Ultraprocessed Food Versus Diet Quality in Relation to Cardiometabolic Health and All-Cause Mortality: NHANES 1999–2018

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Abstract

Objectives. To examine associations of ultraprocessed foods (UPFs, defined by Nova) with cardiometabolic risk factors, prevalent conditions, and mortality, before and after comprehensively adjusting for nutritional quality.

Methods. We analyzed data from 47 999 adults in the National Health and Nutrition Examination Survey (NHANES) 1999–2018. Survey-weighted, multivariable adjusted linear or logistic regression evaluated cross-sectional associations with risk factors and disease prevalence, and Cox models evaluated prospective associations with all-cause mortality. Models were compared before and after adjustment for each individual's Food Compass Score (i.FCS) to test independence from nutritional quality.

Results. Every 10% of energy supplied from UPFs was associated with higher body mass index, HbA1c, diastolic blood pressure, total-to-high-density lipoprotein cholesterol (HDL-C); lower HDL-C and low-density lipoprotein cholesterol (LDL-C); greater prevalence of metabolic syndrome (odds ratio [OR] = 1.07; 95% confidence interval [CI] = 1.05, 1.09), diabetes (OR = 1.03; 95% CI = 1.00, 1.07), and cancer (OR = 1.05; 95% CI = 1.02, 1.08); and higher risk of all-cause mortality (hazard ratio = 1.04; 95% CI = 1.02, 1.07). When we adjusted for i.FCS, associations were only partly attenuated, remaining significant. By comparison, adjustment for saturated fat, added sugar, or sodium had little effect. Findings were consistent in population subgroups, except for stronger associations among lower-income adults.

Conclusions. UPF consumption is associated with adverse risk factors, disease conditions, and all-cause mortality, only partly explained by nutritional quality. (*Am J Public Health*. 2026;116(7):1015–1024. https://doi.org/10.2105/AJPH.2026.308499)

Ultraprocessed foods (UPFs) are characterized by industrial processes and additives uncommon in home cooking that alter shelf life, flavor, texture, fat content, or production costs.[1] The potential health risks of UPFs are drawing significant public and policy attention, based on growing evidence from observational studies and randomized controlled trials linking UPF consumption with adverse health outcomes.[2–6] With UPFs supplying approximately 53% of adults' and 62% of children's energy,[7] understanding health effects is critical.

Controversy exists over the independent relevance of ultraprocessing per se.[8] Observed harms may be attributable to poor nutritional profiles, notably saturated fat, sodium, and sugar, rather than processing itself. If so, renewed focus would be needed on such nutrients, and the concept of UPFs may be a distraction from effective clinical, public health, and policy efforts targeting nutrient goals. Conversely, other features of UPFs—such as loss of natural cell structure, reduced polyphenols and other bioactives, presence of industrial additives, and packaging contaminants[2]—could also produce harms not captured by traditional nutrient-focused metrics or policies.[2]

The nutritional profiles of UPFs are considered part of the mechanisms of harm, but whether processing itself has long-term harms, independent of major nutrients, remains unclear. Two randomized controlled trials found that UPFs increase short-term calorie consumption independent of major nutrient characteristics.[3,7] Understanding whether UPFs are linked to harms beyond nutritional characteristics is critical for informing research, clinical, and policy efforts to improve healthful eating and address diet-related diseases.[9]

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We investigated the relationship of UPFs with cardiometabolic risk factors, prevalent disease conditions, and all-cause mortality in the National Health and Nutrition Examination Survey (NHANES), a nationally representative survey of US adults. We evaluated these associations with and without adjusting for diverse aspects of nutritional quality, comprehensively measured by a validated nutrient profiling score. We also explored UPF subtypes—sugar-sweetened beverages (SSBs), processed meats, and other UPFs—and population subgroups. We hypothesized that adjustment for nutrient quality would attenuate but not eliminate associations between UPFs and adverse outcomes.

METHODS

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We analyzed 47 999 adults aged 20 to 85 years from 10 cycles of NHANES (1999–2000 to 2017–2018), a nationally representative survey of the noninstitutionalized US population.[10] The sample included all participants with 1 or more dietary recall, with no additional exclusion criteria. We evaluated all-cause and cause-specific mortality via National Death Index linkage through 2018 (81 participants excluded for missing National Death Index data).[11] We examined UPF associations with cardiometabolic risk factors and disease conditions cross-sectionally and, with mortality, prospectively.

Ultraprocessed Foods and Nutrient Quality

NHANES interviewers conducted dietary recalls using the Automated Multiple Pass Method. One 24-hour dietary recall was available for participants in the 1999–2002 cycles, and 2 were available for most participants from 2003 onward, which were averaged. Two investigators independently classified foods using the Nova system: unprocessed or minimally processed (group 1), culinary ingredients (group 2), processed foods (group 3), and UPFs (group 4).[12] Foods were defined as UPFs if they were industrial formulations using ingredients uncommon in home cooking (e.g., flavorings, colorings, emulsifiers, and other additives) or undergoing multiple processing stages. We also separated SSBs and ultraprocessed meats, which include preservatives other than sodium (e.g., nitrites) and are linked with adverse health outcomes.

We assessed nutritional quality using Food Compass 2.0, a comprehensive food rating system validated against healthy diet patterns, including the Healthy Eating Index, and health outcomes.[13] This system evaluates a broader range of nutritional attributes than most nutrient profiling systems and is energy-weighted, providing a standardized measure of food healthfulness. The algorithm scores foods and beverages from 1 (least healthy) to 100 (most healthy) based on 54 attributes across 9 domains (Table 1). To isolate nutritional quality independent of UPFs, we modified the Food Compass Score to remove Nova classification and artificial additives from the processing domain. An individual-level Food Compass Score (i.FCS) was calculated from calorie-weighted scores of all foods and beverages consumed.[13]

TABLE 1—
Food Compass 2.0 Attributes

Outcomes

Risk factors included body mass index (BMI; kg/m^2); systolic and diastolic blood pressure (BP; mm Hg); high-density lipoprotein cholesterol (HDL-C; mg/dL), low-density lipoprotein cholesterol (LDL-C; mg/dL), triglycerides (mg/dL), total-to-high-density lipoprotein cholesterol (HDL-C) ratio; and hemoglobin A1c (HbA1c; %) and fasting plasma glucose (mg/dL).[10] Prevalent disease conditions included the following: metabolic syndrome (≥ 3 criteria: waist circumference ≥ 88 cm [women] or 102 cm [men], triglycerides ≥ 150 mg/dL or on lipid-lowering medication, HDL-C < 50 mg/dL [women] or < 40 mg/dL [men] or on lipid-lowering medication, BP ≥ 130 mmHg systolic or ≥ 85 mmHg diastolic or on antihypertensive medication, and fasting plasma glucose ≥ 100 mg/dL or on diabetes medication)[14]; diabetes (HbA1c > 6.5%, fasting plasma glucose > 126 mg/dL, or diabetes medication)[15]; cardiovascular disease (CVD; self-reported coronary heart disease, heart failure, stroke, myocardial infarction, angina or use of angina, hypertension or lipid-lowering medication); cancer (self-reported); lung disease (self-reported history of emphysema, bronchitis, asthma, chronic obstructive pulmonary disease); optimal cardiometabolic health (defined by adiposity: (BMI < 25 kg/m^2 and waist circumference (WC) ≤ 88 cm [women]/WC ≤ 102 cm [men]); blood glucose (fasting plasma glucose < 100 mg/dL and HbA1c < 5.7% without diabetes medication); blood lipids (total-to-HDL-C ratio < 3.5:1 without lipid-lowering medication); blood pressure (systolic BP < 120 mmHg, diastolic BP < 80 mmHg without antihypertensive medication); and history of CVD (no self-reported coronary heart disease, heart failure, myocardial infarction, stroke, or angina).[16] We assessed missing outcomes using Predictive Means Matching based on available predictors.[17,18]

Covariates

We assessed major demographic characteristics and lifestyle factors by standard NHANES methods, including age, gender, race/ethnicity, education, household income, smoking, alcohol use, and physical activity as Metabolic Equivalent of Task (MET)-hours per week.[10]

Statistical Analysis

We calculated descriptive statistics across quintiles of percentage of total energy (%E) consumed from UPFs, incorporating NHANES survey weight to generate nationally representative estimates.[19] In analyses of relationships with clinical risk factors, prevalent health conditions, and mortality, UPF consumption was evaluated per 10%E, and i.FCS was evaluated per standard deviation (SD; approximately 10 units). Survey-weighted linear regression with robust standard errors assessed associations of UPFs and i.FCS with continuous risk factors, and survey-weighted logistic regression with robust standard errors evaluated associations with prevalent health conditions. Cox proportional hazards assessed associations of UPFs and i.FCS with all-cause and cause-specific mortality, with study time as the time scale and time at risk calculated from the date of each participant's baseline dietary assessment until death or end of follow-up on December 31, 2019. We tested the proportional hazards assumption using Schoenfield residuals, and it was not violated.

We adjusted all models for age (years, years squared), gender, race and ethnicity (non-Hispanic White, non-Hispanic Black, Mexican American, Asian/other), education (< high school graduate, high school graduate, some college education [or associate degree], college graduate or more), household income (based on poverty-to-income ratio, continuous), smoking status (never, former, current), alcohol use (%E from alcohol), total physical activity (MET-hours per week), and prevalent diabetes (given evidence for reverse causation in sugar intake in this group). To assess effects independent of nutritional quality, we evaluated all risk estimates for UPFs with and without adjustment for i.FCS, calculating for each outcome the percent change and absolute change in the β coefficient for UPFs mediated through nutritional quality.[20] Additional models separately adjusted for added sugar (%E), saturated fat (%E), and sodium intake (mg/day).

In secondary analyses, we explored subcategories of UPF in relation to clinical risk factors, prevalent health conditions, and mortality risk, including SSBs, processed meats, and other UPFs (per 10%E), and population subgroups in relation to mortality risk, including by age (< 65, ≥ 65 years), gender, race (Asian/other race, non-Hispanic Black, other Hispanic, Mexican American, non-Hispanic White), education (≤ high school, > high school), and income (at the median, lower [poverty-to-income ratio ≤ 2.15], higher [poverty-to-income ratio > 2.15]). To assess statistical significance of differences by subgroup, multiplicative interaction terms were added to each model to compute *P* values for interaction. We evaluated trends in consumption of these UPF subgroups over time across the survey cycles.

RESULTS

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Among the included 47 999 US adults, those with higher UPF consumption were more likely to be younger, non-Hispanic White or Black, and a current smoker, and to have lower education and income, higher overall energy intake, and higher physical activity (Table 2).

TABLE 2—
Characteristics of 47 999 US Adults Aged 20 Years and Older According to Quintiles of Ultraprocessed Food (UPF) Consumption: National Health and Nutrition Examination Survey (NHANES), 1999–2018

Ultraprocessed Foods and Risk Factors

Higher UPF consumption was associated with major cardiometabolic risk factors, including (per 10%E) higher BMI (0.30 kg/m^2; 95% confidence interval [CI] = 0.26, 0.35), HbA1c (0.01%; 95% CI = 0.00, 0.01), diastolic BP (0.13 mmHg; 95% CI = 0.04, 0.22), and total-to-HDL-C ratio (0.02 units; 95% CI = 0.01, 0.03) and lower HDL-C (−0.53 mg/dL; 95% CI = −0.63, −0.42; Table 3). UPF consumption was not significantly associated with systolic BP, triglycerides, LDL-C, or fasting plasma glucose. When we evaluated prevalent diseases, UPF consumption was further associated with higher prevalence of metabolic syndrome (odds ratio [OR] = 1.07; 95% CI = 1.05, 1.09), diabetes (1.03; 95% CI = 1.00, 1.07), CVD (1.05; 95% CI = 1.02, 1.08), lung disease (1.07; 95% CI = 1.05, 1.09), and lower prevalence of optimal cardiometabolic health (0.93; 95% CI = 0.90, 0.96).

TABLE 3—
Association of Ultraprocessed Food (UPF) Consumption With Risk Factors and Disease Outcomes Among 47 999 Adults: National Health and Nutrition Examination Survey (NHANES), 1999–2018

After further adjustment for i.FCS, many of these associations of UPFs were partly attenuated but remained significant (Table 3). For example, the association of UPFs with higher BMI was attenuated by 16.7%, diastolic BP by 84.6%, and HDL-C by 81.1%. Associations of UPFs with higher total-to-HDL-C ratio were actually reversed (−0.02 units; 95% CI = −0.03, −0.01), whereas an inverse association with LDL-C became apparent (−1.04 mg/dL; 95% CI = −1.40, −0.68). When we evaluated prevalent diseases, associations of UPFs with metabolic syndrome were attenuated by 27.9%, CVD by 39.4%, and lower optimal cardiometabolic health by 43.7%, whereas the association with diabetes was strengthened by 65.1%. No appreciable changes were observed for cancer or lung disease. Findings were similar in posthoc sensitivity analyses excluding individuals with prevalent diabetes (Table A, available as a supplement to the online version of this article at http://www.ajph.org).

Ultraprocessed Foods and Mortality

During 20.8 years of follow-up, 7481 deaths occurred, including 2619 from cardiometabolic disease and 1691 from cancer. Each 10% greater UPF consumption was prospectively associated with a 4% higher risk of all-cause mortality (hazard ratio [HR] = 1.04; 95% CI = 1.02, 1.07; Table 4). After adjustment for i.FCS, the relationship of UPF consumption with total mortality was attenuated by 24.6% but remained significant (1.03; 95% CI = 1.00, 1.05). Cause-specific associations were directionally similar but not statistically significant.

TABLE 4—

Association of Ultraprocessed Food (UPF) Consumption With Mortality Among 47 918 Adults: National Health and Nutrition Examination Survey (NHANES), 1999–2018

Saturated Fat, Added Sugar, and Sodium

In analyses evaluating saturated fat, added sugar, and sodium as potential mediators of the associations between UPFs and each outcome, little consistent attenuation was observed (Table B). Adjustment for added sugar (%E) attenuated UPF associations with diastolic BP, HDL-C, CVD, cancer, and lung disease; strengthened associations with BMI, systolic BP, triglycerides, LDL-C, fasting plasma glucose, and diabetes; and reversed associations with the total-to-HDL ratio. Adjustment for saturated fat attenuated UPF associations with BMI, systolic BP, diastolic BP, fasting plasma glucose, and diabetes; and strengthened associations with LDL-C and HDL-C. Generally, most associations remained statistically significant even following attenuation. Adjustment for sodium (mg/day) attenuated UPF associations with systolic BP, LDL-C, and fasting plasma glucose. UPF associations with all-cause mortality were only slightly attenuated after adjusting for added sugar, were unchanged after adjusting for saturated fat, and were slightly strengthened after adjusting for sodium.

Ultraprocessed Food Subgroups

SSB consumption (per 10%) positively associated with BMI (0.34 kg/m^2; 95% CI = 0.22, 0.46), systolic BP (0.35 mmHg; 95% CI = 0.12, 0.59), diastolic BP (0.40 mmHg; 95% CI = 0.21, 0.60), LDL-C (1.05 mg/dL; 95% CI = 0.34, 1.76), and the total-to-HDL-C ratio (0.14 units; 95% CI = 0.12, 0.16), and inversely with HDL-C (−1.79 mg/dL; 95% CI = −2.01, −1.58; Table C). SSB consumption also was associated with higher prevalence of metabolic syndrome (OR = 1.14; 95% CI = 1.10, 1.19), CVD (1.13; 95% CI = 1.06, 1.20), cancer (1.10; 95% CI = 1.04, 1.17), and lung disease (1.10; 95% CI = 1.07, 1.16), and lower prevalence of optimal cardiometabolic health (0.86; 95% CI = 0.71, 0.92). After adjustment for i.FCS, these associations were attenuated by 20.6% for BMI, 68.6% for systolic BP, 45% for diastolic BP, 38% for HDL-C, 50% for total-to-HDL-C ratio, 20.4% for metabolic syndrome, 22% for cardiovascular disease, 0% for lung disease, and 44.7% for optimal cardiometabolic health. Associations of SSBs with LDL-C were reversed after adjusting for i.FCS.

Processed meat consumption (per 10%) was positively associated with BMI (0.82 kg/m^2; 95% CI = 0.37, 1.00), systolic BP (0.60 mmHg; 95% CI = 0.22, 0.98), diastolic BP (0.47 mmHg; 95% CI = 0.20, 0.75), fasting plasma glucose (0.55 mg/dL; 95% CI = 0.01, 1.09), metabolic syndrome (1.17; 95% CI = 1.11, 1.23), and diabetes (1.14; 95% CI = 1.04, 1.25), and inversely associated with optimal cardiometabolic health (0.81; 95% CI = 0.71, 0.92; Table C). Adjusting for i.FCS attenuated these associations by 6.1% for BMI, 25% for systolic BP, 23.4% for diastolic BP, 5.5% for fasting plasma glucose, 11% for metabolic syndrome, and 17.3% for optimal cardiometabolic health. Associations with diabetes were unchanged after adjusting for i.FCS.

Other UPF consumption (per 10%) was positively associated with BMI (0.24 kg/m^2; 95% CI = 0.19, 0.29), HbA1c (0.01%; 95% CI = 0.00, 0.02), metabolic syndrome (1.05; 95% CI = 1.03, 1.07), CVD (1.04; 95% CI = 1.01, 1.07), cancer (1.05; 95% CI = 1.01, 1.08), and lung disease (1.06; 95% CI = 1.04, 1.09), and inversely associated with LDL-C (−0.55 mmHg; 95% CI = −0.90, 0.20), HDL-C (−0.28 mmHg; 95% CI = −0.39, 0.17) and optimal cardiometabolic health (0.96; 95% CI = 0.92, 0.99). These associations were only partly attenuated after adjusting for i.FCS, including 12.5% attenuation for BMI and 92.9%

attenuation for HDL-C. Associations were strengthened by 109.1% for LDL-C and 200% for the total-to-HDL-C ratio, and unchanged for HbA1c after adjusting for i.FCS (Table C).

In prospective assessment of mortality, other UPFs (1.03; 95% CI = 1.01, 1.06) and SSBs (1.16; 95% CI = 1.09, 1.23) each were positively associated with all-cause mortality; Table C). SSBs also were positively associated with cardiometabolic disease-specific (1.11; 95% CI = 1.02, 1.21) and cancer-specific (1.18; 95% CI = 1.06, 1.30) mortality. Processed meats were not significantly associated with all-cause or cause-specific mortality. Adjusting for i.FCS only partly attenuated associations for other UPFs and SSBs with all-cause mortality, with 33% and 17.7% attenuations, respectively. SSB association was attenuated by 8.7% for cardiometabolic-disease specific mortality and 15.6% for cancer-specific mortality after adjusting for i.FCS.

When we evaluated trends in UPF subgroups over time, consumption of ultraprocessed sweet snacks and sweets, savory snacks, ready-to-eat or ready-to-heat mixed dishes, animal-based products, whole-grain foods, and dairy foods increased, whereas ultraprocessed SSBs, refined grain foods, vegetables and beans, fats and oils, condiments, and sauces decreased; Figure A).

Population Subgroups

The relationships of UPFs with all-cause mortality, and the partial attenuation after adjustment for i.FCS, were similar in all population groups except by household income (*P* interaction = .005; Figure B). A positive association between UPFs and mortality was observed among lower-income adults (1.07; 95% CI = 1.04, 1.11), but not higher-income adults (1.02; 95% CI = 0.98, 1.05), and little attenuation occurred among lower income adults after adjustment for i.FCS (13.9%).

DISCUSSION

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UPF consumption was associated with adverse cardiometabolic risk profiles, greater chronic disease prevalence, and higher all-cause mortality. After adjustment for the nutritional quality (i.FCS), many associations were attenuated, but generally only partly, suggesting that common nutritional metrics explain only part of the observed harms. Adjustment for saturated fat, added sugar, and sodium had little effect, suggesting these are not key mediators. SSBs, processed meats, and other UPFs associated with cardiometabolic risk factors and conditions; SSBs and other UPFs were also associated with all-cause mortality. Findings were generally consistent across most demographic subgroups, except income: associations of UPFs with mortality were stronger, and largely unaffected by adjustment for nutritional quality, among lower-income adults.

The adverse health effects of UPFs may operate through multiple mechanisms. Evidence from observational, animal, in vitro, and human studies have raised concerns about the adverse features of UPFs, including harmful nutrients like starch, sugar, and salt; loss of fiber, polyphenols, and other bioactives; loss of natural food structure, speeding digestion in the stomach and small intestine and reducing nourishment to the gut microbiome; the harms of certain additives like specific sweeteners, flavorings, colorants, emulsifiers, or preservatives; introduction of toxins like furans, heterocyclic amines, polycyclic aromatic hydrocarbons, or acrylamide; and packaging contaminants such as phthalates, bisphenols, mineral oils, or microplastics.[2,7] Combinations of relevant pathways can vary across UPF products, but the Nova classification suggests that processing confers risk beyond nutrients.

Our new findings support this concept. Food Compass includes types of fat, carbohydrate and added sugar, fiber, protein, vitamins, minerals, sodium, omega 3's and other trace lipids, and even certain bioactives such as carotenoids and polyphenols. Food Compass also incorporates food-based ingredients (e.g., quantities of fruits, vegetables, nuts, fish) and other aspects of processing that do not qualify as UPFs (e.g., fermentation). Adjustment for these features only partly attenuated most of the observed associations. Our results are consistent with short-term randomized controlled trials demonstrating that UPF diets increase energy intake and body weight compared with unprocessed diets, despite being matched for macronutrients, fiber, sugar, and sodium.[3]

At least 20 US states have passed or proposed bills addressing different aspects of UPFs, using varying definitions, from bans or warning labels on certain additives to restrictions on UPFs in school meals. Laws or bills in Alabama, Arizona, Arkansas, Connecticut, Florida, Kentucky, Louisiana, Maryland, Missouri, New Jersey, North Carolina, South Carolina, Texas, and West Virginia focus on a small number of specific food or color additives, which may fail to capture most UPFs. Other states, such as Pennsylvania and Massachusetts, have proposed—but not yet passed—broader definitions consistent with Nova: industrial formulations containing cosmetic, functional, or technical additives uncommon in home kitchens. In October 2025, California passed a definition of UPFs with 2 required criteria: (1) the presence of industrial ingredients with cosmetic, technical, or functional effects,[21] similar to criteria in Pennsylvania[22] and Massachusetts,[23] and (2) a requirement for

minimum levels of sodium, added sugar, or saturated fat. The latter criterion creates a loophole, excluding many current and future UPF formulations that meet the thresholds for the 3 targeted nutrients but still have adverse characteristics. Our findings that saturated fat, added sugar, and sodium generally have little influence on the associations of UPFs with adverse health outcomes suggest that policies defining and addressing UPFs should not include these nutrients as additional criteria.

No current states have included nitrite preservatives, widely used in processed meats, as part of the UPF definition. We found that processed meat consumption was associated with greater BMI, higher BP and glucose levels, metabolic syndrome, and diabetes, and less optimal cardiometabolic health, but not with all-cause mortality.

The current administration recently released the MAHA Strategy to address chronic disease in youths, which included several plans related to UPFs.[24] This included plans to develop a federal definition of UPFs, enabling coherent standards across labeling, marketing, procurement, and research. In July 2025, the Food and Drug Administration (FDA) and Department of Agriculture jointly released a public Request for Information on this topic. In addition, the strategy includes plans to reform the FDA's "Generally Recognized as Safe" pathway, which allows industrial ingredients to enter the food supply through self-affirmed safety determinations by manufacturers.[25] Our new findings support the need to consider UPFs separately from conventional nutritional criteria. The recently published 2025 Dietary Guidelines for Americans has also included recommendations discouraging consumption of highly processed foods.

Our observation that associations with mortality were strongest among lower-income adults was not expected and requires further evaluation in other studies. UPFs exhibit considerable heterogeneity, and it is plausible that lower-income Americans consume UPFs with more adverse features than higher-income Americans do because of challenges around cost, access, knowledge, time to shop and cook, health and nutrition literacy, and more.[26]

Our findings in a nationally representative US population align with findings from large-scale prospective cohorts in other populations (NutriNet-Santé, Moli-Sani, Seguimiento Universidad de Navarra [SUN], Framingham, National Institutes of Health–AARP).[5,27–29] Across multiple large cohorts, associations between high UPF intake and increased risks for all-cause mortality, CVD, and type-2 diabetes largely persisted after adjusting for the overall nutritional quality (e.g., via Programme National Nutrition Santé—Guidelines Score, Healthy Eating Index–2015, Modified Food Standard Agency–Nutrient Profiling System, or Mediterranean diet adherence) or selected nutrients or indices such as energy density, carbohydrates, protein, total fat, fiber, saturated fat, and sodium. For example, although these adjustments sometimes attenuated the risk estimates (e.g., SUN type 2 diabetes HR from 1.65 to 1.50; NutriNet-Santé CVD HR from 1.13 to 1.11), the associations were not eliminated, and in several cases were not materially altered (e.g., Moli-Sani mortality HR from 1.19 to 1.20; Framingham mortality remains HR = 1.09).[5,27–29] Our new findings build upon these limited prior results by using a comprehensive validated nutritional profiling score in a large, nationally representative population, evaluating risk factors, prevalent disease, and all-cause mortality.

Strengths and Limitations

The large study population of nearly 50 000 adults provided statistical power to test associations. The use of 24-hour recalls provided product-specific assessment of UPFs and nutritional quality compared with food frequency questionnaires, which only assess broad food categories. NHANES includes a range of well-measured sociodemographic, dietary, lifestyle, and outcome data, reducing measurement error and increasing the ability to adjust for confounding factors.

Although repeated 24-hour recalls are a gold standard approach for assessing population dietary consumption, individuals' intakes may be partly misclassified because of diet variation over time, which would attenuate associations. Processed foods may be more commonly misreported in dietary recalls than minimally processed foods.[13] Associations with risk factors and prevalent diseases were cross-sectional, subject to reverse causation; however, the findings were broadly consistent in prospective analyses of all-cause mortality. These findings are observational, and residual confounding cannot be excluded.

Public Health Implications

UPFs constitute a substantial portion of the American diet, accounting for more than 50% of adult and about 60% of child caloric intake.[7] The observed associations, such as a 0.3-unit difference in BMI and 4% higher risk of all-cause mortality, therefore translate into meaningful estimated public health burdens when considered at the population level. These findings emphasize the value of incorporating more unprocessed and minimally processed foods into the diet and limiting UPF intake. Efforts to improve overall nutritional quality among both individuals and communities, including reducing UPFs, can contribute to chronic disease prevention and help alleviate health care

costs. Addressing structural and policy-related barriers to accessing healthier foods remains critical for promoting equitable dietary improvements across populations.

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CONFLICTS OF INTEREST

D. Mozaffarian reports service on scientific advisory boards for Beren Therapeutics, Brightseed, Calibrate, Elysium Health, Filtricine, HumanCo, Instacart Health, January Inc, WndrHLTH; scientific consulting for Amazon Health; equity in Calibrate and HumanCo; and chapter royalties from UpToDate. All other authors declare no conflict of interests.

HUMAN PARTICIPANT PROTECTION

The Tufts University institutional review board exempted this investigation from human participant review because it was based on nationally representative, de-identified data sets.

References

1.. Monteiro CA, Cannon G, Levy RB, et al. Ultra-processed foods: what they are and how to identify them. *Public Health Nutr.* 2019;22(5):936–1023. https://doi.org/10.1017/S1368980018003762 Crossref, Medline, Google Scholar

2.. Touvier M, da Costa Louzada ML, Mozaffarian D, Baker P, Juul F, Srour B. Ultra-processed foods and cardiometabolic health: public health policies to reduce consumption cannot wait. *BMJ.* 2023;383:e075294. https://doi.org/10.1136/bmj-2023-075294 Medline, Google Scholar

3.. Hall KD, Ayuketah A, Brychta R, et al. Ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake. *Cell Metab.* 2019; 30(1):67–77.e63. https://doi.org/10.1016/j.cmet.2019.05.008 Crossref, Medline, Google Scholar

4.. Wang L, Du M, Wang K, et al. Association of ultra-processed food consumption with colorectal cancer risk among men and women: results from three prospective US cohort studies. *BMJ.* 2022;378:e068921. https://doi.org/10.1136/bmj-2021-068921 Medline, Google Scholar

5.. Bonaccio M, Di Castelnuovo A, Ruggiero E, et al. Joint association of food nutritional profile by Nutri-Score front-of-pack label and ultra-processed food intake with mortality: Moli-Sani Prospective Cohort Study. *BMJ.* 2022;378:e070688. https://doi.org/10.1136/bmj-2022-070688 Medline, Google Scholar

6.. Wang L, Steele EM, Du M, et al. Association between ultraprocessed food consumption and mortality among US adults: Prospective Cohort Study of the National Health and Nutrition Examination Survey, 2003–2008. *J Acad Nutr Diet.* 2025;125(7):875–887.e7. https://doi.org/10.1016/j.jand.2024.11.014 Medline, Google Scholar

7.. Hamano S, Sawada M, Aihara M, et al. Ultra-processed foods cause weight gain and increased energy intake associated with reduced chewing frequency: a randomized, open-label, crossover study. *Diabetes Obes Metab.* 2024; 26(11):5431–5443. https://doi.org/10.1111/dom.15922 Medline, Google Scholar

8.. Scientific Advisory Committee on Nutrition. Processed foods and health: rapid evidence update. GOV.UK. 2025. Available at: https://www.gov.uk/government/publications/processed-foods-and-health-sacns-rapid-evidence-update. Accessed October 11, 2025. Google Scholar

9.. Dietary Guidelines Advisory Committee. *Scientific Report of the 2025 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and Secretary of Agriculture.* Washington, DC: US Dept of Agriculture; 2024. Google Scholar

10.. Zipf G, Chiappa M, Porter KS, et al. National Health and Nutrition Examination Survey: plan and operations, 1999–2010. *Vital Health Stat 1.* 2013;1(56):1–37. Google Scholar

11.. *The Linkage of National Center for Health Statistics Survey Data to the National Death Index–2019 Linked Mortality File (LMF): Linkage Methodology and Analytic Considerations, June 2022.* Hyattsville, MD: National Center for Health Statistics; 2022. Google Scholar

12.. Williams AM, Couch CA, Emmerich SD, Ogburn DF. Ultra-processed food consumption in youth and adults: United States, August 2021–August 2023. *NCHS Data Brief.* 2025;536(536):1–11. https://doi.org/10.15620/cdc/174612 Google Scholar

13.. Barrett EM, Shi P, Blumberg JB, O'Hearn M, Micha R, Mozaffarian D. Food Compass 2.0 is an improved nutrient profiling system to characterize healthfulness of foods and beverages. *Nat Food.* 2024;5(11):911–915. https://doi.org/10.1038/s43016-024-01053-3 Medline, Google Scholar