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Relationship Between Ultraprocessed Food Intake and Cardiovascular Health Among U.S. Adolescents: Results From the National Health and Nutrition Examination Survey 2007–2018

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Abstract

Purpose: Studies of the association between ultraprocessed foods (UPF) and cardiovascular disease risk factors have been mainly focused on the adult population. This study examined the association between usual percentage of calories (%kcal) from UPF and the American Heart Association's seven cardiovascular health (CVH) metrics among U.S. adolescents aged 12–19 years.

Methods: We used data from the National Health and Nutrition Examination Survey 2007–2018 (n = 5,565). The NOVA food system was used to classify UPF according to the extent and purpose of food processing. Each CVH metric was given a score of 0, 1, or 2 (poor, intermediate, or ideal health, respectively). Scores of six metrics were summed (excluding diet) to categorize CVH as low (0–7), moderate (8–0), or high (11–12). The National Cancer Institute's methods were used to estimate usual %kcal from UPF. Multivariable linear regression and multinomial logistic regression were used to evaluate the association between UPF and CVH.

Results: Among youth, 12.1% had low CVH, 56.3% moderate, and 31.6% high. The mean usual %kcal from UPF was 65.7%. Every 5% increase in calories from UPF was associated with .13 points lower CVH scores ($p < .001$). Comparing Q2, Q3, and Q4 to Q1 of UPF intake, the adjusted odds ratios for low versus high CVH were 1.43 (95% confidence interval 1.16–1.76), 1.86 (1.29–2.66), and 2.59 (1.49–4.55), respectively. The pattern of association was largely consistent across subgroups.

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Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jadohealth.2021.09.031.

Conclusions: U.S. adolescents consume about two thirds of daily calorie from UPF. There was a graded inverse association between %kcal from UPF and CVH score.

Keywords

Adolescents; Ultraprocessed foods; Usual percentage of calories; Cardiovascular health; NHANES; Odds ratio

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Ultraprocessed foods (UPFs) are industrial formulations made entirely or mostly from substances extracted from foods (oils, fats, sugar, starch, and proteins), derived from food constituents (hydrogenated fats and modified starch), or synthesized in laboratories from food substrates or other organic sources (flavor enhancers, colors, and several food additives) [1]. UPFs—including chips, cookies, candy, soft drinks, and ready-to-eat products such as pizza, instant soup, hot dogs, and chicken nuggets—are usually palatable, low in cost, and have a long shelf-life. Studies conducted in several countries, most of them using national dietary intake surveys, have shown that UPFs are typically energy-dense products, high in calories, added sugar, un-healthy fats, and salt, and low in dietary fiber, protein, vitamins, and minerals [2]. Studies carried out in different populations in Europe, U.S., and Brazil have shown that high intake of overall UPFs are associated with cardiovascular disease (CVD) risk factors such as overweight and/or obesity [3], dyslipidemia [4], hypertension [5], metabolic syndrome [6], and type 2 diabetes [7], as well as with CVD incidence [8] and mortality [9]. However, most of these studies have focused on the adult population [10].

In the 2010 “Strategic Impact Goal Through 2020 and Beyond,” the American Heart Association (AHA) identified a set of seven cardiovascular health (CVH) metrics (body mass index [BMI], smoking, physical activity, dietary intake, total cholesterol, blood pressure, and fasting glucose) that can be modified to lower cardiovascular risk and are categorized into three levels (poor, intermediate, and ideal health) [11]. The presence of a higher number of ideal CVH metrics is associated with a graded and significantly lower risk of CVD incidence and mortality [12,13]. A recent study reported an inverse association between UPF and the AHA’s CVH metrics among U.S. adults [14]. A recent study reported that the number of adolescents with all seven cardiovascular protective factors declined significantly from 27.6% to 9.6% from 1988–1994 to 2011–2016 [15], indicating a substantial burden of cardiovascular risk factors among adolescents in the U.S. Although a few studies have examined the association between UPFs and individual cardiovascular risk factors such as BMI, overweight, obesity, waist circumference, body fat, hypertension [10], and metabolic syndrome [6] among adolescents, none have assessed the association between UPFs and the AHA’s CVH metrics using nationally representative survey data. We hypothesized that high intake of UPF might also be associated with reduced CVH among adolescents. In this study, we examined the association between usual percentage of total daily calories (%kcal) from UPF and CVH in adolescents, using the 2007–2018 National Health and Nutrition Examination Survey (NHANES) data.

Methods

Data source and participants

NHANES is a large, cross-sectional, nationally representative survey of the U.S. noninstitutionalized civilian population conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention. Each cycle's sample is obtained using a complex, stratified, multistage probability cluster sampling design [16]. In the Mobile Examination Center, NHANES uses the Computer-Assisted Personal Interviewing system to collect detailed dietary information of the types and amounts of foods and beverages consumed during the previous 24-hour period (midnight to midnight). NHANES 24-hour dietary recall data provide calories for each individual food and beverage, and total calories for each participant. During the 2007–2018 NHANES cycles, among 7,582 participants aged 12–19 years who were examined at the mobile examination center, 7,140 had a complete and reliable first 24-hour dietary recall. We excluded 1,575 adolescents who had missing information on CVH or covariates, leaving 5,565 adolescents for analysis. Study protocols for NHANES were approved by the National Center for Health Statistics ethics review board. Signed informed consent was obtained from all participants.

Estimated ultraprocessed food

Dietary intake data were collected using up to two 24-hour dietary recalls, administered in person during the first recall, and via phone 3–10 days later during the second recall throughout the week including the weekends. The 24-hour dietary recalls were administered by trained interviewers using the automated multipass method, a research-based, multiple pass approach employing five steps designed to enhance complete and accurate food recall and reduce respondent burden [16].

Briefly, U.S. Department of Agriculture (USDA) Food and Nutrient Database for Diet Studies (FNDDS) uses 8-digit food codes to convert consumed foods and beverages into gram amounts and determine their nutrient values. In this study, energy and nutrient contents were assigned to foods by using the cycle-specific USDA's FNDDS [17] and Standard Reference (SR) databases (for homemade recipes) [18].

All reported foods and beverages were classified according to NOVA system [1] into four groups based on the nature, extent, and purpose of industrial food processing: (1) unprocessed or minimally processed foods (e.g., fresh or frozen fruits or vegetables, grains, meats, fish, milk/plain yogurt); (2) processed culinary ingredients (e.g., table sugar, plant oils, fats, salt, and other substances extracted from foods or nature and used for culinary preparations); (3) processed foods (e.g., cheese, canned fruits and vegetables, canned/smoked/cured meats and fishes, salted nuts, and other foods manufactured with the addition of salt or sugar or other culinary ingredients to unprocessed or minimally processed foods); and (4) UPFs (e.g., industrial grain foods, sweet or savory packaged snacks, sausages, chicken nuggets and other reconstituted meats, sugar-sweetened beverages, and other ready-to-eat/heat formulations of several ingredients).

For all food items judged to be homemade recipes, the classification was applied to the underlying ingredients' SR codes obtained from the USDA's FNDDS (USDA SR) [17,18].

Further details on procedures to classify food items according to NOVA [1] and to estimate NOVA calorie contributions are described elsewhere [19]. The current analyses focused on UPF.

The National Cancer Institute method to estimate the between- and within-person variations in intake requires at least some respondents to have multiple days of dietary intake [20]. Usual intake distribution estimates were calculated, and adjusted for age in years, sex, race and Hispanic origin, the first- or second-day dietary recalls (all participants had a first-day and 87.7% had a second-day dietary recall), and the day of the week when 24-hour recall was collected (weekday [Monday–Thursday] vs. weekend [Friday–Sunday]).

Cardiovascular health metrics

The definitions of ideal, intermediate, and poor CVH metrics for adolescents are presented in Supplemental Table 1. NHANES only collected fasting blood samples among half of participants (47.6% of adolescents). In order to maximize the sample size, we used hemoglobin A1c values <5.7%, 5.7%–6.4%, and ≥6.5% measured among almost all participants as a proxy for fasting plasma glucose levels <100, 100 to <126, and ≥126 mg/dL, respectively, following the American Diabetes Association recommendations [21]. To be consistent with 2007–2014 cycles, data from NHANES 2015 to 2018 cycles were adjusted using the backward calibration equation to take into account changes in glucose measurement methods over time.

Ideal weight was defined as BMI <85th percentile, intermediate as 85the95th percentile, and poor as >95th percentile. BMI was calculated as weight in kilograms divided by height in meters squared. Ideal physical activity was defined as ≥60 minutes of moderate or vigorous activity daily and intermediate physical activity was defined as 1–59 minutes of moderate or vigorous activity daily. Poor physical activity was defined as no daily moderate or vigorous activity. Smoking can only be defined as ideal or poor health for adolescents using NHANES data. Adolescents whose responses were “never tried” or “never smoked whole cigarette” were categorized as ideal smoking health. Poor smoking health was assigned if the response was “tried in prior 30 days.” Ideal cholesterol was defined as total cholesterol <170 mg/dL, intermediate cholesterol as 170–199 mg/dL, and poor cholesterol as ≥200 mg/dL. Total cholesterol and plasma glucose were measured with the enzymatic method [16]. Ideal blood pressure was defined as blood pressure <90th percentile, intermediate as 90th–95th percentile, and poor as >95th percentile. For adolescents aged 18–19 years, ideal blood pressure was defined as untreated blood pressure <120/80 mm Hg; intermediate as untreated blood pressure 120–139 mm Hg/80–89 mm Hg, or treated blood pressure <140/90 mm Hg; and poor as treated or untreated blood pressure ≥140/90 mmHg. Mean blood pressure was estimated from up to three readings, obtained under standard conditions during a single physical examination.

Each CVH metric was scored as 0, 1, or 2 to represent poor, intermediate, or ideal health, respectively. An overall score ranging from 0 to 12 was obtained as the sum of 6 metrics (excluding diet component because UPFs were derived from dietary data), which was then categorized as low (0–7), moderate (8–10), or high (11–12) CVH [22].

Other covariates

Other sociodemographic data included age, sex, self-reported race and Hispanic origin (non-Hispanic White, non-Hispanic Black, Hispanic, and other), parents' educational attainment defined based on the education of the first household member 18 years of age or older listed on the household member roster, who owns or rents the residence where members of the household reside (below high school, high school graduate, college or above, and missing [n = 200]), health insurance (yes or no), and poverty–income ratio (PIR, the ratio of household income to the poverty threshold after accounting for inflation and family size: <1.30, ≥1.30, and missing [n = 521]). Higher PIR represents higher income.

Statistical analyses

Statistical analyses were performed using SUDAAN version 11 (RTI International) accounting for the complex sampling design. Characteristics were expressed as means and 95% confidence intervals (CI) for continuous variables, or as percentages and 95% CIs for categorical variables. Trends across CVH metrics categories were compared by *t*-test. We compared characteristics between included and excluded adolescents (Supplemental Table 2).

Restricted cubic spline with four knots (20th, 40th, 60th, and 80th percentiles) was used to examine departure from a linear relationship between usual %kcal from UPF and CVH scores [23]; there was no evidence of nonlinearity ($p = .87$). We then calculated the adjusted differences in CVH scoresby using the mid-point of the lowest quartile (Q1) of intake (54.4% of calories from UPF) as the reference [24].

We used multinomial logistic regression to estimate the adjusted odds ratios (ORs) for low and moderate CVH versus high CVH comparing Q2, Q3, and Q4 to Q1 of usual %kcal from UPF. The base model adjusted for age as a continuous variable, sex, race, and Hispanic origin; the second model was additionally adjusted for parents' education attainment, health insurance, and PIR. Results were also stratified by age group (12–15 and 16–19 years), sex, race and Hispanic origin, educational level, health insurance, and PIR, and interactions between UPF intake and covariates were assessed by including the interaction terms in the multinomial logistic regression models based on the Wald-*F* test.

The association between UPF and individual components of CVH metrics was also examined. We calculated ORs for poor and intermediate CVH versus ideal CVH for each component, comparing Q2, Q3, and Q4 to Q1 of usual %kcal from UPF and adjusted for the rest of the CVH components in addition to the covariates. False discovery rate–adjusted *p*-values were presented, given multiple comparisons.

We used the first-day 24-hour dietary recall sampling weights dividing by six (data from six NHANES cycles) to represent the noninstitutionalized U.S. population and account for sampling probability and nonresponse. All statistical tests were two-tailed, and a $p < .05$ was considered significant.

Sensitivity analyses

The CVH score is calculated using factors which differ in their nature and potential role linking UPF and CVD. Although BMI, total cholesterol, blood pressure, fasting plasma glucose, and diet quality are five potential mechanisms linking UPF to CVD, smoking and physical activity are not. We conducted several sensitivity analyses to test the robustness of the results: (1) we examined the association between %kcal from UPF and the four CVH metrics (BMI, total cholesterol, blood pressure, and fasting plasma glucose) (Supplemental Table 3) and (2) we examined the association between %kcal from UPF and the four aforementioned CVH metrics plus the dietary component. We used the Healthy Eating Index 2010 (HEI-2010) score instead of AHA's dietary score for the diet component because the current recommendation for daily sodium intake in federal guidelines is <2,300 mg/day, which does not align with the 1,500 mg/day in the AHA dietary scores, and also because HEI-2010 is a continuous scale and therefore more sensitive and informative. We defined top 10% of HEI-2010 scores as having an ideal diet, >50% and <90% as intermediate, and 50% as poor diet [25] (Supplemental Table 4). (3) We examined the association between %kcal from UPF and the AHA 7 CVH metrics (including diet component of HEI-2010) (Supplemental Table 5). (4) We examined the association between the percentage of UPF by weight and CVH metrics [26] (Supplemental Table 6). (5) We examined the association between %kcal from UPF and the AHA 6 CVH metrics (excluding diet component) excluding participants with total energy intake <800 or >4,200 in men, and <500 or >3,500 in women [27] (Supplemental Table 7). (6) We examined the association between %kcal from UPF and the AHA 6 CVH metrics (excluding diet component) excluding participants if their reported energy intake was not within ±1 standard deviation (SD), ±1.5 SD, and ±2 SD of the predicted energy requirements [28] (Supplemental Tables 8–10). Details of sensitivity analyses are presented in Supplemental Material.

Results

The mean age of the 5,565 adolescents was 15.5 years. Half (49.5%) of U.S. adolescents were female, 55.6% were non-Hispanic white, 13.5% were non-Hispanic black, 22.4% were Hispanic, 46.9% of their parents had >12 years of education, 88.5% had health insurance, and 63.4% had a PIR of ≥130%. The weighted prevalence of low, moderate, and high CVH was 12.1%, 56.3%, and 31.6%, respectively. Younger age, non-Hispanic white, parents with higher education level, health insurance, or a higher PIR were associated with higher CVH scores, whereas non-Hispanic black and Hispanic adolescents were more likely to have lower CVH scores (Table 1). Compared to adolescents who were excluded from the analyses, those included in the analyses were older and less likely to be non-Hispanic black; their parents also had higher education and PIR levels (Supplemental Table 2).

The mean usual %kcal from UPF was 65.7%, and the mid-point of quartiles of intake was 54.4%, 62.8%, 69.0%, and 76.8%, respectively. Every 5% increase in calories from UPF was associated with .13 points lower CVH score ($p < .001$) (Figure 1). Comparing Q2, Q3, and Q4 to Q1 of UPF intake, the adjusted ORs for low versus high CVH were 1.43 (95% CI 1.16–1.76), 1.86 (1.29–2.66), and 2.59 (1.49–4.55), respectively. The corresponding ORs for moderate versus high CVH were 1.27 (1.11–1.45), 1.51 (1.19–1.91), and 1.88 (1.31–2.72) (Table 2).

The associations between %kcal from UPF and CVH were largely consistent by age, sex, race and Hispanic origin, parents' education years, health insurance, and PIR subgroups although the associations were not statistically significant for several subgroups (Table 3, false discovery rate–adjusted p values >.05 for all interactions).

Figure 2 shows the fully adjusted ORs (95% CI) for poor or intermediate CVH (versus ideal) comparing Q2, Q3, and Q4 to Q1 of UPF intake for each individual CVH metric. Usual %kcal from UPF was significantly associated with overweight, obesity, and elevated blood pressure, but not associated with poor smoking status, physical inactivity, diabetes, or hypertension, and was inversely associated with total cholesterol.

In sensitivity analyses, we examined the association between %kcal from UPF and four CVH metrics, four CVH metrics plus HEI-2010 as well as all seven CVH components, and the association between proportion of UPF by weight and six CVH metrics. The pattern of association remained largely consistent, though the association was stronger for the 5- and 7-CVH component metrics (Supplemental Tables 3–6). We also examined the association between %kcal from UPF and six CVH components excluding implausible energy intake. The association seems to become stronger when more strict criteria on implausible energy intakes were applied.

Discussion

In this nationally representative sample of U.S. adolescents, UPF accounts for about two thirds of daily total calories, and greater consumption of UPF was associated with lower scores on important measures of CVH. The pattern of the association was largely consistent across age, sex, race and Hispanic origin, poverty, parent's education attainments, and insurance status subgroups. Sensitivity analyses suggested that the association remained significant when using different numbers of CVH metrics, or percentage of UPF by weight, or excluding implausible energy intake. The results are consistent with the findings among U.S. adults [14].

Although the growing body of evidence has shown the association between overall UPF and adverse health outcomes among adults, only a few studies, all from Brazil, have focused on the association among adolescents. Three studies examined the association between overall UPF and BMI, overweight, obesity, or percentage body fat among adolescents; none of them found significant associations [10]. Studies have shown the association between certain types of UPF consumption (snacks, fast foods, junk foods, and convenience foods), or soft drink/sweetened beverage consumption, or other specific UPF foods (chocolate, sweets, and ready-to-consume breakfast cereals) and body fat among adolescents [29]. Tavares et al. [6] reported a significant association between high UPF consumption (≥third Quartile) and higher prevalence of metabolic syndrome in a cross-sectional study on adolescents aged 12–19 years. Another cross-sectional study on adolescents aged 14–19 years by de Melo et al. indicated no association between UPF and excess weight, hypertension, or high waist circumference [10]. In addition to the association with CVH, our analyses found that UPF intake was also positively related to overweight, obesity, and elevated blood pressure (Figure 2). The association with hypertension and diabetes did not reach statistical significance, possibly due to the small number of these two conditions among adolescents. Although not all UPFs are high in cholesterol, many high-cholesterol foods (eggs, cheese, beef, shellfish, etc.) are not classified as UPF, which could explain the negative association between UPF and cholesterol.

To a considerable extent, UPFs have replaced whole foods and freshly prepared dishes [1]. In several countries, public health authorities have recently started to promote unprocessed or minimally processed foods and to recommend limiting the consumption of UPF [30,31]. We found that U.S. adolescents consume two thirds of their daily calories from UPF, which is higher than U.S. adults (55%) [14] and adolescents in Brazil (50%) [32]. Studies have suggested that healthy diet habits established during childhood and adolescence moderately continue into adulthood [33]. Furthermore, societies and school should promote programs and policies that make the healthy choice easy, affordable, and accessible and protect children from heavy marketing of UPF [34].

Studies have suggested several mechanisms for the association between UPF and CVD risk factors [35]. UPFs are low in nutrients, and high in fats, sodium, added sugar, and energy density [2]. The palatability of and lack of fiber in UPF encourage people to overeat these foods, and may facilitate high glycemic loads [35]. UPF has been associated with urinary concentration of environmental chemicals in the food packaging such as phthalates and bisphenol, which are associated with obesity, diabetes, hypertension, and coronary artery disease [36]. Although the mechanisms are most likely the same for adolescents and adults, due to younger age, adolescents may have less cumulative exposure to UPF compared to adults. Higher UPF intake could also have additional currently unknown effects among adolescents. More than 95% of American youth attend school and consume as much as 35%–40% of their daily caloric intake there [37]. Items acquired from school vending machines, snack bars, and canteens are likely to be UPFs and have been consistently found to be low in nutrients and high in fat, calories, and sugar although school nutrition policies vary and have changed over time [38]. The school food environment may be adolescent-specific factors that influence UPF consumption, and thereby CVH health.

The strengths of this study include the use of a nationally representative survey, and used individual consumption data. We used a measurement error model to estimate usual %kcal from UPF from two 24-hour dietary recalls accounting for within-individual variation in intake. We have performed a comprehensive number of sensitivity analyses for robustness of our findings. Our study was subject to limitations. First, NHANES did not always consistently determine food processing information, such as location of meals and product brands, which could lead to potential misclassification errors. Second, the first 24-hour dietary recall was conducted in person and the second recall was collected via telephone interview. However, previous research found 24-hour recalls obtained by telephone interviews to be as effective as those obtained in person [39]. Third, several individual CVH metrics had small numbers of poor health because adolescents had low prevalence of these conditions, such as hypertension and diabetes. The association between

UPF and these individual CVH did not reach statistical significance. Fourth, higher UPF consumption could be a proxy for a less healthy overall lifestyle, and residual confounding could overestimate the association with CVH [40]. Fifth, about 22% of participants were excluded from the analyses because of missing information on CVH or covariates. The participants included were older, less likely to be non-Hispanic black, and had parents with higher education and PIR levels. The potential lack of external validity of results might under- or overestimate the true association between UPF and CVH. In addition, reverse causality could underestimate the association between UPF consumption and CVH, if adolescents who develop overweight/obesity or other conditions change their diet and reduce UPF consumption. Finally, as our analysis was cross-sectional, causal associations between UPF and CVH could not be determined.

Our study indicated that U.S. adolescents consume about two thirds of their daily calories from UPF, and higher consumption of UPF was associated with low CVH, overweight, obesity, and elevated blood pressure. Our analyses highlight the importance of limiting the consumption of UPF among adolescents. Societies and schools should implement policies and practices to make the healthy choice more affordable and accessible. Parents can model healthy behaviors, and healthcare providers can encourage adolescents to establish healthier eating habits that might help improve their CVH throughout the life course.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

[1]. Monteiro CA, Cannon G, Moubarac JC, et al. The UN decade of nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr 2018;21:5–17. [PubMed: 28322183]

[2]. Monteiro CA, Cannon G, Levy RB, et al. Ultra-processed foods: What they are and how to identify them. Public Health Nutr 2019;22:936–41. [PubMed: 30744710]

[3]. Mendonca RD, Pimenta AM, Gea A, et al. Ultraprocessed food consumption and risk of overweight and obesity: The University of Navarra Follow-up (SUN) cohort study. Am J Clin Nutr 2016;104:1433–40. [PubMed: 27733404]

[4]. Rauber F, Campagnolo PD, Hoffman DJ, Vitolo MR. Consumption of ultra-processed food products and its effects on children's lipid profiles: A longitudinal study. Nutr Metab Cardiovasc Dis 2015;25:116–22. [PubMed: 25240690]

[5]. Mendonca RD, Lopes AC, Pimenta AM, et al. Ultra-processed food consumption and the incidence of hypertension in a Mediterranean cohort: The Seguimiento Universidad de Navarra Project. Am J Hypertens 2017;30: 358–66. [PubMed: 27927627]

[6]. Tavares LF, Fonseca SC, Garcia Rosa ML, Yokoo EM. Relationship between ultra-processed foods and metabolic syndrome in adolescents from a Brazilian Family Doctor Program. Public Health Nutr 2012;15:82–7. [PubMed: 21752314]

[7]. Srour B, Fezeu LK, Kesse-Guyot E, et al. Ultraprocessed food consumption and risk of type 2 diabetes among participants of the NutriNet-Santé Prospective Cohort. JAMA Intern Med 2020;180:283–91.

[8]. Srour B, Fezeu LK, Kesse-Guyot E, et al. Ultra-processed food intake and risk of cardiovascular disease: Prospective cohort study (NutriNet-Sante). BMJ 2019;365:l1451. [PubMed: 31142457]

[9]. Bonaccio M, Di Castelnuovo A, Costanzo S, et al. , On behalf of the Moli-sani Study Investigators. Ultra-processed food consumption is associated with increased risk of all-cause and cardiovascular mortality in the Moli-sani Study. Am J Clin Nutr 2021;113:446–55. [PubMed: 33333551]

[10]. Elizabeth L, Machado P, Zinöcker M, et al. Ultra-processed foods and health outcomes: A narrative review. Nutrients 2020;12:1955. [PubMed: 32630022]

[11]. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: The American Heart Association's strategic impact goal through 2020 and beyond. Circulation 2010;121:586–613. [PubMed: 20089546]

[12]. Folsom AR, Yatsuya H, Nettleton JA, et al. , For the Atherosclerosis Risk in Communities (ARIC) Study Investigators. Community prevalence of ideal cardiovascular health, by the American Heart Association definition, and relationship with cardiovascular disease incidence. J Am Coll Cardiol 2011; 57:1690–6. [PubMed: 21492767]

[13]. Yang Q, Cogswell ME, Flanders WD, et al. Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among US adults. JAMA 2012;307:1273–83. [PubMed: 22427615]

[14]. Zhang Z, Jackson S, Martinez E, et al. Association between ultra-processed food intake and cardiovascular health among U.S. adults: A cross-sectional analysis of the NHANES 2011e2016. Am J Clin Nutr 2021;113:428–36. [PubMed: 33021623]

[15]. Hecht EM, Williams AYP, Abrams GA, Passman RS. Cardiovascular risk factors in young adolescents: Results from the national health and nutrition examination survey 1988–2016. South Med J 2021;114:261–5. [PubMed: 33942107]

[16]. CDC national health and nutrition examination survey [Internet]. Available at: https://www.cdc.gov/nchs/nhanes/index.htm. Accessed July 2, 2021.

[17]. USDA website. Available at: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds/. Accessed July 2, 2021.

[18]. US Department of Agriculture, Agricultural Research Service. Nutrient data laboratory. USDA national nutrient database for standard reference. 2016. Available at: http://www.ars.usda.gov/nea/bhnrc/mafcl. Accessed July 2, 2021.

[19]. Martinez Steele E, Baraldi LG, Louzada ML, et al. Ultra-processed foods and added sugars in the US diet: Evidence from a nationally representative cross-sectional study. BMJ Open 2016;6:e009892.

[20]. Guenther PM, Kott PS, Carriquiry AL. Development of an approach for estimating usual nutrient intake distributions at the population level. J Nutr 1997;127:1106–12. [PubMed: 9187624]

[21]. American Diabetes Association. Standards of medical care in diabetes–2010. Diabetes Care 2010;33:S11–61. [PubMed: 20042772]

[22]. Gooding HC, Ning H, Perak AM, et al. Cardiovascular health decline in adolescent girls in the NGHS cohort, 1987–1997. Prev Med Rep 2020;20: 101276. [PubMed: 33344149]

[23]. Desquilbet L, Mariotti F. Dose-response analyses using restricted cubic spline functions in public health research. Stat Med 2010;29: 1037–57. [PubMed: 20087875]

[24]. Kipnis V, Midthune D, Buckman DW, et al. Modeling data with excess zeros and measurement error: Application to evaluating relationships between episodically consumed foods and health outcomes. Biometrics 2009;65: 1003–10. [PubMed: 19302405]

[25]. Yang Q, Yuan K, Gregg EW, et al. Trends and clustering of cardiovascular health metrics among U.S. adolescents 1988–2010. J Adolesc Health 2014; 55:513–20. [PubMed: 24746492]

[26]. Fiolet T, Srour B, Sellem L, et al. Consumption of ultra-processed foods and cancer risk: Results from NutriNet-Santé prospective cohort. BMJ 2018; 360:k322. [PubMed: 29444771]

[27]. Banna JC, McCroy MA, Fialkowski MK, Boushey C. Examining plausibility of self-reported energy intake data: Considerations for method selection. Front Nutr 2017;4:45. [PubMed: 28993807]

[28]. Huang TT, Roberts SB, Howarth NC, McCrory MA. Effect of screening out implausible energy intake reports on relationships between diet and BMI. Obes Res 2005;13:1205–57. [PubMed: 16076990]

[29]. Costa CS, Del-Ponte B, Assunção MCF, Santos IS. Consumption of ultra-processed foods and body fat during childhood and adolescence: A systematic review. Public Health Nutr 2018;21:148–59. [PubMed: 28676132]

[30]. Ministry of Health of Brazil. Dietary guidelines for the Brazilian population. 2014. Available at: http://189.28.128.100/dab/docs/portaldab/publicacoes/guia_alimentar_populacao_ingles.pdf. Accessed July 2, 2021.

[31]. Haut Conseil de la Sante Publique. Avis relatif a la revision des reperes alimentaires pour les adultes du futur Programme National Nutrition Sante 2017–2021. 2017. Available at: www.hcsp.fr/Explore.cgi/Telecharger?NomFichier=hcspa20170216_reperesalimentairesactua2017.pdf. Accessed July 2, 2021.

[32]. Enes CC, Camargo CMD, Justino MIC. Ultra-processed food consumption and obesity in adolescents. Rev Nutr 2019;32:e18170.

[33]. Movassagh EZ, Baxter-Jones ADG, Kontulainen S, et al. Tracking dietary patterns over 20 years from childhood through adolescence into young adulthood: The Saskatchewan Pediatric Bone Mineral Accrual study. Nutrients 2017;9:990. [PubMed: 28885565]

[34]. Labonté MÈ, Poon T, Gladanac B, et al. Nutrient profile models with applications in government-led nutrition policies aimed at health promotion and noncommunicable disease prevention: A systematic review. Adv Nutr 2018;9:741–88. [PubMed: 30462178]

[35]. Juul F, Vaidean G, Parekh N. Ultra-processed foods and cardiovascular diseases: Potential mechanisms of action. Adv Nutr 2021;00:1–8.

[36]. Martínez Steele E, Khandpur N, da Costa Louzada ML, Monteiro CA. Association between dietary contribution of ultra-processed foods and urinary concentrations of phthalates and bisphenol in a nationally representative sample of the US population aged 6 years and older. PLoS One 2020;15: e0236738. [PubMed: 32735599]

[37]. Briefel RR, Wilson A, Gleason PM. Consumption of low-nutrient, energy-dense foods and beverages at school, home, and other locations among school lunch participants and nonparticipants. J Am Diet Assoc 2009;109: S79–90. [PubMed: 19166676]

[38]. State legislation and policy reports. Available at: https://schoolnutrition.org. Accessed July 2, 2021.

[39]. Tran KM, Johnson RK, Soultanakis RP, et al. In-person vs. telephone administered multiple-pass 24-hour recalls in women: Validation with doubly labeled water. J Am Diet Assoc 2000;100:777–83. [PubMed: 10916515]

[40]. Schuit AJ, van Loon AJ, Tijhuis M, Ocké M. Clustering of lifestyle risk factors in a general adult population. Prev Med 2002;35:219–24. [PubMed: 12202063]

IMPLICATIONS AND CONTRIBUTION

U.S. adolescents consume about two thirds of their calories from ultraprocessed foods. Higher intake of ultraprocessed foods was associated with inadequate cardiovascular health among adolescents. Encouraging adolescents to establish healthier eating habits might help improve cardiovascular health throughout the life course.

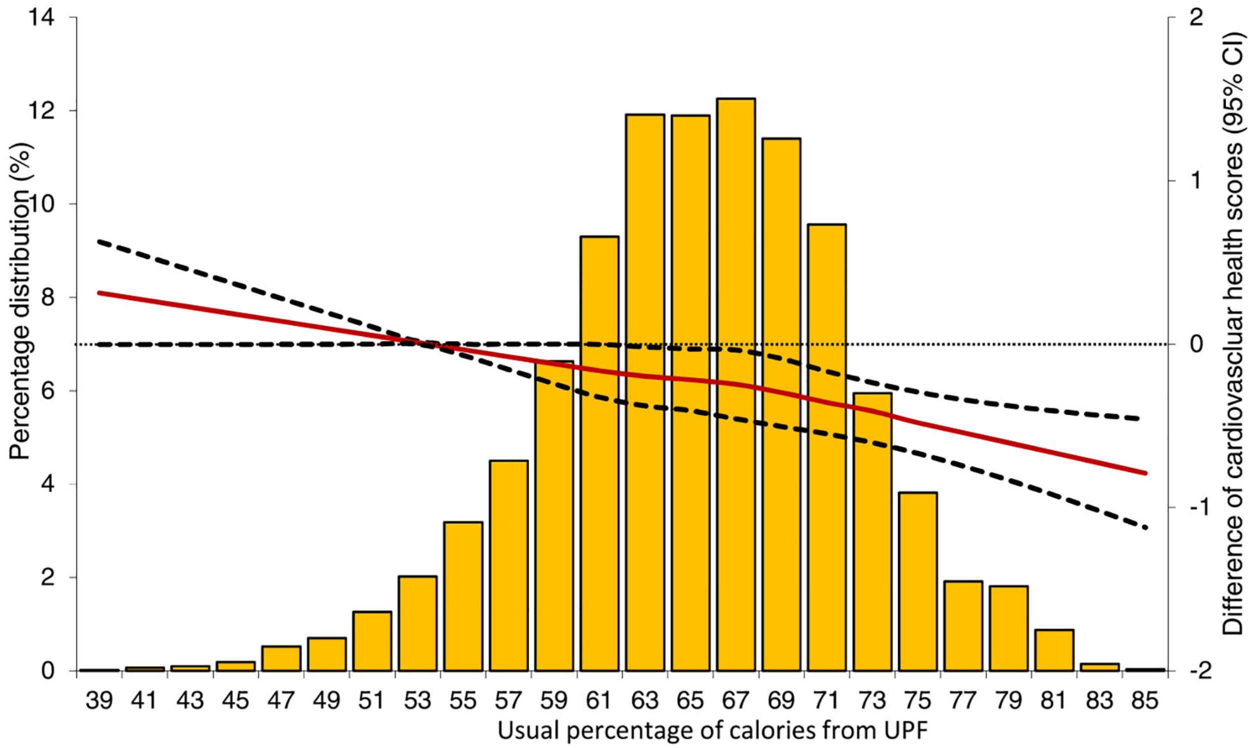

Figure 1.

Distributions of usual %kcal from UPF and adjusted differences in CVH scores (54.4% as reference). Multivariable linear regression models were used to estimate the adjusted differences in CVH scores and corresponding 95% CI, and were adjusted for age, sex, race and Hispanic origin, education attainment of household head, health insurance, and poverty–income ratio. The bar chart represents the distribution of usual %kcal from UPF. The solid line represents the point estimate of adjusted differences in CVH scores, and the dashed lines represent corresponding 95% CI. %kcal = percentage of calories; CI = confidence interval; CVH = cardiovascular health (excluding diet component); UPF = ultraprocessed foods.

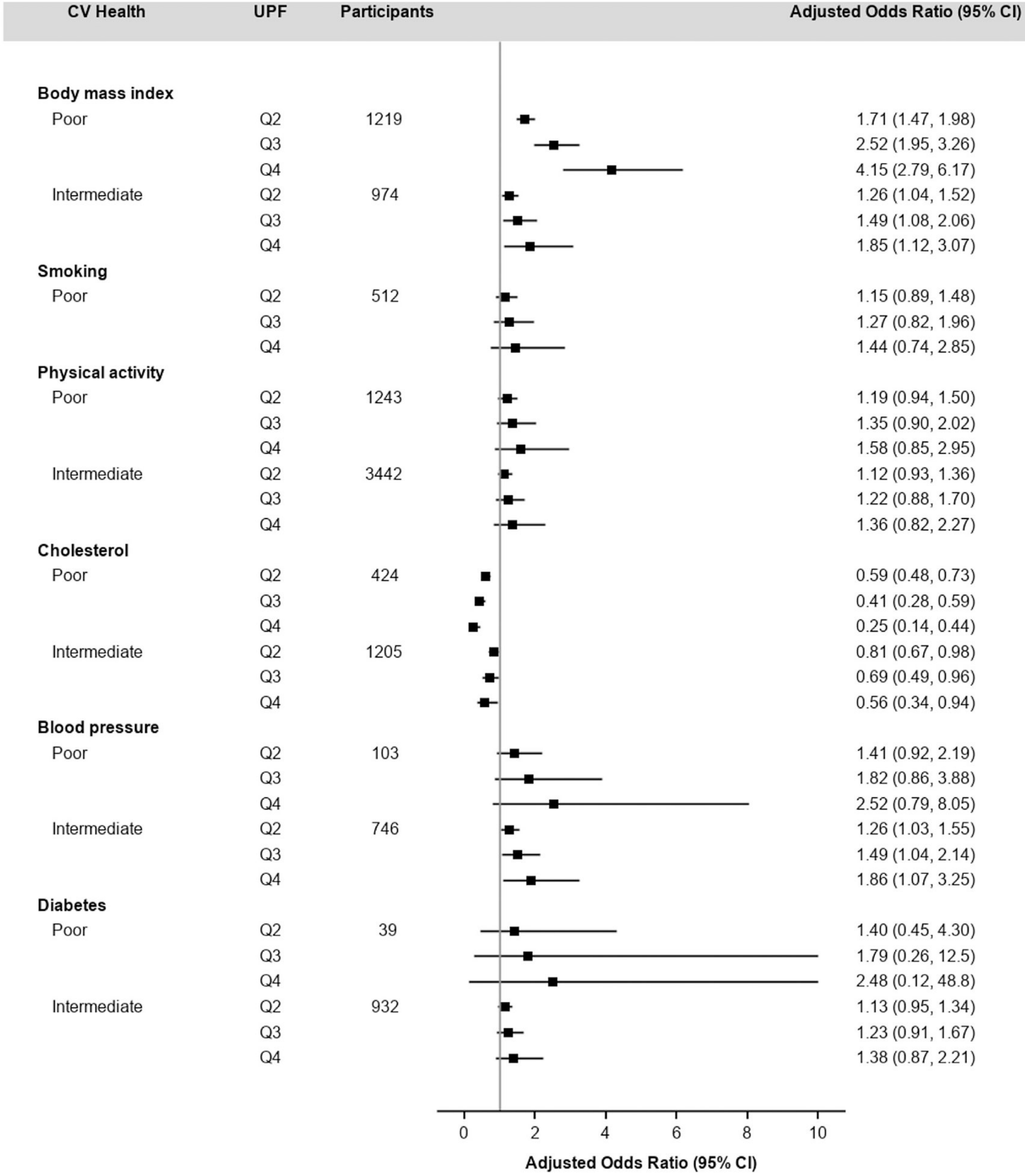

Figure 2.

Adjusted odds ratio (95% CI) of individual CVH metric. Multinomial logistic regression models were used to estimate odds ratios and corresponding 95% CI, and were adjusted for age, sex, race and Hispanic origin, education attainment of household head, health insurance, and poverty–income ratio. CI = confidence interval; CVH = cardiovascular health (excluding diet component); UPF = ultraprocessed foods.

Table 1

Comparison of selected characteristics by cardiovascular health metric categories among U.S. adolescents aged 12–19 years, NHANES 2007–2018[a]

Characteristics	Overall (n = 5,565)	Low CVH score 0–7 (n = 707)	Moderate CVH score 8–10 (n = 3,221)	High CVH score 11–12 (n = 1,637)	*p* Value for trend[b]
Age (years), mean (SE)	15.5 (.05)	16.5 (.10)	15.6 (.07)	15.1 (.09)	<.001
Male, % (SE)	50.5 (1.14)	52.7 (2.88)	48.1 (1.42)	54.0 (1.93)	.71
Race and Hispanic origin, % (SE)					
Non-Hispanic white	55.6 (2.02)	49.3 (3.49)	52.2 (2.17)	64.0 (2.32)	<.001
Non-Hispanic black	13.5 (1.11)	18.7 (2.22)	14.3 (1.17)	10.3 (1.08)	<.001
Hispanic	22.4 (1.62)	25.7 (2.60)	24.2 (1.80)	17.9 (1.64)	<.001
Other	8.6 (.66)	6.3 (1.06)	9.4 (.83)	7.9 (.91)	.20
Education attainment of household head, % (SE)					
Below high school	27.8 (1.41)	31.7 (2.54)	29.7 (1.54)	23.0 (1.91)	.006
High school graduate	21.6 (1.17)	21.3 (2.02)	22.0 (1.29)	21.0 (1.95)	.89
College or above	46.9 (1.76)	42.6 (2.63)	44.4 (1.70)	53.0 (2.78)	.002
Unknown	3.7 (.46)	4.4 (1.35)	3.8 (.58)	3.1 (.53)	.35
Poverty–income ratio,[c] % (SE)					
0%–129%	29.0 (1.57)	39.4 (2.80)	31.1 (1.73)	21.2 (1.80)	<.001
≥130%	63.4 (1.75)	52.5 (3.08)	61.0 (1.93)	71.9 (2.12)	<.001
Unknown	7.6 (.54)	8.1 (1.30)	7.8 (.69)	7.0 (.95)	.49
Any health insurance, % (SE)					
Yes	88.5 (.80)	86.1 (1.78)	86.8 (1.01)	92.4 (.94)	.002
No	11.5 (.80)	13.9 (1.78)	13.2 (1.01)	7.6 (.94)	

CVH = cardiovascular health (excluding diet component); NHANES = National Health and Nutrition Examination Survey; SE = standard error; UPF = ultraprocessed foods.

[a] Each CVH metric was scored as 0, 1, or 2 to represent poor, intermediate, or ideal cardiovascular health, respectively. An overall score ranging from 0 to 12 was obtained as the sum of six metrics (excluding diet component because UPFs were derived from dietary data), which was then categorized as low (0–7), moderate (8–10), or high (11–12) CVH.

[b] *p* value for trend across cardiovascular health metric categories was assessed by *t*-test.

[c] Poverty–income ratio is the ratio of family income to the Department of Health and Human Services poverty measure. Higher poverty–income ratio represents higher income.

Table 2

Odds ratios and 95% confidence intervals for cardiovascular health metrics associated with UPF, U.S. adolescents aged 12–19 years, NHANES 2007–2018

	Quartiles of usual percentage of calories from UPF[a] (n = 5,565)				*p* value[b]
	Q1	**Q2**	**Q3**	**Q4**	
Mid-point and range of usual percentage of calories from UPF	54.4% (42.3%–59.3%)	62.8% (59.4%–65.9%)	69.0% (66.0%–72.4%)	76.8% (72.5%–87.5%)	
Health metrics					
Age, sex, and race and Hispanic origin adjusted					
Low versus high CVH	1.00	1.50 (1.22–1.85)	2.02 (1.41–2.91)	2.96 (1.70–5.17)	<.001
Moderate versus high CVH	1.00	1.30 (1.14–1.49)	1.58 (1.25–2.00)	2.03 (1.42–2.90)	<.001
Fully adjusted[c]					
Low versus high CVH	1.00	1.43 (1.16–1.76)	1.86 (1.29–2.66)	2.59 (1.49–4.55)	<.001
Moderate versus high CVH	1.00	1.27 (1.11–1.45)	1.51 (1.19–1.91)	1.88 (1.31–2.72)	<.001

CI = confidence interval; CVH = cardiovascular health (excluding diet component); high CVH = CVH metrics scores 11–12; moderate CVH = CVH metrics scores 8–10; low CVH = CVH metrics scores 0–7; NHANES = National Health and Nutrition Examination Survey; UPF = ultraprocessed foods.

[a] UPF was defined based on the NOVA food classification system using the 24-hour dietary recall data.

[b] *p*-value of beta-coefficient for percentage of calories (continuous) from UPF in the multinomial logistic regression models.

[c] Multinomial logistic regression models were used to estimate odds ratios and corresponding 95% CI, and were adjusted for age, sex, race and Hispanic origin, education attainment of household head, health insurance, and poverty–income ratio (poverty–income ratio is the ratio of family income to the Department of Health and Human Services poverty measure).

Table 3

Adjusted odds ratio and 95% confidence intervals for cardiovascular health metrics associated with UPF by selected subgroups, U.S. adolescents, NHANES 2007–2018

	Quartiles of usual percentage of calories from UPF[a] (n = 5,565)				FDR-adjusted *p* value[b]
	Q1	**Q2**	**Q3**	**Q4**	
Mid-point and range of usual percentage of calories from UPF	40.4% (26.1%–46.6%)	51.2% (46.7%–55.3%)	59.5% (55.4%–64.2%)	70.5% (64.3%–86.0%)	
Age (years)					
12–15 (n = 2,795)					
Low versus high CVH	1.00	1.42 (.96–2.10)	1.84 (.94–3.62)	2.55 (.90–7.31)	.12
Moderate versus high CVH	1.00	1.32 (1.03–1.68)	1.61 (1.06–2.45)	2.08 (1.09–3.99)	.07
16–19 (n = 2,770)					
Low versus high CVH	1.00	1.36 (1.09–1.71)	1.72 (1.16–2.55)	2.31 (1.25–4.29)	.031
Moderate versus high CVH	1.00	1.19 (1.01–1.41)	1.36 (1.02–1.83)	1.62 (1.03–2.55)	.08
Sex					
Male (n = 2,883)					
Low versus high CVH	1.00	1.39 (1.07–1.81)	1.76 (1.12–2.78)	2.39 (1.18–4.89)	.051
Moderate versus high CVH	1.00	1.16 (.98–1.39)	1.30 (.96–1.76)	1.50 (.94–2.40)	.12
Female (n = 2,682)					
Low versus high CVH	1.00	1.46 (1.04–2.04)	1.93 (1.08–3.46)	2.74 (1.12–6.79)	.07
Moderate versus high CVH	1.00	1.39 (1.13–1.71)	1.77 (1.24–2.54)	2.40 (1.39–4.20)	.011
Race and Hispanic origin					
NHW (n = 1,595)					
Low versus high CVH	1.00	1.45 (1.02–2.06)	1.91 (1.04–3.51)	2.69 (1.06–6.96)	.08
Moderate versus high CVH	1.00	1.26 (1.00–1.59)	1.49 (.99–2.23)	1.83 (.99–3.44)	.11
NHB (n = 1,302)					
Low versus high CVH	1.00	1.13 (.80–1.59)	1.23 (.69–2.22)	1.38 (.56–3.41)	.51
Moderate versus high CVH	1.00	1.25 (.96–1.64)	1.47 (.93–2.34)	1.80 (.89–3.67)	.13
Hispanic (n = 1,931)					
Low versus high CVH	1.00	1.44 (1.00–2.05)	1.88 (1.01–3.53)	2.67 (1.01–7.15)	.10
Moderate versus high CVH	1.00	1.18 (.97–1.42)	1.33 (.96–1.85)	1.55 (.93–2.60)	.12
Other (n = 737)					

	Quartiles of usual percentage of calories from UPF[a] (n = 5,565)				FDR-adjusted *p* value[b]
	Q1	Q2	Q3	Q4	
Low versus high CVH	1.00	1.48 (.96–2.28)	2.00 (.94–4.25)	2.92 (.91–9.61)	.12
Moderate versus high CVH	1.00	1.32 (.93–1.87)	1.63 (.89–3.00)	2.13 (.83–5.57)	.14
Education attainment of household head					
Below high school (n = 1,926)					
Low versus high CVH	1.00	2.05 (1.42–2.96)	3.48 (1.84–6.58)	6.77 (2.55–18.2)	.003
Moderate versus high CVH	1.00	1.60 (1.25–2.04)	2.25 (1.48–3.45)	3.48 (1.82–6.73)	.003
High school graduate (n = 1,183)					
Low versus high CVH	1.00	1.42 (.92–2.19)	1.84 (.87–3.87)	2.53 (.81–8.08)	.13
Moderate versus high CVH	1.00	1.48 (1.05–2.09)	1.97 (1.09–3.57)	2.83 (1.14–7.10)	.07
College or above (n = 2,256)					
Low versus high CVH	1.00	1.15 (.82–1.61)	1.28 (.71–2.29)	1.46 (.59–3.63)	.45
Moderate versus high CVH	1.00	1.06 (.88–1.27)	1.10 (.80–1.51)	1.16 (.71–1.90)	.57
Poverty–income ratio					
0%–129% (n = 2,058)					
Low versus high CVH	1.00	1.53 (1.10–2.13)	2.08 (1.17–3.69)	3.08 (1.28–7.53)	.046
Moderate versus high CVH	1.00	1.39 (1.13–1.70)	1.76 (1.24–2.50)	2.39 (1.39–4.14)	.011
≥130% (n = 2,986)					
Low versus high CVH	1.00	1.34 (.96–1.88)	1.67 (.93–2.99)	2.19 (.89–5.47)	.12
Moderate versus high CVH	1.00	1.20 (.97–1.48)	1.37 (.95–1.97)	1.62 (.93–2.86)	.12
Any health insurance					
Yes (n = 4,770)					
Low versus high CVH	1.00	1.39 (1.10–1.76)	1.76 (1.18–2.63)	2.38 (1.29–4.45)	.029
Moderate versus high CVH	1.00	1.28 (1.11–1.49)	1.53 (1.19–1.96)	1.91 (1.30–2.83)	.011
No (n = 795)					
Low versus high CVH	1.00	1.55 (.97–2.47)	2.15 (.95–4.87)	3.25 (.92–11.7)	.12
Moderate versus high CVH	1.00	1.10 (.78–1.54)	1.18 (.65–2.12)	1.29 (.52–3.24)	.58

CI = confidence interval; CVH = cardiovascular health (excluding diet component); high CVH = CVH metrics scores 11–12; moderate CVH = CVH metrics scores 8–10; low CVH = CVH metrics scores 0e7; FDR = false discovery rate; NHANES = National Health and Nutrition Examination Survey; NHB = non-Hispanic blacks; NHW = non-Hispanic whites; PIR = poverty–income ratio; UPF = ultraprocessed foods.

[a] Multinomial logistic regression models were used to estimate odds ratios and the corresponding 95% CI, and were adjusted for age, sex, race and Hispanic origin, education attainment of household head, health insurance, and poverty–income ratio (poverty–income ratio is the ratio of family income to the Department of Health and Human Services poverty measure).

[b]FDR adjusted *p*-value of beta-coefficient for percentage of calories (continuous) from UPF in the multinomial logistic regression models. The FDR-adjusted *p*-values for the interaction between UPF and age group, sex, race and Hispanic origin, education, health insurance, and PIR were .589, .490, .768, .263, .490, and .513, respectively.