

APPENDIX TEXT 1. DIETARY INFORMATION COLLECTION IN NHANES

All participants are eligible for 24-hour dietary recall interviews. The first dietary recall interview is collected in-person in the Mobile Examination Center (MEC), and the second interview is collected by telephone 3 to 10 days later. The interview data were saved electronically by trained dietary interviewers using USDA's dietary data collection instrument, the Automated Multiple Pass Method (AMPM), a fully computerized recall method. The AMPM is designed to systematically help participants report their food and beverage intake in detail while minimizing respondent burden. A standard set of measuring guides are used to help participants report the volume and dimensions of the food items consumed. The USDA Food Patterns Equivalents Database, which disaggregates mixed foods into their component parts. Nutrients were derived from cycle-specific versions of the USDA Food and Nutrient Database for Dietary Studies.

APPENDIX TEXT 2. FOOD CLASSIFICATION ACCORDING TO PROCESSING

Food items were initially classified into 4 groups shown in Appendix Table 1. This was accomplished by taking into account, the following 3 variables from the NHANES recall databases: “Main Food Description”, “Additional Food Description” and “SR Code Description”. Thereafter, the food item classification was modified, if necessary, taking 2 variables into account: “Combination Food Type” and “Source of food”. Thus, most “Frozen meals” or “Lunchables” or food items consumed in “Restaurant fast food/pizza” or acquired at a “Vending machine”, were classified as ultra-processed foods.

As explained in the Subjects and Methods section, when Food Codes were judged to be a handmade recipe, the classification was applied to the underlying ingredients (SR Codes), to enable a more precise food item classification.¹

It must be noted, however, that SR Codes and their proportions are not necessarily the ingredients and proportions consumed by the participant. One of the reasons is that links between FNDDS and SR were developed to estimate the nutrient content of a Food Code and not the ingredient intake.²

Absence of data or discrepancies regarding degree of processing were solved opting for the lesser degree of processing (conservative criterion), which could have led to a slight underestimation of ultra-processed food consumption.

We classified homemade recipes with unknown ingredients based on expected principal ingredients, which could slightly underestimate ultra-processed food consumption.

Regarding bread, the classification distinguishes between handmade bread (either homemade or made in restaurants or artisanal bakeries), and industrial bread (made in industrial bakeries or factories), either processed (when made only of ingredients used in the making of handmade breads -flour, yeast, water, salt, and, sometimes, walnuts, dried fruits and other whole foods-) or ultra-processed (when adding substances not commonly used in the making of handmade breads -such as hydrogenated fat, sugars, starches, and additives). In our study, because of the large amount of industrial breads with unknown ingredients (approximately 3.7% of all industrial bread had fully known ingredients in cycle 2009–2010) and the very low consumption of processed breads when ingredients were reported (approximately 2.3% of industrial breads were processed in cycle 2009–2010), we ended up classifying all industrial bread as ultra-processed foods. This might overestimate ultra-processed food consumption.

Assessing Energy and Added Sugar Contents

For some handmade recipes, the sum of the “calorie intake per SR Code” (calculated by us) of all underlying SR Codes did not add up exactly to the “calorie intake per Food Code” (provided by NHANES). In these cases, the “final calorie intake per SR code” was calculated as follows:

Final calorie intake per SR code

$$= \text{NHANES Calorie intake per Food Code} * \left(\frac{\text{Calculated Calorie intake per SR code}}{\sum_{n=1}^{\infty} \text{Calculated Calorie intake per SR Code}} \right)$$

Appendix Table 1. NOVA Food Classification Based on the Extent and Purpose of Industrial Processing^{3,4}

| Food groups and definition | Examples |
|--|---|
| <p>1 Unprocessed or minimally processed foods Natural foods are those obtained directly from plants or animals (such as green leaves and fruits, or eggs and milk) and purchased for consumption without having undergone any alteration following their removal from nature. Minimally processed foods are natural foods that have been submitted to cleaning, removal of inedible or unwanted parts, fractioning, grinding, drying, fermentation, pasteurization, cooling, freezing, or other processes which do not add substances to the original food. Purpose of minimum processes is to preserve foods and make it possible to store them and, sometimes, also to decrease stages of food preparation (cleaning and removing inedible parts) or facilitate their digestion, or render them more palatable (grinding or fermentation).</p> | <p>Natural, packaged, cut, chilled or frozen vegetables, fruits, potatoes, cassava, and other roots and tubers; bulk or packaged white, parboiled and wholegrain rice; whole or separated corn; grains of wheat and other cereals that are dried, polished, or ground as grits or flour; dried or fresh pasta made from wheat flour and water; all types of beans; lentils, chickpeas, and other legumes; dried fruits, fruit juices fresh or pasteurized without added sugar or other substances; nuts, peanuts, and other oilseeds without salt or sugar; fresh and dried mushrooms and other fungi; fresh and dried herbs and spices; fresh, frozen, dried beef, pork, poultry and other meat and fish; pasteurized, ‘long-life’ and powdered milk; fresh and dried eggs, yoghurt without sugar; and tea, herbal infusions, coffee, and tap, spring and mineral water.</p> |
| <p>2 Processed culinary ingredients These are substances extracted from natural foods or from nature itself by processes such as pressing, grinding, crushing, pulverizing, and refining. Purpose of processing here is to obtain ingredients used in homes and restaurants kitchens to season and cook natural or minimally processed foods and to create with them varied and enjoyable dishes such as soups and broths, salads, rice and beans dishes, grilled or roasted vegetables and meat, and homemade breads, pies, cakes, and desserts.</p> | <p>Plant oils; coconut and animal fats (including butter and lard); table sugar, maple syrup (100%), molasses and honey; and table salt.</p> |
| <p>3 Processed foods These are relatively simple products manufactured essentially with the addition of salt or sugar or other substance of common culinary use, such as oil or vinegar, to natural or minimally processed foods. Purpose here is to prolong duration of foods and modify their palatability.</p> | <p>Canned and bottled vegetables, legumes or fruits; salted nuts or seeds; salted, smoked or cured meat or fish; canned sardine and tuna; and cheese.</p> |

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|--|---|
| <p>Alcoholic beverages produced by the fermentation of group 1 food items such as wine, beer and cider will be classified in this group.</p> | |
| <p>4 Ultra-processed foods These are food and drink products whose manufacture involves several stages and various processing techniques and ingredients, many of which are used exclusively by industry. Purpose of processing here is to create durable, accessible, convenient, and highly palatable, ready-to-drink, ready-to-eat, or ready-to-heat products typically consumed as snacks or desserts or as fast meals which replace dishes prepared from scratch. Alcoholic beverages produced by fermentation of group 1 food items followed by distillation and eventual addition of sugars or other substances, such as rum, whiskey, vodka, gin, and liqueurs, will be classified in this group.</p> | <p>Confectionery, soft drinks, sweetened juices and dairy drinks, powders for juices, sausages, chicken and fish nuggets or sticks and other pre-prepared frozen dishes, dried products such as cake mix, powdered soup, instant noodles, ready-seasonings, and an infinity of new products including packaged snacks, morning cereals, cereal bars, and ‘energy’ drinks. Sugar substitutes, sweeteners and all syrups (excluding 100% maple syrup). Breads and baked goods become ultra-processed products when, in addition to wheat flour, yeast, water, and salt, their ingredients include substances such as hydrogenated vegetable fat, sugar, starch, whey, emulsifiers, and other additives.</p> |

APPENDIX TEXT 3. DIETARY AMERICAN HEART ASSOCIATION (AHA) SCORES AND HEALTHY EATING INDEX SCORES

The American Heart Association (AHA) Diet Scores

To assess a summary diet score, we constructed a continuous diet score based on the AHA 2020 Strategic Impact Goal dietary targets, which have been significantly associated with cardiovascular and metabolic outcomes in multiple analyses.⁵ The primary dietary targets are fruits/vegetables, whole grains, fish and shellfish, nuts/legumes/seeds, sugar-sweetened beverages, processed meat, sodium, and saturated fat (Appendix Table 2). To best assess changes, we constructed a continuous score. Intake of each dietary item was scored from 0–10 (beneficial components) or 10–0 (harmful components) depending on whether consumption was encouraged or discouraged, respectively. For beneficial dietary components, individuals with zero intake received the lowest score (0). For harmful dietary components, the lowest score (0) was assigned to a higher level approximately equivalent to the 80th to 90th percentile of intake among U.S. adults and rounded to a practical value (e.g., 4500mg/d of sodium, one 50-g servings/d of processed meat, two 8-oz servings/d of sugar-sweetened beverages, and 15% energy of saturated fat). Optimal intake (i.e., at or greater than the target AHA level for encouraged foods/nutrients; or at or less than the target AHA level for discouraged foods/nutrients) was assigned a score of 10, and intermediate intake was scored linearly between 0 and 10. The scoring ranges are provided in Appendix Table 2. Details regarding the AHA score was published elsewhere.⁶

The Healthy Eating Index (HEI) 2015

The HEI is a measure of diet quality, independent of quantity, that can be used to assess compliance with the U.S. Dietary Guidelines for Americans (DGAs) and monitor changes in dietary patterns. The original HEI was released by the United States Department of Agriculture's (USDA) Center for Nutrition Policy and Promotion in 1995 and since then it has been significantly updated through a collaboration with the USDA and National Cancer Institute (NCI).⁷ The HEI-2015 is the latest iteration of the index and was designed to align with key dietary recommendations from the *2015-2020 DAGs*. The HEI-2015 contains 13 components that sum to a total maximum score of 100 points (Appendix Table 3). Each of the components is scored on a density basis out of 1,000 calories, with the exception of Fatty Acids, which is a ratio of unsaturated to saturated fatty acid. Currently, several methods associated with SAS macros that have been developed for use with the HEI are available to the public, and details can be found on the NCI website: <https://epi.grants.cancer.gov/hei/hei-scores-for-describing-dietary-intake.html>.

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Appendix Table 2. Dietary Components of the American Heart Association (AHA) 2020 Strategic Impact Goals and Scoring Standards

| Component | Points range | Scoring standard ^a | |
|---------------------------------------|--------------|-------------------------------|--------------------------|
| | | Max | Min |
| AHA score ^b | 0–80 | | |
| Fruits and vegetables ^c | 0–10 | ≥4.5 cups equiv. per day | 0 |
| Whole grains | 0–10 | ≥3 oz equiv. per day | 0 |
| Fish and shellfish | 0–10 | ≥1 oz equiv. per day | 0 |
| Nuts, seeds, and legumes ^d | 0–10 | ≥4 servings per day | 0 |
| Sugar-sweetened beverages | 10–0 | ≤5.14 fl oz per day | >16 fl per day |
| Processed meat | 10–0 | ≤0.5 oz equiv. per day | >1.764 oz equiv. per day |
| Sodium | 10–0 | ≤1500 mg per day | >4500 mg per day |
| Saturated fat | 10–0 | ≤7% energy | >15% energy |

^aIntakes between the minimum and maximum standards are scored proportionately.

^bAll AHA dietary variables were energy-adjusted to 2000kcal/d prior to analysis.

^cAccording to the AHA 2020 Goals, up to 3 cups/wk (0.42 cups/d) of starchy vegetables (e.g., potatoes, peas, corn) could be included; this maximum was incorporated into the analysis, with higher intake not contributing toward the score. 100% fruit juice could also be included; while its contribution was not capped in the original AHA 2020 Goals and thus not in our score, some organizations recommend no more than 1 serving/d of 100% fruit juice.

^dA serving of nuts, seeds and legumes is 1-oz equivalent of nuts and seeds or ½ cup of legume.

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Appendix Table 3. Dietary Components of Healthy Eating Index (HEI)-2015 and Scoring Standards

| Component | Points range | Scoring standard ^a | |
|---|--------------|--------------------------------|-------------------------------|
| | | Max | Min |
| HEI-2015 adequacy | | | |
| Total fruits ^b | 0–5 | ≥0.8 cup equiv. per 1,000 kcal | 0 |
| Whole fruits ^c | 0–5 | ≥0.4 cup equiv. per 1,000 kcal | 0 |
| Total vegetables ^d | 0–5 | ≥1.1 cup equiv. per 1,000 kcal | 0 |
| Greens and beans ^d | 0–5 | ≥0.2 cup equiv. per 1,000 kcal | 0 |
| Whole grains | 0–10 | ≥1.5 oz equiv. per 1,000 kcal | 0 |
| Dairy ^e | 0–10 | ≥1.3 cup equiv. per 1,000 kcal | 0 |
| Total protein foods ^f | 0–5 | ≥2.5 oz equiv. per 1,000 kcal | 0 |
| Seafood and plant proteins ^{e,g} | 0–5 | ≥0.8 oz equiv. per 1,000 kcal | 0 |
| Fatty acids ^h | 0–10 | (PUFAs + MUFAs)/SFAs ≥2.5 | (PUFAs + MUFAs)/SFAs ≤1.2 |
| HEI-2015 moderation | | | |
| Refined grains | 0–10 | ≤1.8 oz equiv. per 1,000 kcal | ≥4.3 oz equiv. per 1,000 kcal |
| Sodium | 0–10 | ≤1.1 grams per 1,000 kcal | ≥2.0 grams per 1,000 kcal |
| Added sugars | 0–10 | ≤6.5% of energy | ≥26% of energy |
| Saturated fats | 0–10 | ≤8% of energy | ≥16% of energy |

^aIntakes between the minimum and maximum standards are scored proportionately.

^bIncludes 100% fruit juice.

^cIncludes all forms except juice.

^dIncludes legumes (beans and peas).

^eIncludes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.

^fIncludes legumes (beans and peas).

^gIncludes seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).

^hRatios of poly- and monosaturated fatty acids (PUFAs and MUFAs) to saturated fatty acids (SFAs).

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Appendix Table 4. Associations of Quintiles of the Contribution of Ultra-Processed Foods to Total Energy Intake With Healthy Eating Index -2015, NHANES 2015–2016 and 2017–2018

| HEI-2015 score | Regression coefficients (95% CI) | | | | | Predicted margins (95% CI) | | | | |
|----------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|----------------------|----------------------|----------------------|----------------------|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q1 | Q2 | Q3 | Q4 | Q5 |
| Children | | | | | | | | | | |
| Total score | 0.0 (ref) | -5.39 (-6.81, -3.97) | -8.43 (-10.0, -6.83) | -10.9 (-12.9, -9.02) | -16.5 (-18.2, -14.8) | 57.8 (56.3, 59.2) | 52.4 (51.1, 53.6) | 49.3 (48.2, 50.5) | 46.8 (45.3, 48.3) | 41.3 (40.4, 42.1) |
| Component scores | | | | | | | | | | |
| Adequacy components | | | | | | | | | | |
| Total vegetables | 0.0 (ref) | -0.46 (-0.66, -0.26) | -0.77 (-0.96, -0.57) | -0.99 (-1.18, -0.79) | -1.19 (-1.38, -1.01) | 2.93 (2.78, 3.08) | 2.47 (2.31, 2.62) | 2.16 (2.02, 2.30) | 1.94 (1.83, 2.05) | 1.73 (1.65, 1.82) |
| Greens and beans | 0.0 (ref) | -0.59 (-0.84, -0.34) | -0.96 (-1.26, -0.66) | -1.24 (-1.50, -0.99) | -1.62 (-1.88, -1.36) | 2.08 (1.85, 2.31) | 1.49 (1.31, 1.67) | 1.13 (0.95, 1.30) | 0.84 (0.70, 0.98) | 0.46 (0.33, 0.60) |
| Total fruits | 0.0 (ref) | -0.27 (-0.46, -0.08) | -0.56 (-0.79, -0.33) | -0.78 (-1.04, -0.51) | -1.64 (-1.87, -1.40) | 3.37 (3.19, 3.55) | 3.10 (2.94, 3.26) | 2.81 (2.58, 3.05) | 2.60 (2.36, 2.84) | 1.74 (1.55, 1.92) |
| Whole fruits | 0.0 (ref) | -0.38 (-0.60, -0.17) | -0.65 (-0.86, -0.44) | -0.74 (-1.06, -0.43) | -1.61 (-1.88, -1.33) | 3.37 (3.18, 3.56) | 2.99 (2.74, 3.24) | 2.72 (2.53, 2.91) | 2.63 (2.33, 2.92) | 1.76 (1.56, 1.97) |
| Whole grains | 0.0 (ref) | -0.08 (-0.41, 0.25) | 0.15 (-0.49, 0.19) | -0.19 (-0.68, 0.30) | -0.84 (-1.21, -0.48) | 3.34 (3.04, 3.65) | 3.26 (2.90, 3.63) | 3.20 (2.94, 3.45) | 3.15 (2.75, 3.55) | 2.50 (2.27, 2.73) |
| Total dairy | 0.0 (ref) | -0.18 (-0.62, 0.25) | 0.09 (-0.30, 0.47) | -0.08 (-0.46, 0.31) | -0.69 (-1.07, -0.31) | 7.03 (6.64, 7.43) | 6.85 (6.52, 7.18) | 7.12 (6.91, 7.33) | 6.96 (6.64, 7.27) | 6.34 (6.04, 6.65) |
| Total protein foods | 0.0 (ref) | -0.40 (-0.56, -0.25) | -0.57 (-0.73, -0.41) | -0.90 (-1.03, -0.76) | -1.27 (-1.43, -1.12) | 4.50 (4.40, 4.60) | 4.10 (3.97, 4.23) | 3.93 (3.78, 4.08) | 3.61 (3.49, 3.72) | 3.23 (3.09, 3.36) |
| Seafood and plant protein | 0.0 (ref) | -0.33 | -0.67 | -0.92 | -1.52 | 2.65 | 2.32 | 1.98 | 1.73 | 1.13 |

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|------------------------------|-------|----------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|--------------|
| | | (-0.61, -0.06) | (-0.95, 0.39) | (-1.22, 0.61) | (-1.78, 1.26) | (2.42, 2.87) | (2.09, 2.54) | (1.79, 2.17) | (1.55, 1.91) | (0.98, 1.28) |
| (PUFAs+MUFAs)/SFAs | 0.0 | -0.19 | -0.25 | -0.19 | 0.07 | 3.77 | 3.58 | 3.52 | 3.58 | 3.84 |
| | (ref) | (-0.74, 0.36) | (-0.72, 0.23) | (-0.70, 0.32) | (-0.43, 0.58) | (3.36, 4.17) | (3.28, 3.87) | (3.24, 3.80) | (3.24, 3.92) | (3.50, 4.18) |
| Moderation components | | | | | | | | | | |
| Sodium | 0.0 | 0.03 | -0.03 | 0.32 | 0.06 | 4.64 | 4.67 | 4.61 | 4.96 | 4.70 |
| | (ref) | (-0.29, 0.36) | (-0.43, 0.37) | (-0.18, 0.83) | (-0.35, 0.47) | (4.29, 4.99) | (4.36, 4.99) | (4.36, 4.85) | (4.64, 5.28) | (4.45, 4.94) |
| Refined grains | 0.0 | -1.08 | -1.47 | -2.03 | -2.39 | 6.43 | 5.34 | 4.95 | 4.40 | 4.04 |
| | (ref) | (-1.48, 0.68) | (-1.86, 1.09) | (-2.44, 1.62) | (-2.84, 1.93) | (6.07, 6.78) | (5.03, 5.66) | (4.59, 5.31) | (4.15, 4.64) | (3.72, 4.36) |
| Saturated fat | 0.0 | -0.43 | -0.38 | -0.58 | -0.65 | 5.30 | 4.87 | 4.92 | 4.72 | 4.65 |
| | (ref) | (-1.06, 0.19) | (-0.98, 0.22) | (-1.16, 0.01) | (-1.22, 0.07) | (4.75, 5.85) | (4.52, 5.21) | (4.56, 5.29) | (4.41, 5.03) | (4.40, 4.90) |
| Added sugars | 0.0 | -1.02 | -2.06 | -2.64 | -3.20 | 8.35 | 7.33 | 6.28 | 5.71 | 5.15 |
| | (ref) | (-1.24, 0.79) | (-2.36, 1.76) | (-2.99, 2.30) | (-3.48, 2.91) | (8.13, 8.56) | (7.13, 7.53) | (6.01, 6.56) | (5.42, 5.99) | (4.89, 5.40) |
| Adults | | | | | | | | | | |
| Total score | 0.0 | -4.83 | -8.18 | -11.4 | -16.3 | 61.0 | 56.2 | 52.9 | 49.7 | 44.7 |
| | (ref) | (-5.93, 3.73) | (-9.41, 6.96) | (-12.7, 10.0) | (-17.5, 15.2) | (59.9, 62.2) | (55.3, 57.2) | (51.7, 54.0) | (48.4, 50.9) | (43.9, 45.5) |
| Component scores | | | | | | | | | | |
| Adequacy components | | | | | | | | | | |
| Total vegetables | 0.0 | -0.26 | -0.55 | -0.79 | -1.22 | 3.82 | 3.56 | 3.26 | 3.02 | 2.60 |
| | (ref) | (-0.41, 0.10) | (-0.70, 0.40) | (-0.96, 0.62) | (-1.39, 1.05) | (3.70, 3.93) | (3.45, 3.67) | (3.14, 3.38) | (2.88, 3.17) | (2.50, 2.70) |
| Greens and beans | 0.0 | -0.41 | -0.85 | -1.03 | -1.69 | 2.80 | 2.39 | 1.95 | 1.77 | 1.11 |
| | (ref) | (-0.61, 0.21) | (-1.11, 0.58) | (-1.23, 0.83) | (-1.88, 1.50) | (2.64, 2.95) | (2.24, 2.54) | (1.77, 2.13) | (1.62, 1.92) | (0.99, 1.23) |
| Total fruits | 0.0 | -0.49 | -0.63 | -0.93 | -1.43 | 2.88 | 2.39 | 2.25 | 1.95 | 1.45 |
| | (ref) | (-0.72, 0.26) | (-0.85, 0.41) | (-1.14, 0.71) | (-1.65, 1.21) | (2.71, 3.06) | (2.23, 2.55) | (2.07, 2.43) | (1.79, 2.11) | (1.33, 1.57) |

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| Whole fruits | 0.0 (ref) | -0.39 (-0.62, -0.17) | -0.62 (-0.81, -0.43) | -0.79 (-0.98, -0.60) | -1.40 (-1.64, -1.17) | 3.04 (2.85, 3.23) | 2.65 (2.46, 2.83) | 2.42 (2.22, 2.62) | 2.25 (2.09, 2.42) | 1.64 (1.48, 1.80) |
| Whole grains | 0.0 (ref) | 0.004 (-0.35, 0.35) | -0.21 (-0.62, 0.20) | -0.50 (-0.78, -0.23) | -0.68 (-0.99, -0.37) | 3.03 (2.75, 3.31) | 3.04 (2.82, 3.25) | 2.82 (2.53, 3.11) | 2.53 (2.30, 2.77) | 2.36 (2.07, 2.64) |
| Total dairy | 0.0 (ref) | 0.37 (-0.01, 0.76) | 0.75 (0.43, 1.06) | 0.49 (0.19, 0.79) | 0.37 (-0.03, 0.76) | 4.67 (4.38, 4.96) | 5.04 (4.72, 5.37) | 5.42 (5.20, 5.64) | 5.16 (4.91, 5.41) | 5.04 (4.79, 5.28) |
| Total protein foods | 0.0 (ref) | -0.07 (-0.14, 0.01) | -0.24 (-0.32, -0.16) | -0.28 (-0.37, -0.20) | -0.68 (-0.79, -0.57) | 4.75 (4.71, 4.79) | 4.68 (4.61, 4.75) | 4.51 (4.44, 4.58) | 4.47 (4.38, 4.56) | 4.07 (3.99, 4.16) |
| Seafood and plant protein | 0.0 (ref) | -0.23 (-0.44, -0.01) | -0.69 (-0.93, -0.46) | -0.81 (-1.07, -0.55) | -1.48 (-1.71, -1.24) | 3.54 (3.36, 3.72) | 3.31 (3.17, 3.45) | 2.84 (2.65, 3.04) | 2.73 (2.53, 2.92) | 2.06 (1.92, 2.20) |
| (PUFAs+MUFAs)/SFAs | 0.0 (ref) | -0.65 (-1.10, -0.20) | -0.90 (-1.30, -0.50) | -0.93 (-1.26, -0.61) | -1.02 (-1.41, -0.63) | 5.59 (5.28, 5.89) | 4.94 (4.60, 5.28) | 4.69 (4.43, 4.95) | 4.65 (4.39, 4.92) | 4.57 (4.32, 4.82) |
| Moderation components | | | | | | | | | | |
| Sodium | 0.0 (ref) | -0.002 (-0.36, 0.35) | -0.07 (-0.44, 0.30) | -0.005 (-0.38, 0.37) | -0.10 (-0.36, 0.38) | 4.09 (3.85, 4.33) | 4.09 (3.78, 4.39) | 4.02 (3.75, 4.28) | 4.08 (3.83, 4.34) | 4.10 (3.85, 4.35) |
| Refined grains | 0.0 (ref) | -0.81 (-1.12, -0.50) | -1.39 (-1.80, -0.98) | -1.66 (-1.97, -1.35) | -2.17 (-2.45, -1.89) | 7.61 (7.37, 7.85) | 6.80 (6.60, 7.0) | 6.22 (5.92, 6.52) | 5.95 (5.72, 6.18) | 5.44 (5.19, 5.68) |
| Saturated fat | 0.0 (ref) | -1.02 (-1.41, -0.63) | -1.10 (-1.52, -0.68) | -1.46 (-1.86, -1.05) | -1.55 (-1.95, -1.16) | 6.40 (6.08, 6.72) | 5.38 (5.12, 5.65) | 5.30 (5.04, 5.56) | 4.94 (4.69, 5.20) | 4.84 (4.61, 5.20) |
| Added sugars | 0.0 (ref) | -0.88 (-1.15, -0.60) | -1.66 (-1.91, -1.41) | -2.67 (-2.96, -2.38) | -3.39 (-3.78, -2.98) | 8.83 (8.62, 9.04) | 7.95 (7.75, 8.16) | 7.17 (6.93, 7.40) | 6.16 (5.91, 6.41) | 5.44 (5.15, 5.73) |

^aData were weighted to be nationally representative, and adjusted for age, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and others), education (less than high school, high school graduate or GED, some college, or college

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graduate or above), ratio of family income to poverty (<1.30, 1.30–1.849, 1.85–2.99, and ≥ 3.0), and BMI categories (underweight, normal weight, overweight, and obese). Individuals with missing data on education (n=242 for children, n=10 for adults) and income (n=461 for children, n=1,038 for adults) were excluded.

PUFAs, polysaturated fatty acids; MUFAs, monosaturated fatty acids; SFAs, saturated fatty acids; NHANES, National Health and Nutrition Examination Survey; HEI, Healthy Eating Index.

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Appendix Table 5. Weighted Associations of Quintiles of the Contribution of Ultra-Processed Foods to Total Energy Intake with Poor Diet Quality, NHANES 2015–2016 and 2017–2018^a

| Overall and subgroups | Children | | | Adults | | |
|-----------------------|-------------|-------------------|-------------------------------|-------------|-------------------|-------------------------------|
| | Sample size | OR (95% CI) | Predicted margins, % (95% CI) | Sample size | OR (95% CI) | Predicted margins, % (95% CI) |
| Overall | | | | | | |
| Ultra-processed food | | | | | | |
| Q1 (lowest) | 1,157 | 1 (ref) | 31.3 (26.2, 36.5) | 2,277 | 1 (ref) | 18.1 (14.3, 22.0) |
| Q2 | 1,063 | 1.75 (1.32, 2.33) | 43.9 (38.2, 49.5) | 1,945 | 1.94 (1.49, 2.52) | 29.4 (25.7, 33.0) |
| Q3 | 998 | 2.07 (1.50, 2.86) | 47.8 (42.2, 53.3) | 1,877 | 3.04 (2.20, 4.20) | 38.9 (34.0, 43.8) |
| Q4 | 985 | 2.92 (2.08, 4.10) | 55.9 (50.2, 61.7) | 1,780 | 4.47 (3.31, 6.03) | 47.8 (43.1, 52.4) |
| Q5 (highest) | 1,077 | 5.96 (4.62, 7.68) | 71.6 (68.1, 75.1) | 1,879 | 7.46 (5.70, 9.77) | 59.7 (55.3, 64.1) |
| Female | | | | | | |
| Q1 (lowest) | 605 | 1 (ref) | 30.3 (23.3, 37.4) | 1,220 | 1 (ref) | 16.9 (13.3, 20.6) |
| Q2 | 551 | 1.54 (1.08, 2.20) | 39.6 (33.1, 46.1) | 1,020 | 1.88 (1.30, 2.71) | 27.1 (22.2, 32.1) |
| Q3 | 501 | 1.99 (1.34, 2.95) | 45.5 (38.5, 52.4) | 950 | 2.98 (2.02, 4.38) | 36.5 (30.4, 42.6) |
| Q4 | 460 | 2.88 (1.81, 4.59) | 54.2 (46.0, 62.5) | 898 | 3.82 (2.63, 5.55) | 42.1 (36.2, 48.0) |
| Q5 (highest) | 527 | 6.18 (4.20, 9.10) | 70.9 (65.6, 76.3) | 948 | 6.07 (4.58, 8.05) | 52.9 (47.7, 58.0) |
| Male | | | | | | |
| Q1 (lowest) | 552 | 1 (ref) | 31.9 (24.7, 39.2) | 1,057 | 1 (ref) | 19.5 (14.2, 24.7) |

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| | | | | | | |
|---------------------------|-----|-------------------|-------------------|-----|-------------------|-------------------|
| Q2 | 512 | 2.05 (1.42, 2.95) | 48.3 (41.8, 54.7) | 925 | 1.97 (1.34, 2.91) | 31.7 (26.6, 36.8) |
| Q3 | 497 | 2.20 (1.38, 3.52) | 50.0 (42.9, 57.1) | 927 | 3.10 (2.10, 4.58) | 41.7 (35.6, 47.8) |
| Q4 | 525 | 3.07 (2.02, 4.67) | 57.9 (51.8, 64.1) | 882 | 5.13 (3.68, 7.14) | 53.6 (47.8, 59.3) |
| Q5 (highest) | 550 | 5.96 (4.0, 8.86) | 72.3 (67.3, 77.2) | 931 | 9.25 (6.15, 13.9) | 66.9 (61.5, 72.3) |
| Non-Hispanic White | | | | | | |
| Q1 (lowest) | 253 | 1 (ref) | 37.7 (29.4, 45.9) | 531 | 1 (ref) | 19.3 (13.4, 25.2) |
| Q2 | 321 | 1.31 (0.84, 2.03) | 43.8 (35.0, 52.5) | 647 | 1.82 (1.19, 2.80) | 29.6 (24.1, 35.2) |
| Q3 | 341 | 1.40 (0.92, 2.12) | 45.3 (38.4, 52.2) | 680 | 2.81 (1.77, 4.46) | 38.8 (32.6, 45.0) |
| Q4 | 328 | 1.97 (1.18, 3.31) | 53.4 (45.6, 61.2) | 740 | 4.17 (2.74, 6.35) | 47.8 (41.6, 53.9) |
| Q5 (highest) | 385 | 4.24 (2.88, 6.26) | 70.3 (65.1, 75.5) | 807 | 6.05 (4.20, 8.70) | 56.4 (50.3, 62.5) |
| Non-Hispanic Black | | | | | | |
| Q1 (lowest) | 179 | 1 (ref) | 34.2 (22.6, 45.8) | 363 | 1 (ref) | 24.0 (16.6, 31.4) |
| Q2 | 193 | 1.76 (0.94, 3.29) | 47.0 (39.6, 54.4) | 368 | 1.95 (1.13, 3.36) | 37.4 (29.5, 45.2) |
| Q3 | 236 | 3.37 (2.01, 5.66) | 62.1 (54.2, 69.7) | 426 | 2.98 (1.91, 4.67) | 47.2 (39.7, 54.7) |
| Q4 | 247 | 3.23 (1.46, 7.13) | 61.1 (50.6, 71.7) | 457 | 3.73 (2.41, 5.78) | 52.5 (46.8, 58.3) |
| Q5 (highest) | 330 | 7.02 (3.92, 12.6) | 76.6 (70.9, 82.4) | 574 | 8.03 (5.37, 12.0) | 69.6 (64.9, 74.3) |
| Hispanic | | | | | | |
| Q1 (lowest) | 416 | 1 (ref) | 25.1 (17.9, 32.4) | 701 | 1 (ref) | 16.4 (13.9, 18.9) |

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| | | | | | | |
|--|-----|-------------------|-------------------|-----|-------------------|-------------------|
| Q2 | 370 | 2.26 (1.40, 3.65) | 42.5 (36.9, 48.2) | 606 | 2.32 (1.71, 3.15) | 30.9 (25.3, 36.4) |
| Q3 | 270 | 2.64 (1.73, 4.03) | 46.2 (36.8, 55.6) | 559 | 3.45 (2.45, 4.85) | 39.7 (34.1, 45.3) |
| Q4 | 263 | 4.49 (2.83, 7.10) | 58.9 (48.4, 69.5) | 405 | 6.03 (4.07, 8.93) | 53.1 (44.3, 62.0) |
| Q5 (highest) | 246 | 9.46 (5.11, 17.5) | 74.9 (65.9, 83.6) | 329 | 12.1 (8.09, 18.0) | 69.1 (62.3, 75.8) |
| Others | | | | | | |
| Q1 (lowest) | 309 | 1 (ref) | 23.7 (16.7, 30.7) | 682 | 1 (ref) | 11.8 (8.15, 15.4) |
| Q2 | 179 | 2.39 (1.56, 3.66) | 41.6 (30.2, 52.9) | 324 | 1.70 (1.02, 2.85) | 18.0 (13.1, 22.8) |
| Q3 | 151 | 3.11 (1.42, 6.82) | 47.7 (32.4, 63.0) | 212 | 3.58 (2.10, 6.09) | 30.1 (22.0, 38.1) |
| Q4 | 147 | 4.79 (2.74, 8.37) | 57.8 (47.2, 68.5) | 178 | 4.43 (2.87, 6.83) | 34.2 (26.0, 42.4) |
| Q5 (highest) | 116 | 7.01 (4.20, 11.7) | 66.3 (58.4, 74.1) | 169 | 14.1 (7.68, 26.0) | 59.2 (49.0, 69.5) |
| Less than high school graduate | | | | | | |
| Q1 (lowest) | 280 | 1 (ref) | 25.1 (14.5, 35.7) | 549 | 1 (ref) | 22.7 (17.0, 28.3) |
| Q2 | 248 | 2.95 (1.54, 5.65) | 48.8 (40.4, 57.3) | 419 | 2.0 (1.15, 3.49) | 36.0 (27.3, 44.6) |
| Q3 | 220 | 3.28 (1.64, 6.58) | 51.4 (40.1, 62.7) | 405 | 3.42 (2.13, 5.50) | 48.0 (38.9, 57.2) |
| Q4 | 158 | 7.27 (4.16, 12.7) | 69.5 (60.3, 78.8) | 329 | 5.66 (3.60, 8.89) | 59.6 (51.9, 67.2) |
| Q5 (highest) | 175 | 12.7 (6.11, 26.3) | 80.0 (71.0, 88.3) | 339 | 10.6 (6.05, 18.6) | 72.5 (64.9, 80.2) |
| High school graduate or GED (or some college for child^b) | | | | | | |

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| | | | | | | |
|----------------------------------|-----|-------------------|-------------------|-----|-------------------|-------------------|
| Q1 (lowest) | 502 | 1 (ref) | 36.1 (28.7, 43.5) | 417 | 1 (ref) | 22.2 (14.2, 30.1) |
| Q2 | 549 | 1.69 (1.19, 2.40) | 48.4 (41.4, 55.3) | 412 | 2.24 (1.39, 3.61) | 38.5 (31.0, 45.9) |
| Q3 | 525 | 1.75 (1.23, 2.48) | 49.2 (44.0, 54.4) | 441 | 3.35 (1.88, 5.97) | 48.0 (38.4, 57.5) |
| Q4 | 569 | 2.54 (1.64, 3.95) | 58.2 (51.6, 64.9) | 445 | 4.50 (2.45, 8.26) | 55.1 (46.5, 63.7) |
| Q5 (highest) | 689 | 4.83 (3.23, 7.21) | 72.2 (68.2, 76.3) | 539 | 8.26 (4.98, 13.7) | 68.9 (60.8, 76.9) |
| Some college | | | | | | |
| Q1 (lowest) | | | | 565 | 1 (ref) | 21.7 (15.6, 27.7) |
| Q2 | | | | 564 | 1.44 (0.93, 2.23) | 28.4 (21.8, 35.0) |
| Q3 | | | | 578 | 2.55 (1.63, 4.0) | 40.8 (33.8, 47.8) |
| Q4 | | | | 646 | 3.53 (2.16, 5.77) | 48.6 (40.1, 57.0) |
| Q5 (highest) | | | | 693 | 5.71 (4.09, 7.98) | 60.1 (53.7, 66.5) |
| College graduate or above | | | | | | |
| Q1 (lowest) | 302 | 1 (ref) | 27.7 (18.9, 36.5) | 741 | 1 (ref) | 10.8 (6.59, 15.0) |
| Q2 | 213 | 1.25 (0.68, 2.32) | 32.0 (23.8, 40.3) | 548 | 2.24 (1.26, 3.97) | 20.7 (15.7, 25.7) |
| Q3 | 210 | 2.01 (0.98, 4.10) | 42.2 (30.6, 53.8) | 452 | 3.29 (1.72, 6.29) | 27.3 (20.5, 34.1) |
| Q4 | 219 | 2.27 (1.17, 4.39) | 44.9 (35.1, 54.8) | 359 | 5.23 (2.98, 9.18) | 36.6 (29.7, 43.5) |
| Q5 (highest) | 179 | 6.19 (3.20, 12.0) | 67.3 (56.5, 78.1) | 307 | 7.38 (4.56, 11.9) | 44.2 (36.5, 51.9) |

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| Ratio of family income to poverty level | | | | | | |
|---|-----|-------------------|-------------------|-----|-------------------|-------------------|
| <1.30 | | | | | | |
| Q1 (lowest) | 398 | 1 (ref) | 34.1 (25.6, 42.5) | 610 | 1 (ref) | 22.9 (15.4, 30.4) |
| Q2 | 403 | 1.82 (1.25, 2.66) | 48.2 (40.8, 55.7) | 498 | 1.88 (1.11, 3.17) | 35.4 (29.4, 41.5) |
| Q3 | 348 | 1.91 (1.23, 2.96) | 49.3 (40.6, 58.0) | 460 | 2.92 (1.80, 4.72) | 45.6 (37.7, 53.5) |
| Q4 | 352 | 3.87 (2.33, 6.44) | 66.1 (58.0, 74.2) | 501 | 4.73 (3.01, 7.41) | 57.1 (49.9, 64.4) |
| Q5 (highest) | 436 | 6.84 (4.46, 10.5) | 77.3 (71.3, 82.3) | 535 | 9.64 (6.04, 15.4) | 72.6 (67.0, 78.3) |
| 1.30 to 1.849 | | | | | | |
| Q1 (lowest) | 156 | 1 (ref) | 26.7 (17.9, 35.6) | 281 | 1 (ref) | 12.3 (8.51, 16.0) |
| Q2 | 142 | 2.27 (1.35, 3.81) | 44.2 (35.7, 52.7) | 243 | 3.14 (1.99, 4.96) | 29.9 (23.4, 36.3) |
| Q3 | 138 | 2.64 (1.32, 5.26) | 47.8 (34.4, 61.1) | 254 | 4.79 (2.78, 8.26) | 39.0 (30.7, 47.2) |
| Q4 | 130 | 5.06 (2.69, 9.52) | 62.8 (55.5, 70.1) | 218 | 8.92 (4.51, 17.6) | 53.6 (40.1, 67.2) |
| Q5 (highest) | 162 | 6.07 (2.82, 13.1) | 66.7 (58.6, 74.9) | 297 | 16.9 (10.9, 26.4) | 68.1 (57.8, 78.3) |
| 1.85 to 2.99 | | | | | | |
| Q1 (lowest) | 194 | 1 (ref) | 35.2 (21.4, 49.1) | 318 | 1 (ref) | 16.3 (9.72, 22.8) |
| Q2 | 179 | 1.43 (0.73, 2.77) | 43.2 (33.8, 52.5) | 341 | 2.53 (1.58, 4.05) | 31.9 (23.0, 40.0) |
| Q3 | 169 | 1.85 (0.82, 4.21) | 49.3 (40.6, 57.9) | 372 | 3.87 (2.07, 7.23) | 41.1 (33.7, 48.6) |
| Q4 | 195 | 3.02 (1.36, 6.71) | 60.5 (51.3, 69.8) | 342 | 5.96 (3.25, 10.9) | 51.1 (42.9, 59.4) |

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| | | | | | | |
|-----------------------|-----|-------------------|-------------------|-----|-------------------|-------------------|
| Q5 (highest) | 180 | 5.08 (2.70, 9.59) | 71.5 (62.9, 80.0) | 363 | 12.1 (6.95, 21.1) | 67.0 (60.9, 73.1) |
| ≥ 3.0 | | | | | | |
| Q1 (lowest) | 284 | 1 (ref) | 29.2 (19.5, 38.9) | 774 | 1 (ref) | 17.6 (12.4, 22.9) |
| Q2 | 243 | 1.66 (0.93, 2.97) | 39.9 (30.0, 49.7) | 660 | 1.67 (1.06, 2.63) | 25.9 (20.7, 31.1) |
| Q3 | 245 | 2.08 (1.09, 3.98) | 45.0 (35.1, 54.9) | 593 | 2.68 (1.67, 4.31) | 35.3 (27.7, 42.9) |
| Q4 | 244 | 1.99 (1.02, 3.89) | 44.0 (34.1, 53.8) | 559 | 3.53 (2.34, 5.32) | 41.4 (35.9, 46.8) |
| Q5 (highest) | 221 | 5.81 (3.21, 10.5) | 68.1 (58.8, 77.3) | 501 | 4.80 (3.20, 7.20) | 48.5 (43.1, 53.9) |
| BMI categories | | | | | | |
| Underweight | | | | | | |
| Q1 (lowest) | 41 | 1 (ref) | 18.0 (0, 39.1) | 35 | 1 (ref) | 22.7 (0, 46.1) |
| Q2 | 31 | 4.37 (0.60, 31.7) | 43.8 (20.2, 67.5) | 22 | 3.79 (0.41, 34.6) | 46.2 (12.9, 79.5) |
| Q3 | 29 | 5.37 (0.72, 40.0) | 48.2 (23.3, 73.1) | 30 | 1.55 (0.20, 11.7) | 29.7 (2.18, 57.2) |
| Q4 | 23 | 6.86 (0.99, 47.6) | 53.4 (26.9, 79.8) | 26 | 4.42 (0.94, 20.9) | 49.2 (26.8, 71.6) |
| Q5 (highest) | 31 | 8.07 (1.08, 60.4) | 56.8 (34.0, 79.6) | 34 | 12.4 (2.43, 63.3) | 68.1 (43.1, 93.2) |
| Normal weight | | | | | | |
| Q1 (lowest) | 700 | 1 (ref) | 30.9 (25.5, 36.3) | 667 | 1 (ref) | 14.9 (9.93, 19.9) |
| Q2 | 623 | 1.64 (1.14, 2.37) | 42.0 (34.4, 49.6) | 524 | 2.18 (1.28, 3.70) | 26.2 (20.5, 31.9) |
| Q3 | 574 | 1.83 (1.24, 2.72) | 44.6 (36.7, 52.5) | 432 | 4.47 (2.57, 7.78) | 40.1 (32.4, 47.8) |
| Q4 | 574 | 2.57 (1.64, 4.02) | 52.7 (45.0, 60.4) | 361 | 5.02 (2.79, 9.03) | 42.6 (34.3, 50.9) |

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| | | | | | | |
|-------------------|-----|-------------------|-------------------|-----|-------------------|-------------------|
| Q5 (highest) | 627 | 6.53 (4.89, 8.70) | 73.3 (69.3, 77.4) | 390 | 7.47 (4.39, 12.7) | 51.1 (42.8, 59.4) |
| Overweight | | | | | | |
| Q1 (lowest) | 164 | 1 (ref) | 36.3 (22.4, 50.1) | 801 | 1 (ref) | 17.1 (11.8, 22.4) |
| Q2 | 174 | 1.03 (0.54, 1.97) | 36.9 (26.9, 46.8) | 639 | 1.69 (1.08, 2.64) | 25.5 (18.8, 32.1) |
| Q3 | 179 | 1.59 (0.69, 3.70) | 46.4 (38.1, 54.7) | 598 | 3.21 (2.12, 4.87) | 38.6 (32.2, 45.0) |
| Q4 | 166 | 2.57 (1.16, 5.69) | 57.0 (46.7, 67.4) | 545 | 4.09 (2.78, 6.02) | 44.1 (37.4, 50.8) |
| Q5 (highest) | 168 | 3.45 (1.54, 7.73) | 63.4 (56.6, 70.2) | 515 | 7.24 (4.33, 12.1) | 57.4 (49.7, 65.2) |
| Obese | | | | | | |
| Q1 (lowest) | 252 | 1 (ref) | 30.3 (22.9, 37.6) | 774 | 1 (ref) | 21.1 (15.3, 26.9) |
| Q2 | 235 | 2.78 (1.68, 4.61) | 53.5 (45.1, 61.9) | 760 | 1.91 (1.22, 2.99) | 33.4 (27.4, 39.4) |
| Q3 | 216 | 3.55 (1.93, 6.53) | 59.2 (49.5, 69.0) | 817 | 2.53 (1.64, 3.89) | 39.6 (33.8, 45.4) |
| Q4 | 222 | 4.64 (2.74, 7.86) | 65.2 (55.0, 75.4) | 848 | 4.42 (2.88, 6.77) | 52.9 (47.3, 58.4) |
| Q5 (highest) | 251 | 7.49 (3.93, 14.2) | 74.8 (66.1, 83.5) | 940 | 7.30 (5.20, 10.2) | 64.5 (60.0, 69.0) |

^aAll models adjusted for age, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and others), education (less than high school, high school graduate or GED, some college, or college graduate or above), ratio of family income to poverty (<1.30, 1.30–1.849, 1.85–2.99, and ≥3.0), and BMI categories (underweight, normal weight, overweight and obese). Individuals with missing data on education (n=242 for children, n=10 for adults) and income (n=461 for children, n=1,038 for adults) were excluded.

^bFor children, education refers to parental/household educational levels. Due to the existing categorization in NHANES 2017–2018 (less than high school, high school graduate or GED or some college, and college graduate and above), we combined the high school graduate or GED and some college together for previous NHANES cycle 2015–2016.

NHANES, National Health and Nutrition Examination Survey.

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Appendix Table 6. Weighted Association of Major Food Groups and Nutrients with Quintiles of the Contribution of Ultra-Processed Foods to Total Energy Intake After Adjustment for Age, Sex, Race/Ethnicity, Parental Education, Income and BMI Among U.S. Children, NHANES 2015–2018^a

| Variables | Regression coefficients (95% CI) | | | | | Predicted margins (95% CI) | | | | |
|--------------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|----------------------|----------------------|----------------------|----------------------|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q1 | Q2 | Q3 | Q4 | Q5 |
| Foods ^b | | | | | | | | | | |
| Total fruits, servings/day | 0.0 (ref) | -0.25 (-0.42, -0.08) | -0.42 (-0.64, -0.21) | -0.54 (-0.74, -0.35) | -0.94 (-1.10, -0.77) | 1.51 (1.34, 1.67) | 1.26 (1.12, 1.39) | 1.09 (0.92, 1.25) | 0.96 (0.82, 1.11) | 0.57 (0.50, 0.64) |
| Intact/whole fruit | 0.0 (ref) | -0.28 (-0.41, -0.15) | -0.39 (-0.53, -0.25) | -0.41 (-0.59, -0.23) | -0.72 (-0.86, -0.58) | 1.08 (0.94, 1.22) | 0.80 (0.68, 0.92) | 0.69 (0.61, 0.77) | 0.68 (0.52, 0.83) | 0.37 (0.31, 0.42) |
| 100% fruit juice | 0.0 (ref) | -0.01 (-0.11, 0.09) | -0.13 (-0.27, 0.001) | -0.24 (-0.35, -0.12) | -0.34 (-0.43, -0.25) | 0.58 (0.48, 0.68) | 0.57 (0.47, 0.66) | 0.44 (0.35, 0.54) | 0.34 (0.29, 0.39) | 0.24 (0.19, 0.28) |
| Total vegetables, servings/day | 0.0 (ref) | -0.21 (-0.34, -0.08) | -0.40 (-0.51, -0.29) | -0.46 (-0.59, -0.32) | -0.53 (-0.66, -0.41) | 1.26 (1.16, 1.37) | 1.05 (0.97, 1.14) | 0.86 (0.80, 0.92) | 0.81 (0.74, 0.87) | 0.73 (0.68, 0.77) |
| Whole grains | 0.0 (ref) | -0.004 (-0.16, 0.15) | 0.04 (-0.13, 0.21) | -0.03 (-0.22, 0.16) | -0.21 (-0.33, -0.08) | 0.95 (0.84, 1.07) | 0.95 (0.81, 1.08) | 0.99 (0.88, 1.11) | 0.92 (0.78, 1.07) | 0.75 (0.64, 0.85) |
| Refined grains | 0.0 (ref) | 0.74 (0.40, 1.09) | 0.79 (0.44, 1.15) | 1.30 (0.96, 1.64) | 1.54 (1.18, 1.89) | 5.40 (5.16, 5.63) | 6.14 (5.89, 6.39) | 6.19 (5.92, 6.46) | 6.70 (6.49, 6.91) | 6.93 (6.68, 7.19) |
| Nuts and seeds, servings/day | 0.0 (ref) | -0.12 (-0.28, 0.03) | -0.20 (-0.32, -0.08) | -0.32 (-0.44, -0.20) | -0.41 (-0.50, -0.31) | 0.63 (0.53, 0.73) | 0.50 (0.37, 0.64) | 0.43 (0.33, 0.52) | 0.31 (0.23, 0.38) | 0.22 (0.18, 0.26) |
| Legumes, servings/day | 0.0 (ref) | -0.06 (-0.08, -0.04) | -0.08 (-0.10, -0.05) | -0.09 (-0.12, -0.06) | -0.11 (-0.14, -0.09) | 0.13 (0.11, 0.16) | 0.07 (0.06, 0.09) | 0.06 (0.04, 0.07) | 0.04 (0.03, 0.05) | 0.02 (0.01, 0.03) |
| Processed meat | 0.0 (ref) | 0.20 (0.02, 0.39) | 0.29 (0.08, 0.50) | 0.24 (0.07, 0.42) | 0.36 (0.19, 0.53) | 0.66 (0.53, 0.79) | 0.86 (0.70, 1.03) | 0.95 (0.79, 1.11) | 0.90 (0.76, 1.05) | 1.02 (0.88, 1.16) |

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| Unprocessed red meat | 0.0 (ref) | -0.06 (-0.15, 0.03) | -0.11 (-0.17, 0.05) | -0.19 (-0.25, 0.14) | -0.22 (-0.28, 0.17) | 0.40 (0.35, 0.45) | 0.34 (0.27, 0.41) | 0.30 (0.24, 0.35) | 0.21 (0.18, 0.24) | 0.18 (0.14, 0.22) |
| Poultry | 0.0 (ref) | -0.16 (-0.26, 0.07) | -0.24 (-0.34, 0.14) | -0.24 (-0.35, 0.14) | -0.29 (-0.38, 0.20) | 0.58 (0.48, 0.68) | 0.42 (0.35, 0.48) | 0.34 (0.29, 0.39) | 0.34 (0.27, 0.41) | 0.29 (0.23, 0.35) |
| Fish and shellfish | 0.0 (ref) | -0.05 (-0.08, 0.02) | -0.05 (-0.09, 0.01) | -0.07 (-0.10, 0.04) | -0.09 (-0.12, 0.06) | 0.11 (0.08, 0.14) | 0.06 (0.05, 0.08) | 0.06 (0.03, 0.09) | 0.04 (0.03, 0.06) | 0.02 (0.01, 0.03) |
| Eggs, servings/day | 0.0 (ref) | -0.17 (-0.29, 0.06) | -0.20 (-0.31, 0.09) | -0.28 (-0.39, 0.17) | -0.38 (-0.49, 0.28) | 0.60 (0.51, 0.70) | 0.43 (0.37, 0.49) | 0.40 (0.33, 0.47) | 0.32 (0.28, 0.37) | 0.22 (0.18, 0.26) |
| Total dairy, servings/day | 0.0 (ref) | -0.26 (-0.47, 0.04) | -0.31 (-0.52, 0.09) | -0.34 (-0.55, 0.12) | -0.59 (-0.76, 0.41) | 2.35 (2.15, 2.56) | 2.10 (1.94, 2.25) | 2.05 (1.96, 2.13) | 2.02 (1.89, 2.15) | 1.76 (1.66, 1.87) |
| Milk | 0.0 (ref) | -0.22 (-0.40, 0.05) | -0.26 (-0.43, 0.09) | -0.31 (-0.48, 0.14) | -0.54 (-0.69, 0.40) | 1.40 (1.25, 1.55) | 1.18 (1.06, 1.29) | 1.14 (1.05, 1.23) | 1.09 (0.99, 1.19) | 0.86 (0.79, 0.93) |
| Cheese | 0.0 (ref) | 0.09 (-0.02, 0.20) | 0.07 (-0.04, 0.19) | 0.14 (0.02, 0.26) | 0.10 (-0.02, 0.23) | 0.68 (0.58, 0.78) | 0.77 (0.69, 0.86) | 0.76 (0.69, 0.82) | 0.82 (0.74, 0.90) | 0.79 (0.72, 0.85) |
| Yogurt | 0.0 (ref) | -0.02 (-0.06, 0.009) | 0.02 (-0.03, 0.06) | -0.02 (-0.05, 0.02) | -0.01 (-0.04, 0.02) | 0.07 (0.04, 0.10) | 0.05 (0.03, 0.06) | 0.09 (0.06, 0.11) | 0.05 (0.04, 0.07) | 0.06 (0.04, 0.07) |
| Sugar-sweetened beverages, servings/day | 0.0 (ref) | 0.23 (0.10, 0.36) | 0.41 (0.28, 0.54) | 0.59 (0.45, 0.74) | 0.82 (0.65, 0.98) | 0.65 (0.54, 0.75) | 0.87 (0.76, 0.98) | 1.05 (0.94, 1.17) | 1.24 (1.11, 1.36) | 1.46 (1.29, 1.63) |
| Added sugar, tsp equiv./day | 0.0 (ref) | 3.20 (2.30, 4.09) | 6.45 (5.31, 7.59) | 7.27 (5.98, 8.57) | 10.1 (8.82, 11.5) | 12.1 (11.2, 13.0) | 15.3 (14.5, 16.0) | 18.5 (17.7, 19.4) | 19.4 (18.4, 20.3) | 22.2 (21.2, 23.2) |
| Nutrients | | | | | | | | | | |
| Total fat, %Energy (E) | 0.0 (ref) | 0.92 | 0.72 | 1.04 | 1.63 | 33.9 | 34.8 | 34.6 | 34.9 | 35.5 |

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| | | (-0.19, 2.04) | (-0.39, 1.84) | (0.04, 2.04) | (0.50, 2.75) | (33.0, 34.8) | (33.9, 35.7) | (33.8, 35.4) | (34.4, 35.5) | (35.0, 36.0) |
| Saturated fat, %E | 0.0 (ref) | 0.43 (-0.24, 1.11) | 0.27 (-0.40, 0.94) | 0.51 (-0.11, 1.14) | 0.49 (-0.11, 1.09) | 11.8 (11.2, 12.4) | 12.2 (11.8, 12.6) | 12.1 (11.7, 12.4) | 12.3 (12.0, 12.6) | 12.3 (12.0, 12.5) |
| Monounsaturated fat, %E | 0.0 (ref) | -1.90 (-3.30, 0.53) | -2.70 (-3.80, 1.50) | -3.60 (-5.20, 2.10) | -1.70 (-2.90, 0.37) | 17.0 (15.8, 18.2) | 15.1 (14.3, 15.9) | 14.4 (13.6, 15.1) | 13.4 (12.8, 13.9) | 15.4 (14.5, 16.2) |
| Polyunsaturated fat, %E | 0.0 (ref) | 0.38 (0.002, 0.76) | 0.56 (0.20, 0.92) | 0.72 (0.33, 1.10) | 1.02 (0.59, 1.44) | 7.21 (6.96, 7.45) | 7.59 (7.32, 7.86) | 7.77 (7.54, 8.0) | 7.92 (7.60, 8.25) | 8.22 (7.92, 8.53) |
| Seafood omega-3 fat, mg/day | 0.0 (ref) | -26.0 (-43.0, 8.30) | -34.0 (-52.0, 17.0) | -42.0 (-57.0, 26.0) | -50.0 (-64.0, 35.0) | 89.9 (75.5, 104) | 64.2 (51.1, 77.3) | 55.8 (45.8, 65.8) | 48.1 (41.1, 55.2) | 40.4 (36.1, 44.6) |
| Plant omega-3 fat, mg/day | 0.0 (ref) | -1.70 (-12.0, 8.54) | -3.0 (-12.0, 6.15) | -4.90 (-14.0, 4.27) | -3.30 (-12.0, 4.89) | 152 (146, 157) | 150 (142, 158) | 149 (143, 154) | 147 (140, 153) | 148 (143, 153) |
| Protein, %E | 0.0 (ref) | -2.50 (-3.10, 1.90) | -3.40 (-3.90, 2.90) | -4.40 (-4.90, 3.90) | -5.40 (-5.90, 5.0) | 17.7 (17.2, 18.1) | 15.2 (14.8, 15.6) | 14.3 (13.9, 14.6) | 13.3 (13.0, 13.6) | 12.2 (11.9, 12.6) |
| Carbohydrate, %E | 0.0 (ref) | 1.30 (-0.06, 2.65) | 2.65 (1.34, 3.96) | 3.27 (2.24, 4.31) | 3.63 (2.45, 4.82) | 49.7 (48.6, 50.8) | 51.0 (49.9, 52.1) | 52.3 (51.4, 53.3) | 53.0 (52.4, 53.5) | 53.3 (52.7, 53.9) |
| Sodium, mg/day | 0.0 (ref) | -16.0 (-105, 72.8) | -86.0 (-194, 22.8) | -143 (-281, 4.10) | -99.0 (-224, 25.7) | 3,299 (3,202, 3,395) | 3,283 (3,201, 3,365) | 3,213 (3,138, 3,288) | 3,156 (3,071, 3,241) | 3,199 (3,140, 3,259) |
| Cholesterol, mg/day | 0.0 (ref) | -74.0 (-99.0, 50.0) | -99.0 (-125, 74.0) | -124 (-148, 100) | -156 (-183, 129) | 340 (318, 362) | 265 (251, 280) | 240 (227, 253) | 216 (204, 227) | 184 (173, 194) |
| Fiber, g/day | 0.0 (ref) | -2.0 (-2.70, 1.20) | -2.90 (-3.90, 2.0) | -3.20 (-4.30, 2.10) | -4.70 (-5.70, 3.70) | 17.8 (16.9, 18.7) | 15.8 (15.2, 16.5) | 14.9 (14.3, 15.4) | 14.6 (13.9, 15.3) | 13.1 (12.8, 13.4) |

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| Potassium, mg/day | 0.0 (ref) | -320 (-408, - 233) | -492 (-595, - 390) | -624 (-726, - 521) | -813 (-911, - 716) | 2,707 (2,625, - 2,789) | 2,386 (2,345, - 2,428) | 2,214 (2,156, - 2,273) | 2,083 (2,035, - 2,131) | 1,893 (1,848, - 1,938) |
| Calcium, mg/day | 0.0 (ref) | -39.0 (-96.0, - 17.6) | -66.0 (-124, - 8.90) | -76.0 (-142, - 9.70) | -181 (-231, - 130) | 1,126 (1,072, - 1,180) | 1,086 (1,038, - 1,135) | 1,060 (1,035, - 1,084) | 1,050 (1,003, - 1,097) | 945 (906, - 984) |

^aData were weighted to be nationally representative, and adjusted for age, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and others), parental education (less than high school, high school graduate or GED, some college, or college graduate or above), ratio of family income to poverty (<1.30, 1.30–1.849, 1.85–2.99, and ≥3.0), and BMI categories (underweight, normal weight, overweight and obese).

^bServing sizes: fruits, vegetables, dairy: 1 cup; grains, nuts/seeds, eggs: 1-oz equivalent; meat: 3.5-oz equivalents; sugar-sweetened beverages: 8 fluid oz. Sugar-sweetened beverages includes soft drinks, fruit drinks, sports drinks, presweetened teas and energy drinks with more than 50 kcal per 8 fl oz.

NHANES, National Health and Nutrition Examination Survey.

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Appendix Table 7. Weighted Association of Major Food Groups and Nutrients With Quintiles of the Contribution of Ultra-Processed Foods to Total Energy Intake After Adjustment for Age, Sex, Race/Ethnicity, Education, Income, and BMI Among U.S. Adults, NHANES 2015–2018^a

| Variables | Regression coefficients (95% CI) | | | | | Predicted margins (95% CI) | | | | |
|--------------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|----------------------|----------------------|----------------------|----------------------|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q1 | Q2 | Q3 | Q4 | Q5 |
| Foods/nutrients ^b | | | | | | | | | | |
| Total fruits, servings/day | 0.0 (ref) | -0.27 (-0.41, -0.12) | -0.40 (-0.53, -0.27) | -0.52 (-0.67, -0.37) | -0.74 (-0.86, -0.61) | 1.28 (1.17, 1.40) | 1.02 (0.91, 1.12) | 0.88 (0.79, 0.97) | 0.76 (0.67, 0.85) | 0.55 (0.50, 0.60) |
| Intact/whole fruit | 0.0 (ref) | -0.20 (-0.33, -0.08) | -0.36 (-0.46, -0.26) | -0.43 (-0.56, -0.29) | -0.60 (-0.71, -0.50) | 1.01 (0.90, 1.11) | 0.80 (0.71, 0.90) | 0.65 (0.57, 0.73) | 0.58 (0.50, 0.66) | 0.41 (0.37, 0.45) |
| 100% fruit juice | 0.0 (ref) | -0.23 (-0.48, 0.02) | -0.22 (-0.46, 0.03) | -0.29 (-0.57, 0.01) | -0.34 (-0.65, 0.03) | 0.47 (0.19, 0.74) | 0.24 (0.18, 0.30) | 0.25 (0.20, 0.30) | 0.17 (0.14, 0.21) | 0.13 (0.08, 0.18) |
| Total vegetables, servings/day | 0.0 (ref) | -0.45 (-0.58, -0.33) | -0.57 (-0.73, -0.41) | -0.75 (-0.91, -0.59) | -0.97 (-1.10, -0.82) | 2.12 (1.99, 2.26) | 1.67 (1.57, 1.78) | 1.56 (1.45, 1.66) | 1.38 (1.29, 1.46) | 1.16 (1.08, 1.24) |
| Whole grains | 0.0 (ref) | -0.09 (-0.26, 0.07) | -0.11 (-0.29, 0.08) | -0.14 (-0.30, 0.03) | -0.20 (-0.37, -0.02) | 0.98 (0.84, 1.13) | 0.89 (0.80, 0.98) | 0.88 (0.78, 0.98) | 0.84 (0.72, 0.97) | 0.79 (0.63, 0.94) |
| Refined grains | 0.0 (ref) | 0.71 (0.47, 0.94) | 1.14 (0.80, 1.48) | 1.33 (1.06, 1.60) | 1.65 (1.46, 1.84) | 4.26 (4.07, 4.44) | 4.96 (4.79, 5.14) | 5.40 (5.14, 5.65) | 5.59 (5.40, 5.77) | 5.90 (5.72, 6.09) |
| Nuts and seeds, servings/day | 0.0 (ref) | -0.29 (-0.52, -0.06) | -0.61 (-0.82, -0.40) | -0.62 (-0.82, -0.42) | -0.83 (-1.10, -0.59) | 1.24 (1.03, 1.44) | 0.94 (0.79, 1.09) | 0.63 (0.50, 0.76) | 0.62 (0.47, 0.77) | 0.41 (0.33, 0.48) |
| Legumes, servings/day | 0.0 (ref) | -0.04 (-0.08, -0.01) | -0.09 (-0.13, -0.06) | -0.10 (-0.14, -0.07) | -0.14 (-0.17, -0.11) | 0.19 (0.15, 0.22) | 0.14 (0.12, 0.17) | 0.09 (0.07, 0.11) | 0.08 (0.07, 0.09) | 0.05 (0.04, 0.06) |
| Processed meat | 0.0 (ref) | 0.24 (0.09, 0.38) | 0.32 (0.13, 0.51) | 0.55 (0.41, 0.69) | 0.57 (0.41, 0.74) | 0.61 (0.50, 0.71) | 0.84 (0.73, 0.96) | 0.93 (0.80, 1.06) | 1.16 (1.02, 1.29) | 1.18 (1.05, 1.31) |

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| Unprocessed red meat | 0.0 (ref) | -0.06 (-0.15, 0.03) | -0.12 (-0.20, -0.04) | -0.19 (-0.26, -0.12) | -0.23 (-0.29, -0.17) | 0.55 (0.49, 0.61) | 0.49 (0.42, 0.56) | 0.43 (0.37, 0.49) | 0.36 (0.31, 0.41) | 0.32 (0.29, 0.35) |
| Poultry | 0.0 (ref) | -0.07 (-0.15, 0.02) | -0.07 (-0.15, 0.02) | -0.10 (-0.18, -0.01) | -0.13 (-0.21, -0.06) | 0.51 (0.44, 0.58) | 0.44 (0.39, 0.49) | 0.44 (0.39, 0.50) | 0.41 (0.36, 0.46) | 0.38 (0.33, 0.42) |
| Fish and shellfish | 0.0 (ref) | -0.06 (-0.10, -0.02) | -0.10 (-0.15, -0.05) | -0.13 (-0.18, -0.08) | -0.18 (-0.24, -0.13) | 0.27 (0.23, 0.31) | 0.21 (0.17, 0.26) | 0.17 (0.12, 0.21) | 0.14 (0.11, 0.17) | 0.09 (0.06, 0.12) |
| Eggs, servings/day | 0.0 (ref) | -0.15 (-0.28, -0.02) | -0.24 (-0.37, -0.11) | -0.29 (-0.42, -0.16) | -0.44 (-0.60, -0.29) | 0.81 (0.68, 0.95) | 0.66 (0.59, 0.73) | 0.57 (0.51, 0.64) | 0.53 (0.48, 0.58) | 0.37 (0.32, 0.42) |
| Total dairy, servings/day | 0.0 (ref) | 0.13 (-0.001, 0.26) | 0.16 (0.06, 0.26) | 0.08 (-0.02, 0.18) | 0.03 (-0.10, 0.17) | 1.32 (1.22, 1.42) | 1.45 (1.33, 1.57) | 1.48 (1.40, 1.56) | 1.40 (1.31, 1.48) | 1.35 (1.28, 1.43) |
| Milk | 0.0 (ref) | 0.009 (-0.07, 0.09) | 0.02 (-0.07, 0.11) | -0.04 (-0.11, 0.04) | -0.14 (-0.24, -0.03) | 0.62 (0.54, 0.70) | 0.63 (0.57, 0.69) | 0.65 (0.57, 0.72) | 0.59 (0.54, 0.63) | 0.49 (0.43, 0.54) |
| Cheese | 0.0 (ref) | 0.13 (0.05, 0.22) | 0.14 (0.06, 0.23) | 0.16 (0.08, 0.24) | 0.24 (0.16, 0.31) | 0.55 (0.49, 0.60) | 0.68 (0.61, 0.75) | 0.69 (0.63, 0.74) | 0.71 (0.65, 0.76) | 0.78 (0.73, 0.84) |
| Yogurt | 0.0 (ref) | -0.02 (-0.04, 0.003) | 0.002 (-0.02, 0.03) | -0.01 (-0.04, 0.01) | -0.02 (-0.05, 0.009) | 0.09 (0.07, 0.10) | 0.07 (0.05, 0.09) | 0.09 (0.07, 0.11) | 0.08 (0.06, 0.09) | 0.07 (0.04, 0.09) |
| Sugar-sweetened beverages, servings/day | 0.0 (ref) | 0.18 (0.04, 0.32) | 0.39 (0.23, 0.54) | 0.72 (0.54, 0.91) | 1.15 (0.91, 1.40) | 0.58 (0.44, 0.72) | 0.76 (0.66, 0.85) | 0.97 (0.86, 1.08) | 1.30 (1.13, 1.47) | 1.73 (1.54, 1.93) |
| Added sugar, tsp equiv./day | 0.0 (ref) | 2.99 (1.89, 4.09) | 5.14 (3.95, 6.34) | 7.92 (6.79, 9.05) | 11.1 (9.49, 12.7) | 9.91 (8.91, 10.9) | 12.9 (12.3, 13.5) | 15.1 (14.2, 15.9) | 17.8 (17.0, 18.6) | 21.0 (19.9, 22.1) |
| Nutrients | | | | | | | | | | |
| Total fat, %Energy (E) | 0.0 (ref) | 2.03 | 1.98 (0.95, 3.0) | 2.86 | 2.65 | 34.1 | 36.1 | 36.0 | 36.9 | 36.7 |

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| | | (1.08, 2.99) | (1.71, 4.0) | (1.58, 3.72) | (33.3, 34.9) | (35.3, 36.9) | (35.4, 36.7) | (36.2, 37.7) | (36.1, 37.3) | |
| Saturated fat, %E | 0.0 (ref) | 1.17 (0.77, 1.56) | 1.21 (0.75, 1.66) | 1.48 (1.03, 1.93) | 1.50 (1.07,1.92) | 10.6 (10.2, 10.9) | 11.8 (11.4, 12.1) | 11.8 (11.5, 12.1) | 12.1 (11.8, 12.3) | 12.1 (11.8, 12.3) |
| Monounsaturated fat, %E | 0.0 (ref) | -0.80 (-1.80, 0.17) | -1.90 (-3.0, - 0.91) | -1.90 (-2.90, - 0.85) | 0.78 (-3.40, 4.95) | 15.7 (14.8, 16.5) | 14.9 (14.2, 15.5) | 13.7 (13.1, 14.3) | 13.8 (13.0, 14.5) | 16.5 (12.4, 20.5) |
| Polyunsaturated fat, %E | 0.0 (ref) | 0.40 (0.007, 0.80) | 0.61 (0.18, 1.04) | 0.84 (0.34, 1.34) | 0.78 (0.27, 1.29) | 7.93 (7.61, 8.24) | 8.33 (8.02, 8.64) | 8.54 (8.26, 8.81) | 8.76 (8.36, 9.16) | 8.71 (8.40, 9.01) |
| Seafood omega-3 fat, mg/day | 0.0 (ref) | -51 (-75, - 27) | -65 (-97, -32) | -89 (-122, - 56) | -110 (-142, - 78) | 180 (153, 206) | 129 (109, 149) | 115 (90.9, 139) | 90.8 (76.7, 105) | 69.8 (51.4, 88.3) |
| Plant omega-3 fat, mg/day | 0.0 (ref) | -2.10 (-12.0, 8.11) | -3.50 (-18.0, 10.8) | -4.60 (-19.0, 9.61) | -7.80 (-24.0, 8.91) | 181 (169, 194) | 179 (169, 189) | 178 (171, 185) | 177 (169, 185) | 174 (165, 182) |
| Protein, %E | 0.0 (ref) | -1.30 (-1.90, - 0.70) | -2.30 (-2.80, - 1.80) | -3.40 (-3.80, - 2.90) | -4.50 (-5.0, - 3.90) | 18.2 (17.8, 18.6) | 16.9 (16.5, 17.3) | 15.9 (15.6, 16.2) | 14.8 (14.5, 15.2) | 13.7 (13.3, 14.2) |
| Carbohydrate, %E | 0.0 (ref) | 0.01 (-1.10, 1.16) | 1.82 (0.68, 2.96) | 3.10 (1.70, 4.51) | 4.47 (3.13, 5.81) | 44.6 (43.5, 45.8) | 44.7 (44.0, 45.3) | 46.5 (45.7, 47.3) | 47.7 (47.0, 48.5) | 49.1 (48.4, 49.9) |
| Sodium, mg/day | 0.0 (ref) | -67 (-172, 38) | -32 (-127, 62.8) | -46.0 (-168, 74.8) | 371 (-554, 1,296) | 3,452 (3,376, 3,527) | 3,385 (3,293, 3,477) | 3,420 (3,341, 3,498) | 3,405 (3,307, 3,504) | 3,823 (2,925, 4,721) |
| Cholesterol, mg/day | 0.0 (ref) | -42 (-69, - 16) | -77 (-110, - 44) | -97 (-129, - 65) | -138 (-177, - 98) | 368 (335, 401) | 326 (311, 340) | 291 (278, 304) | 271 (259, 283) | 230 (218, 243) |
| Fiber, g/day | 0.0 (ref) | -2.30 (-3.0, - 1.60) | -3.90 (-4.80, - 3.10) | -4.80 (-5.60, - 4.10) | -6.30 (-7.0, - 5.60) | 20.2 (19.4, 20.9) | 17.8 (17.2, 18.5) | 16.2 (15.7, 16.8) | 15.3 (14.8, 15.8) | 13.9 (13.4, 14.3) |

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| | | | | | | | | | | |
|-------------------|--------------|--------------------------|---------------------------|---------------------------|----------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| Potassium, mg/day | 0.0 (ref) | -367 (-437, - 296) | -530 (-625, - 436) | -711 (-804, - 617) | -949 (-1,019, - 879) | 3,098 (3,025, - 3,170) | 2,731 (2,666, - 2,796) | 2,567 (2,504, - 2,630) | 2,387 (2,325, - 2,448) | 2,148 (2,104, - 2,192) |
| Calcium, mg/day | 0.0 (ref) | 13.4 (-46, 72.8) | -0.45 (-39.0, 38.5) | -24.0 (-69.0, 22.0) | -41.0 (-107.0, 25.2) | 956 (920, 991) | 969 (921, 1017) | 955 (930, 980) | 932 (896, 968) | 914 (858, 971) |

^aData were weighted to be nationally representative, and adjusted for age, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and others), education (less than high school, high school graduate or GED, some college, or college graduate or above), ratio of family income to poverty (<1.30, 1.30–1.849, 1.85–2.99, and ≥3.0), and BMI categories (underweight, normal weight, overweight and obese).

^bServing sizes: fruits, vegetables, dairy: 1 cup; grains, nuts/seeds, eggs: 1-oz equivalent; meat: 3.5-oz equivalents; sugar-sweetened beverages: 8 fluid oz. Sugar-sweetened beverages includes soft drinks, fruit drinks, sports drinks, presweetened teas and energy drinks with more than 50 kcal per 8 fl oz.

NHANES, National Health and Nutrition Examination Survey.

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Appendix Table 8. Associations of Quintiles of the Contribution of Ultra-Processed Foods to Total Energy Intake With American Heart Association (AHA) Secondary Dietary Score Among U.S. Children and Adults by Subgroups, NHANES 2015–2016 and 2017–2018^a

| AHA Score | Regression coefficients (95% CI) | | | | | Predicted margins (95% CI) | | | | |
|-----------------------|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|----------------------|----------------------|----------------------|----------------------|
| | Q1 | Q2 | Q3 | Q4 | Q5 | Q1 | Q2 | Q3 | Q4 | Q5 |
| Children | | | | | | | | | | |
| Age, years | | | | | | | | | | |
| 2 to 5 | 0.0 (ref) | -2.54 (-4.75, -0.33) | -6.61 (-9.29, -3.93) | -7.81 (-10.7, -4.88) | -11.4 (-14.8, -8.03) | 40.3 (38.5, 42.1) | 37.8 (36.0, 39.6) | 33.7 (31.9, 35.5) | 32.5 (30.3, 34.7) | 28.9 (26.0, 31.7) |
| 6 to 11 | 0.0 (ref) | -2.33 (-4.26, -0.40) | -4.37 (-7.13, -1.61) | -4.64 (-7.44, -1.83) | -9.47 (-11.5, -7.41) | 37.9 (36.1, 39.7) | 35.6 (33.8, 37.3) | 33.5 (31.3, 35.7) | 33.3 (31.1, 35.5) | 28.4 (27.0, 29.9) |
| 12 to 19 | 0.0 (ref) | -5.58 (-9.01, -2.16) | -4.96 (-7.21, -2.71) | -7.87 (-10.3, -5.45) | -10.2 (-12.3, -8.14) | 36.8 (34.9, 38.7) | 31.2 (28.4, 34.0) | 31.8 (30.1, 33.6) | 28.9 (27.0, 30.8) | 26.6 (25.6, 27.5) |
| Sex | | | | | | | | | | |
| Male | 0.0 (ref) | -4.17 (-6.14, -2.19) | -5.38 (-7.87, -2.89) | -7.14 (-9.72, -4.56) | -10.1 (-12.1, -8.07) | 37.5 (35.8, 39.3) | 33.3 (31.7, 34.9) | 32.1 (30.4, 33.8) | 30.3 (28.4, 32.3) | 27.4 (26.7, 28.1) |
| Female | 0.0 (ref) | -3.58 (-5.79, -1.36) | -5.0 (-7.10, -2.90) | -6.01 (-8.43, -3.59) | -9.91 (-11.7, -8.11) | 38.4 (36.8, 40.0) | 34.8 (32.8, 36.9) | 33.4 (31.5, 35.3) | 32.4 (30.6, 34.3) | 28.5 (27.5, 29.6) |
| Race/ethnicity | | | | | | | | | | |
| Non-Hispanic White | 0.0 (ref) | -2.39 (-5.41, 0.63) | -3.33 (-6.16, -0.50) | -4.49 (-7.37, -1.60) | -8.15 (-10.8, -5.54) | 36.6 (34.3, 39.0) | 34.3 (31.7, 36.8) | 33.3 (31.3, 35.3) | 32.2 (30.0, 34.4) | 28.5 (27.5, 29.5) |
| Non-Hispanic Black | 0.0 (ref) | -3.36 (-6.51, -0.21) | -7.49 (-10.1, -4.89) | -6.91 (-10.7, -3.16) | -10.9 (-13.8, -8.06) | 37.2 (34.1, 40.2) | 33.8 (31.9, 35.6) | 29.7 (28.0, 31.3) | 30.2 (28.2, 32.3) | 26.2 (25.2, 27.2) |
| Hispanic | 0.0 (ref) | -4.99 (-6.96, -3.01) | -5.92 (-7.73, -4.11) | -8.32 (-10.4, -6.23) | -12.1 (-14.3, -9.79) | 38.9 (37.5, 40.3) | 34.0 (32.5, 35.4) | 33.0 (31.3, 34.8) | 30.6 (28.5, 32.7) | 26.9 (24.9, 28.9) |

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| | | | | | | | | | | |
|--|--------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Other | 0.0 (ref) | -5.44 (-8.22, - 2.66) | -6.81 (-11.3, - 2.31) | -10.1 (-12.6, - 7.56) | -11.0 (-13.4, - 8.57) | 39.8 (37.9, 41.7) | 34.3 (31.6, 37.1) | 33.0 (29.4, 36.6) | 29.7 (27.6, 31.8) | 28.8 (27.1, 30.5) |
| Education level^b | | | | | | | | | | |
| Less than high school graduate | 0.0 (ref) | -6.36 (-8.97, - 3.76) | -7.05 (-9.98, - 4.11) | -9.21 (-11.7, - 6.73) | -12.2 (-14.9, - 9.41) | 38.7 (36.4, 41.1) | 32.4 (30.5, 34.3) | 31.7 (28.9, 34.5) | 29.5 (28.0, 31.0) | 26.6 (24.4, 28.7) |
| High school graduate or GED or some college | 0.0 (ref) | -2.71 (-4.72, - 0.70) | -3.71 (-5.64, - 1.89) | -5.88 (-8.37, - 3.39) | -8.69 (-10.6, - 6.77) | 36.0 (34.4, 37.7) | 33.3 (31.2, 35.4) | 32.3 (30.8, 33.7) | 30.2 (28.1, 32.2) | 27.3 (26.6, 28.1) |
| College graduate or above | 0.0 (ref) | -3.88 (-7.75, - 0.01) | -6.14 (-9.48, - 2.81) | -6.20 (-9.21, - 3.18) | -11.4 (-14.6, - 8.12) | 40.7 (38.2, 43.2) | 36.8 (34.0, 39.5) | 34.5 (32.1, 36.9) | 34.5 (32.6, 36.3) | 29.3 (27.4, 31.2) |
| Ratio of family income to poverty level | | | | | | | | | | |
| <1.30 | 0.0 (ref) | -3.89 (-5.59, - 2.18) | -4.95 (-6.98, - 2.91) | -8.57 (-10.5, - 6.61) | -11.5 (-13.2, - 9.68) | 37.0 (35.3, 38.8) | 33.1 (31.4, 34.8) | 32.1 (30.1, 34.0) | 28.4 (26.9, 30.0) | 25.5 (24.4, 26.7) |
| 1.30 to 1.849 | 0.0 (ref) | -2.81 (-5.04, - 0.58) | -5.57 (-9.15, - 2.0) | -8.29 (-11.4, - 5.18) | -8.69 (-12.4, - 5.0) | 37.7 (35.6, 39.7) | 34.9 (33.1, 36.6) | 32.1 (28.8, 35.4) | 29.4 (27.5, 31.3) | 29.0 (26.6, 31.1) |
| 1.85 to 2.99 | 0.0 (ref) | -2.99 (-5.95, - 0.03) | -3.97 (-8.69, 0.75) | -6.73 (-10.8, - 2.70) | -7.62 (-11.6, - 3.66) | 36.8 (33.6, 40.1) | 33.8 (31.7, 35.8) | 32.8 (30.3, 35.2) | 30.0 (28.1, 32.0) | 29.1 (27.3, 31.0) |
| ≥3.0 | 0.0 (ref) | -4.37 (-8.03, - 0.71) | -5.40 (-8.54, - 2.26) | -4.29 (-7.80, - 0.79) | -10.2 (-12.9, - 7.50) | 39.2 (36.7, 41.7) | 34.8 (31.8, 37.9) | 33.8 (31.5, 36.1) | 34.9 (32.4, 37.5) | 29.0 (27.4, 30.7) |
| BMI categories | | | | | | | | | | |
| Underweight | 0.0 (ref) | -12.9 (-21.1, - 4.72) | -14.5 (-23.3, - 5.69) | -16.0 (-24.4, - 7.51) | -17.4 (-26.8, - 8.01) | 46.7 (39.1, 54.3) | 33.8 (29.3, 38.2) | 32.2 (27.1, 37.2) | 30.8 (26.7, 34.8) | 29.3 (24.2, 34.3) |

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| | | | | | | | | | | |
|-----------------------|--------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Normal weight | 0.0 (ref) | -3.17 (-5.49, -0.84) | -4.17 (-6.53, -1.80) | -5.59 (-8.09, -3.09) | -10.2 (-12.3, -8.01) | 38.1 (36.4, 39.9) | 35.0 (32.8, 37.1) | 34.0 (32.0, 35.9) | 32.5 (30.5, 34.6) | 28.0 (27.0, 28.9) |
| Overweight | 0.0 (ref) | -1.97 (-5.39, 1.44) | -4.48 (-8.50, -0.46) | -7.23 (-11.7, -2.71) | -8.27 (-11.9, -4.61) | 36.7 (33.4, 40.1) | 34.8 (32.8, 36.8) | 32.3 (30.5, 34.0) | 29.5 (26.9, 32.2) | 28.5 (27.1, 29.9) |
| Obese | 0.0 (ref) | -5.63 (-8.46, -2.80) | -7.39 (-10.1, -4.64) | -7.75 (-9.92, -5.58) | -9.98 (-12.1, -7.86) | 37.0 (35.5, 38.5) | 31.4 (29.2, 33.6) | 29.6 (27.3, 31.9) | 29.3 (27.4, 31.1) | 27.0 (25.2, 28.9) |
| Adults | | | | | | | | | | |
| Age, years | | | | | | | | | | |
| 20 to 44 | 0.0 (ref) | -4.66 (-6.09, -3.23) | -8.77 (-10.6, -6.96) | -10.7 (-12.4, -9.03) | -14.4 (-16.1, -12.7) | 42.3 (40.8, 43.7) | 37.6 (36.2, 39.0) | 33.5 (32.1, 34.9) | 31.6 (30.0, 33.1) | 27.9 (26.5, 29.2) |
| 45 to 64 | 0.0 (ref) | -3.44 (-5.52, -1.36) | -5.15 (-6.99, -3.30) | -9.43 (-11.8, -7.08) | -10.8 (-12.9, -8.73) | 42.0 (40.8, 43.3) | 38.6 (37.0, 40.2) | 36.9 (35.1, 38.6) | 32.6 (30.7, 34.5) | 31.2 (29.6, 32.8) |
| ≥65 | 0.0 (ref) | -4.34 (-6.97, -1.71) | -6.68 (-9.40, -3.97) | -9.45 (-12.2, -6.75) | -11.7 (-14.2, -9.13) | 44.9 (43.0, 46.7) | 40.5 (38.7, 42.4) | 38.2 (36.1, 40.3) | 35.4 (33.7, 37.1) | 33.2 (31.4, 35.1) |
| Sex | | | | | | | | | | |
| Male | 0.0 (ref) | -4.32 (-6.16, -2.49) | -7.44 (-9.19, -5.69) | -10.6 (-12.3, -8.82) | -13.7 (-15.4, -11.9) | 41.9 (40.5, 43.4) | 37.6 (36.4, 38.8) | 34.5 (33.1, 35.9) | 31.4 (29.9, 32.8) | 28.3 (27.0, 29.5) |
| Female | 0.0 (ref) | -3.92 (-5.45, -2.39) | -6.49 (-7.82, -5.15) | -9.32 (-11.0, -7.60) | -11.6 (-13.2, -9.97) | 43.3 (42.4, 44.3) | 39.4 (38.2, 40.6) | 36.9 (35.5, 38.2) | 34.0 (32.7, 35.4) | 31.8 (30.5, 33.0) |
| Race/ethnicity | | | | | | | | | | |
| Non-Hispanic White | 0.0 (ref) | -4.06 (-5.70, -2.42) | -6.52 (-8.26, -4.79) | -9.61 (-11.5, -7.73) | -11.5 (-13.2, -9.86) | 42.3 (40.9, 43.7) | 38.3 (37.1, 39.5) | 35.8 (34.3, 37.3) | 32.7 (31.2, 34.3) | 30.8 (29.7, 32.0) |
| Non-Hispanic Black | 0.0 (ref) | -4.10 | -7.99 | -10.3 | -13.3 | 41.2 | 37.1 | 33.2 | 30.9 | 27.8 |

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| | | | | | | | | | | |
|--|-------|----------------|----------------|----------------|----------------|--------------|--------------|--------------|--------------|--------------|
| | | (-6.49, -1.71) | (-10.0, -5.96) | (-12.2, -8.31) | (-15.4, -11.3) | (39.2, 43.1) | (35.2, 38.9) | (31.8, 34.5) | (29.6, 32.2) | (26.8, 28.9) |
| Hispanic | 0.0 | -4.02 | -7.24 | -11.2 | -14.8 | 42.6 | 38.6 | 35.4 | 31.5 | 27.8 |
| | (ref) | (-5.53, 2.50) | (-8.79, 5.69) | (-13.3, 8.96) | (-16.3, 13.3) | (41.7, 43.5) | (37.2, 40.0) | (34.1, 36.6) | (29.5, 33.4) | (26.6, 29.0) |
| Other | 0.0 | -3.99 | -7.38 | -9.22 | -15.8 | 45.5 | 41.5 | 38.1 | 36.3 | 29.7 |
| | (ref) | (-6.04, 1.95) | (-9.30, 5.46) | (-12.2, 6.20) | (-18.0, 13.5) | (43.9, 47.1) | (39.7, 43.3) | (36.2, 40.1) | (33.5, 39.1) | (27.6, 31.8) |
| Education level | | | | | | | | | | |
| Less than high school graduate | 0.0 | -4.22 | -6.61 | -11.2 | -13.4 | 40.6 | 36.4 | 34.0 | 29.4 | 27.2 |
| | (ref) | (-6.95, 1.50) | (-9.0, 4.22) | (-13.7, 8.68) | (-16.2, 10.5) | (38.9, 42.3) | (34.0, 38.8) | (31.8, 36.1) | (27.6, 31.2) | (25.3, 29.2) |
| High school graduate or GED | 0.0 | -4.82 | -6.86 | -9.22 | -11.8 | 40.0 | 35.2 | 33.1 | 30.7 | 28.2 |
| | (ref) | (-7.12, 2.53) | (-10.0, 3.70) | (-11.8, 6.65) | (-14.6, 9.02) | (37.9, 42.1) | (33.4, 36.9) | (31.0, 35.2) | (28.8, 32.7) | (26.2, 30.2) |
| Some college | 0.0 | -3.79 | -7.29 | -9.69 | -12.7 | 42.0 | 38.2 | 34.6 | 32.3 | 29.3 |
| | (ref) | (-5.65, 1.94) | (-9.23, 5.35) | (-12.0, 7.35) | (-14.7, 10.7) | (40.2, 43.7) | (36.4, 39.9) | (33.2, 36.1) | (30.2, 34.3) | (28.2, 30.3) |
| College graduate or above | 0.0 | -3.85 | -6.74 | -10.1 | -12.5 | 46.1 | 42.2 | 39.3 | 35.9 | 33.6 |
| | (ref) | (-5.78, 1.93) | (-8.62, 4.85) | (-12.3, 7.92) | (-14.5, 10.4) | (44.6, 47.5) | (40.6, 43.8) | (37.4, 41.3) | (34.4, 37.5) | (31.9, 35.4) |
| Ratio of family income to poverty level | | | | | | | | | | |
| <1.30 | 0.0 | -5.60 | -8.29 | -10.5 | -14.8 | 41.2 | 35.6 | 32.9 | 30.8 | 26.4 |
| | (ref) | (-8.28, 2.92) | (-10.8, 5.76) | (-12.9, 8.02) | (-17.6, 12.0) | (39.2, 43.2) | (33.8, 37.4) | (31.3, 34.5) | (29.1, 32.4) | (24.7, 28.1) |
| 1.30 to 1.849 | 0.0 | -3.05 | -6.17 | -13.1 | -14.3 | 42.7 | 39.7 | 36.5 | 29.6 | 28.4 |
| | (ref) | (-4.91, 1.19) | (-8.88, 3.47) | (-16.0, 10.2) | (-16.6, 12.0) | (41.1, 44.3) | (37.9, 41.4) | (34.2, 38.8) | (27.1, 32.1) | (26.5, 30.3) |
| 1.85 to 2.99 | 0.0 | -6.0 | -7.17 | -10.6 | -14.4 | 42.6 | 36.6 | 35.4 | 31.9 | 28.2 |
| | (ref) | (-8.70, 3.30) | (-10.1, 4.27) | (-13.8, 7.44) | (-17.3, 11.5) | (40.3, 44.9) | (34.5, 38.7) | (33.7, 37.1) | (30.0, 33.9) | (26.7, 29.6) |

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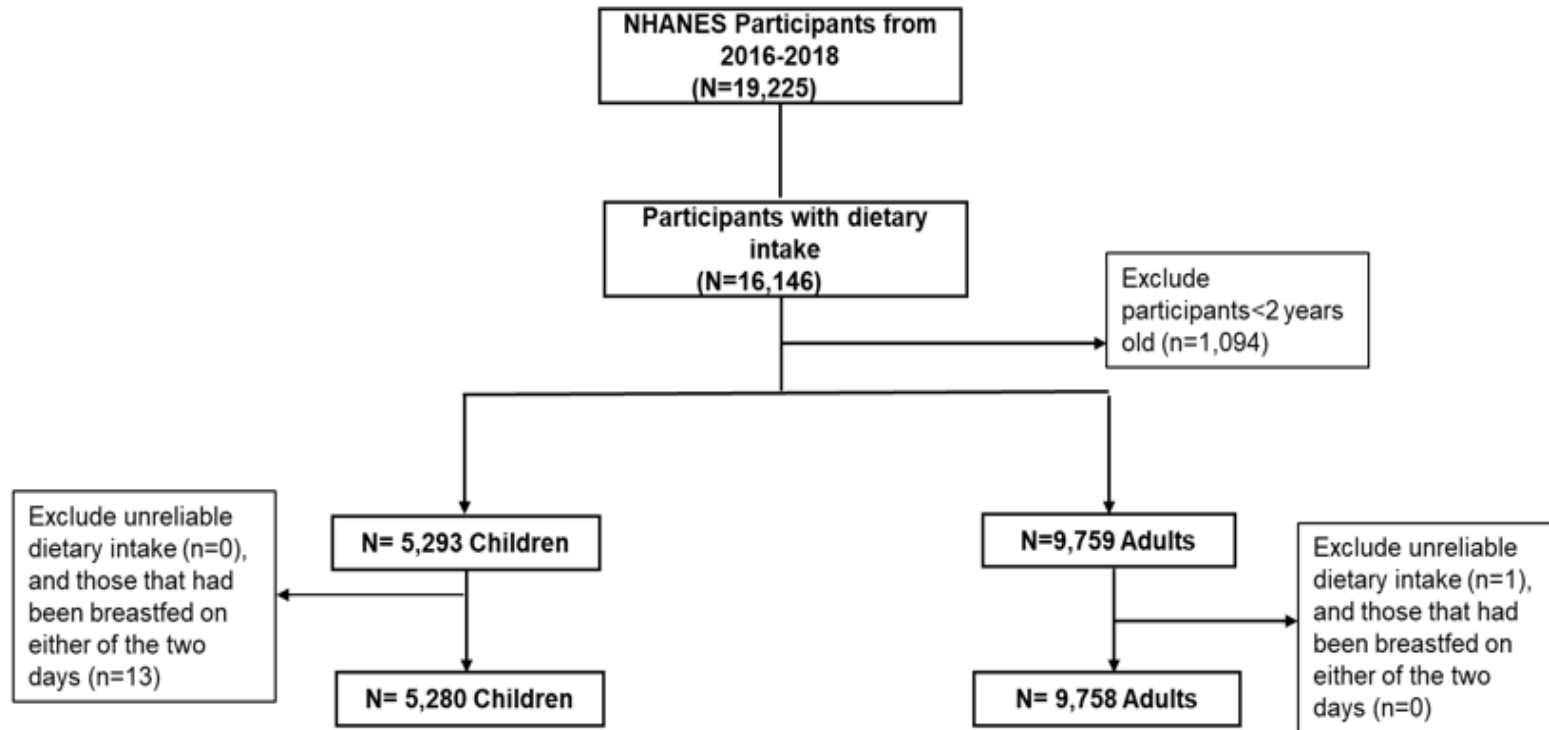
| | | | | | | | | | | |
|-----------------------|--------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| ≥3.0 | 0.0 (ref) | -3.16 (-4.78, - 1.54) | -6.55 (-8.17, - 4.93) | -8.88 (-10.6, - 7.16) | -10.4 (-12.0, - 8.86) | 43.4 (42.2, 44.6) | 40.2 (39.0, 41.5) | 36.8 (35.2, 38.4) | 34.5 (33.0, 36.0) | 33.0 (31.7, 34.2) |
| BMI categories | | | | | | | | | | |
| Underweight | 0.0 (ref) | -10.8 (-23.5, - 1.92) | -6.90 (-16.3, - 2.51) | -9.56 (-19.3, - 0.13) | -15.0 (-23.8, - 6.22) | 45.0 (36.5, 53.4) | 34.2 (25.6, 42.7) | 38.1 (31.3, 44.8) | 35.4 (30.5, 40.3) | 30.0 (25.2, 34.7) |
| Normal weight | 0.0 (ref) | -4.09 (-6.17, - 2.02) | -7.97 (-10.5, - 5.48) | -10.6 (-13.2, - 8.07) | -13.2 (-15.2, - 11.3) | 44.7 (43.2, 46.3) | 40.6 (39.3, 42.0) | 36.8 (34.7, 38.9) | 34.1 (32.0, 36.2) | 31.5 (29.6, 33.4) |
| Overweight | 0.0 (ref) | -4.17 (-6.21, - 2.13) | -7.60 (-9.68, - 5.52) | -9.45 (-11.5, - 7.41) | -12.6 (-15.1, - 10.1) | 43.2 (41.4, 45.0) | 39.0 (37.3, 40.8) | 35.6 (34.1, 37.1) | 33.8 (32.0, 35.5) | 30.6 (29.0, 32.2) |
| Obese | 0.0 (ref) | -3.63 (-5.72, - 1.55) | -5.77 (-7.75, - 3.79) | -9.60 (-11.8, - 7.35) | -11.8 (-13.6, - 10.1) | 40.7 (39.2, 42.2) | 37.1 (36.0, 38.1) | 34.9 (33.5, 36.4) | 31.1 (29.6, 32.6) | 28.9 (27.8, 30.0) |

^aData were weighted to be nationally representative, and adjusted for age, sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and others), education (less than high school, high school graduate or GED, some college, or college graduate or above), ratio of family income to poverty (<1.30, 1.30–1.849, 1.85–2.99, and ≥3.0), and BMI categories (underweight, normal weight, overweight and obese).

NHANES, National Health and Nutrition Examination Survey.

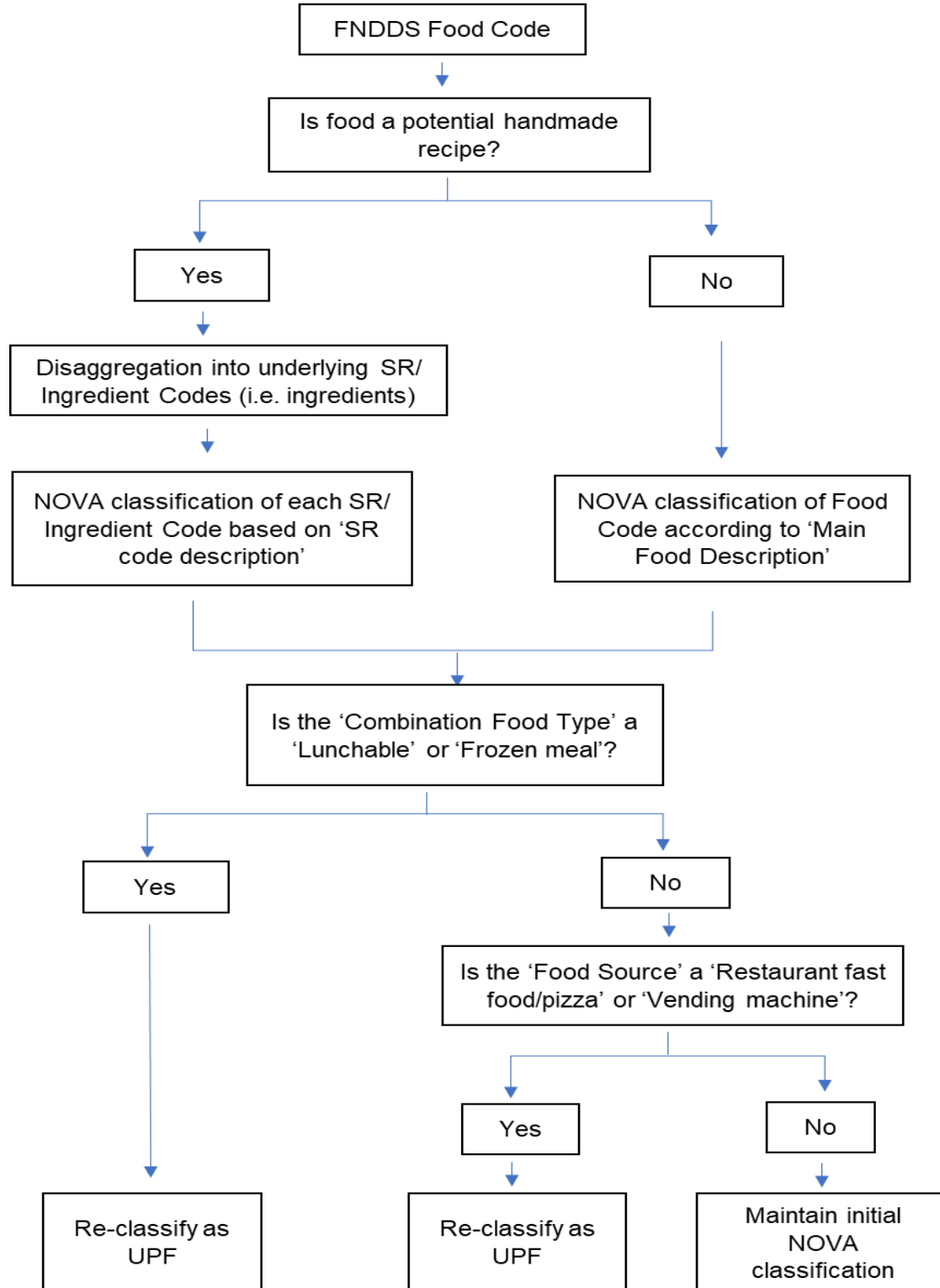
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Appendix Figure 1. Participants flowchart.



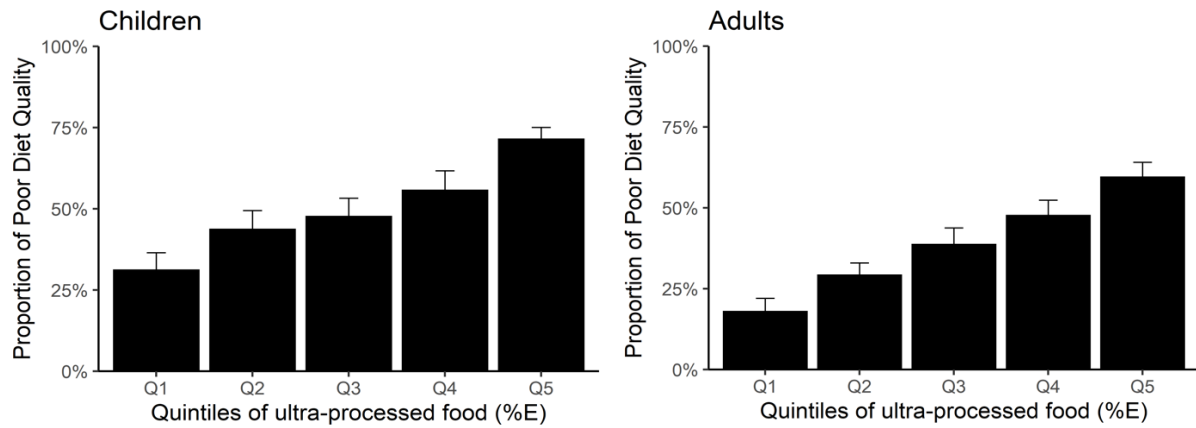
Abbreviation: NHANES, National Health and Nutrition Examination Survey

Appendix Figure 2. Flowchart of the process of food classification according to NOVA in NHANES.



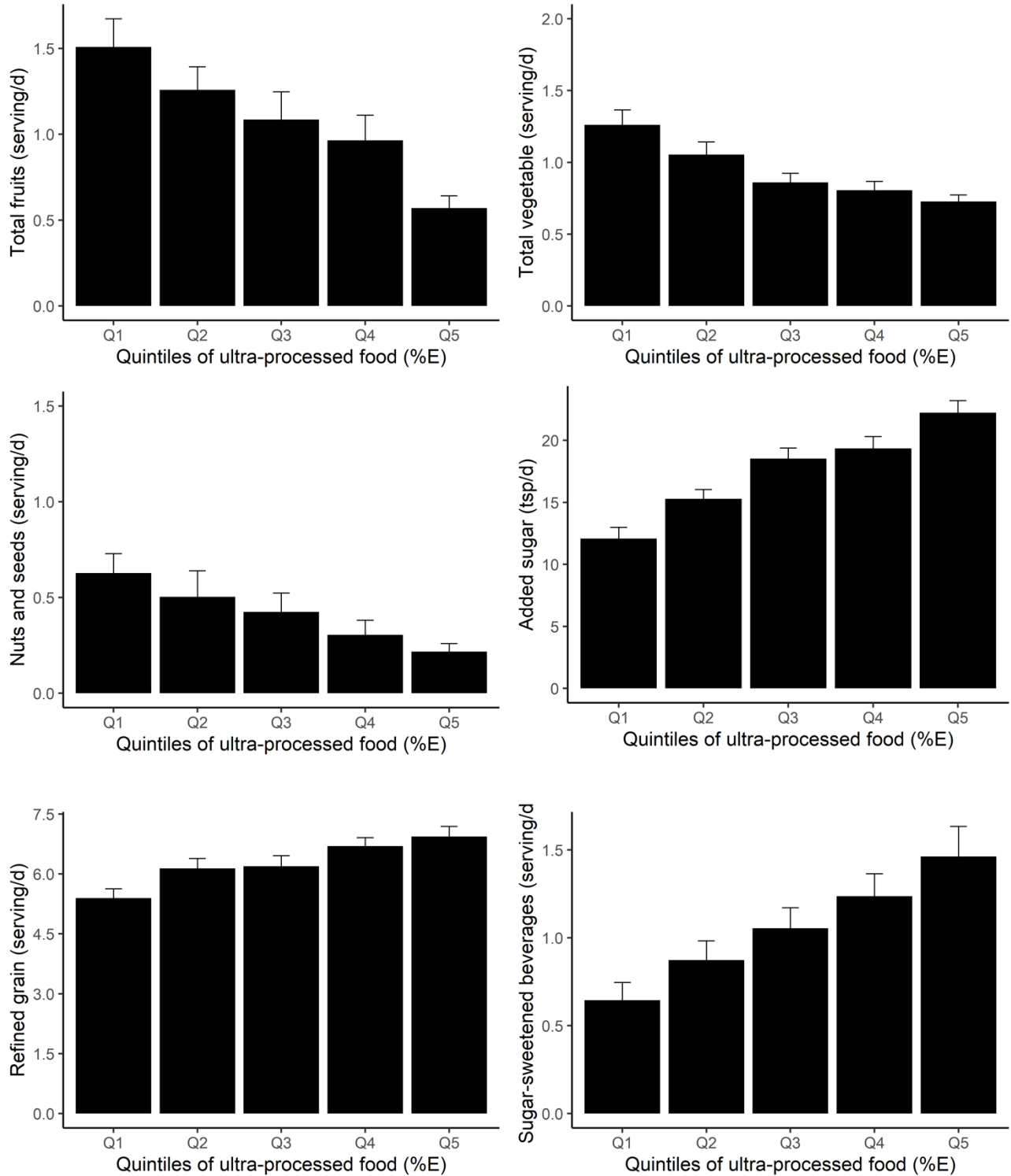
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Appendix Figure 3. Predicted marginal proportions of poor diet quality across quintiles of ultra-processed food consumption (%E) among U.S. children (aged 2–19 years) and adults (aged ≥ 20 years), NHANES 2015–2018. *Notes:* Data were adjusted for NHANES survey weights to be nationally representative. Error bars indicate 95% CIs. NHANES, National Health and Nutrition Examination Survey.



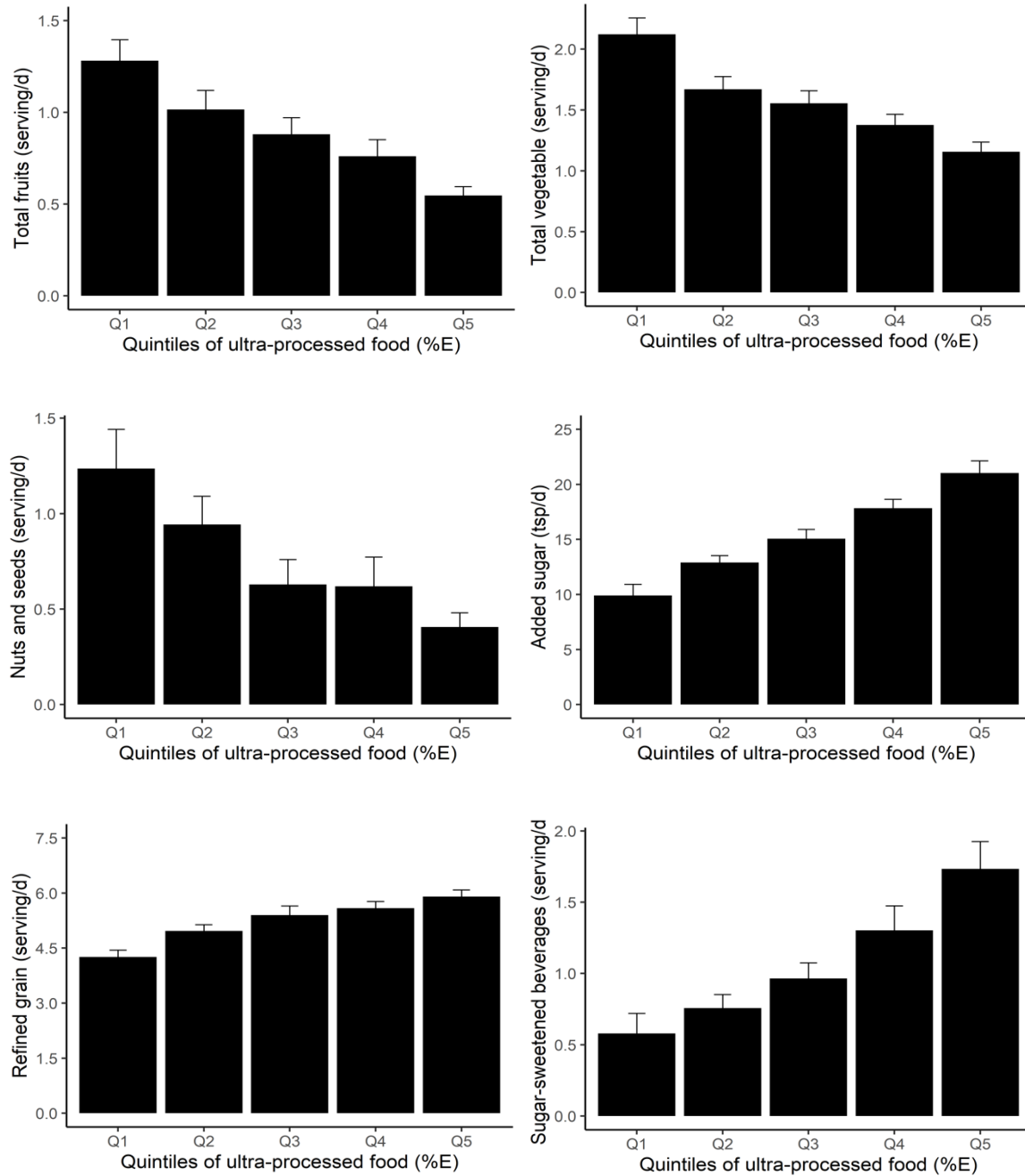
Appendix
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Appendix Figure 4a Children. Predicted marginal means of total fruits (servings/d), total vegetables (serving/d), nuts and seeds (serving/d), added sugar (tsp/d), refined grain (serving/d) and sugar-sweetened beverages (serving/d) across quintiles of ultra-processed food consumption (%E) among U.S. children (aged 2–19 years), NHANES 2015–2018. *Notes:* Data were adjusted for NHANES survey weights to be nationally representative. Error bars indicate 95% CIs. NHANES, National Health and Nutrition Examination Survey.



Appendix
Consumption of Ultra-Processed Foods and Diet Quality Among U.S. Children and Adults
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Appendix Figure 4b Adults Predicted marginal means of total fruits (servings/d), total vegetables (serving/d), nuts and seeds (serving/d), added sugar (tsp/d), refined grain (serving/d) and sugar-sweetened beverages (serving/d) across quintiles of ultra-processed food consumption (%E) among U.S. adults (aged >20 years), NHANES 2015–2018. *Notes:* Data were adjusted for NHANES survey weights to be nationally representative. Error bars indicate 95% CIs. NHANES, National Health and Nutrition Examination Survey.



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