policy mechanism in shifting the availability toward minimally processed foods and away from ultra-processed foods in low-income communities. These strategies are also aligned with the growing national focus on nutrition insecurity and opportunity to use SNAP as a lever to alleviate the dual burden of food insecurity and cardiometabolic disease in low-income populations (72).

Our study is strengthened by the use of a large and representative sample of lower-income adults surveyed over a recent 10-y period. The primary limitation of our study is the cross-sectional nature of the data, which precludes the ability to understand how patterns in food insecurity or SNAP participation influence dietary intake over time. Despite the inclusion of several sociodemographic characteristics, there remains the possibility of unmeasured confounding by contextual factors, such as neighborhood socioeconomic status and food availability, family structure, and other individual-level traits that might influence food insecurity, desire to receive federal assistance, and health behaviors. Another limitation is the use of 24-h dietary recalls, which may be subject to social desirability bias and lead to an underestimation of the dietary contribution of ultra-processed foods. However, this bias is unlikely to affect the observed differences across categories of household food security and SNAP participation status. The standardized approach to

collecting 24-h dietary recalls has also been shown to produce accurate intake estimates with minimal measurement error or bias (73, 74). Although NHANES collects some information indicative of food processing, these data are not consistently determined for all food items, which could lead to modest over- or underestimation of the consumption of ultra-processed foods. There are also other food processing classification systems, such as those developed by the International Food Information Council and University of North Carolina at Chapel Hill (75). Results of investigations of associations between household food security and SNAP participation with ultra-processed food consumption may differ depending on the classification system used. And finally, household food security was assessed over 12 mo preceding this report, which limits our understanding of how chronic or episodic food insecurity relates to ultra-processed food consumption. If the behavioral consequences of food insecurity are more likely to manifest toward the end of the month shortly before income or SNAP benefits are replenished, then this situation may lead to changes in dietary coping mechanisms. Future studies that incorporate repeated assessments of household food security and dietary intake throughout the weeks of a month are needed to tease out these associations.

Ultra-processed food consumption is a risk factor for cardiometabolic and mental health outcomes. Our findings showed that food-insecure adults and adults receiving SNAP have greater consumption of ultra-processed foods than their counterparts, suggesting that ultra-processed food consumption may help to explain the diet-related health disparities observed in these populations. SNAP participation further modified the association between food insecurity and ultra-processed food consumption, such that this association was more pronounced for income-eligible and income-ineligible nonparticipants, and nonsignificant for SNAP participants. These findings support the need for robust programs and policies to simultaneously improve food and nutrition insecurities in low-income populations.

Data Availability

Data described in the manuscript, code book, and analytic code are publicly and freely available without restriction at https://www.cdc.gov/nchs/nhanes/index.htm.

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