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Ultra-Processed Food Consumption as a Risk Factor for Obesity, Metabolic Syndrome, and Cardiovascular Disease: A Narrative Review

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ABSTRACT

Background: Ultra-processed foods, defined in the NOVA system as industrial formulations made largely from food-derived substances and additives, are common in modern diets. Their palatability, convenience, shelf life, and contribution to energy intake have raised concerns about cardiometabolic health.

Aim: This narrative review summarizes evidence on the association between ultra-processed food consumption and obesity, metabolic syndrome, and cardiovascular disease, with emphasis on biological mechanisms, evidence limitations, and public health implications.

Material and methods: Peer-reviewed literature published up to 2026 was reviewed using PubMed and Google Scholar. Priority was given to systematic reviews, meta-analyses, umbrella reviews, cohort studies, observational studies, and mechanistic research.

Results: Higher ultra-processed food consumption has been associated with obesity-related outcomes, metabolic syndrome, type 2 diabetes, cardiovascular disease, and cardiovascular mortality. These associations may be partly explained by the unfavorable nutritional profile of UPF-rich diets, including high energy density, added sugars, sodium, unhealthy fats, and low fiber content. Other factors, such as altered food structure, high palatability, selected additives, and displacement of minimally processed foods, may contribute to excessive energy intake, insulin resistance, inflammation, oxidative stress, dyslipidemia, hypertension, endothelial dysfunction, and gut microbiota changes.

Conclusions: Ultra-processed food consumption is relevant to cardiometabolic health and should be considered in dietary assessment and prevention strategies. Reducing excessive UPF intake while promoting minimally processed, nutrient-dense foods may support long-term health. Further prospective studies, intervention trials, and mechanistic research are needed to clarify causality, dose-response relationships, and the role of food processing versus nutrient composition.

Key words: Food, Processed; Ultra-Processed Foods; Obesity; Metabolic Syndrome; Cardiovascular Diseases; Public Health.

1. Introduction

Ultra-processed foods have become an important component of contemporary dietary patterns. According to the NOVA classification system, which categorizes foods based on the nature, extent, and purpose of industrial processing, UPFs are defined as industrial formulations made primarily from substances extracted from foods, derived from food constituents, or synthesized for industrial use (Monteiro et al., 2017, 2019). These products are typically designed to be convenient, highly palatable, ready-to-eat or ready-to-heat, and shelf-stable. They frequently contain refined starches, protein isolates, sweeteners, emulsifiers, stabilizers, artificial sweeteners, and other additives that are rarely used in domestic food preparation (Canella et al., 2023; Chen et al., 2020; Steele et al., 2017).

The global nutrition transition has been accompanied by a growing contribution of UPFs to daily energy intake. Although consumption has traditionally been highest in high-income countries, increasing intake has also been observed in low- and middle-income countries (Baker et al., 2020; Dicken & Batterham, 2022). This trend is driven by high availability, affordability, convenience, long shelf life, intensive marketing, and changing food environments (Chen et al., 2020; Dicken & Batterham, 2022). As a result, UPFs have become a relevant public health concern.

Higher UPF consumption has been associated in observational studies with several adverse health outcomes, including obesity, metabolic syndrome, type 2 diabetes, cardiovascular disease, and all-cause mortality (Canella et al., 2023; Chen et al., 2020; Srouf & Touvier, 2021). However, these findings should be interpreted cautiously because most available studies identify associations rather than direct causality and may be influenced by residual confounding, differences in dietary assessment methods, socioeconomic factors, and overall diet quality.

Several mechanisms may partly explain the relationship between UPF intake and cardiometabolic risk. UPF-rich diets are commonly characterized by high energy density, high levels of added sugars, sodium, and unhealthy fats, and lower amounts of dietary fiber and

micronutrients (Chen et al., 2020; Steele et al., 2017). In addition, altered food structure, high palatability, selected additives, and displacement of minimally processed foods may contribute to excessive energy intake, insulin resistance, inflammation, dyslipidemia, hypertension, and endothelial dysfunction.

The aim of this narrative review is to summarize current evidence on the association between ultra-processed food consumption and obesity, metabolic syndrome, and cardiovascular disease, with particular emphasis on potential biological mechanisms, limitations of available evidence, and public health implications.

2. Materials and Methods

This narrative review searched and synthesized peer-reviewed literature published up to 2026 using PubMed and Google Scholar. The search focused on ultra-processed food consumption, the NOVA classification, obesity, metabolic syndrome, insulin resistance, type 2 diabetes, cardiovascular disease, biological mechanisms, and public health implications. Search terms included “ultra-processed foods,” “UPF,” “NOVA classification,” “obesity,” “body mass index,” “abdominal obesity,” “metabolic syndrome,” “insulin resistance,” “type 2 diabetes,” “hypertension,” “dyslipidemia,” “cardiovascular disease,” “stroke,” “cardiovascular mortality,” “inflammation,” “oxidative stress,” and “gut microbiota.”

Priority was given to systematic reviews, meta-analyses, umbrella reviews, prospective cohort studies, large observational studies, and relevant mechanistic studies. Older landmark papers were included when necessary to define the NOVA classification and the concept of ultra-processed foods.

Included publications were peer-reviewed English-language articles focused on adult or general populations and relevant to UPF intake and cardiometabolic health. Non-peer-reviewed sources, opinion pieces without scientific data, and studies unrelated to UPF consumption or cardiometabolic outcomes were excluded. Because this was a narrative review, no formal risk-of-bias assessment or quantitative meta-analysis was performed.

3. Results / Description of the State of Knowledge

3.1. Definition and Classification of Ultra-Processed Foods

3.1.1. NOVA classification as the conceptual basis for defining UPF

The NOVA classification system is a widely used framework for categorizing foods according to the extent and purpose of industrial processing, rather than solely according to

their nutrient composition (Monteiro et al., 2017, p. 9, 2019, p. 937). This approach is particularly relevant in nutritional epidemiology because it allows researchers to distinguish foods not only by their macronutrient or micronutrient profile, but also by the degree of industrial formulation and modification involved in their production.

NOVA divides foods into four main groups. Group 1 includes unprocessed or minimally processed foods, such as fruits, vegetables, grains, legumes, milk, eggs, meat, and fish. Group 2 consists of processed culinary ingredients, including oils, butter, sugar, and salt, which are used in food preparation. Group 3 comprises processed foods, usually made by adding salt, sugar, oil, or other culinary ingredients to Group 1 foods in order to improve preservation or palatability. Group 4 includes ultra-processed foods, which are industrial formulations made mostly from substances extracted from foods, derived from food constituents, or synthesized for industrial use (Monteiro et al., 2017, p. 9; Silva et al., 2021, p. 3).

3.1.2. Characteristics of ultra-processed foods

Ultra-processed foods are typically multi-ingredient industrial products that contain little or no intact whole food. They often include substances rarely used in domestic cooking, such as protein isolates, modified starches, hydrogenated fats, hydrolyzed proteins, maltodextrin, high-fructose corn syrup, and other refined ingredients (Canella et al., 2023, p. 13698; Monteiro et al., 2017, p. 9). Their production may involve industrial techniques such as extrusion, moulding, pre-frying, and hydrogenation.

A defining feature of UPFs is the use of additives that improve taste, texture, appearance, shelf life, and consumer acceptability. These include emulsifiers, preservatives, flavour enhancers, colourants, stabilizers, and artificial sweeteners. As a result, UPFs are often ready-to-eat or ready-to-heat, convenient, durable, highly palatable, and commercially attractive. They are also frequently characterized by high energy density, high levels of added sugars, sodium, and unhealthy fats, and relatively low dietary fiber and micronutrient content (Chen et al., 2020, p. 87; Steele et al., 2017, p. 7).

3.1.3. Examples of commonly consumed ultra-processed foods

Commonly consumed UPFs include sugar-sweetened beverages, soft drinks, energy drinks, packaged snacks, confectionery, sweetened breakfast cereals, instant noodles, ready-to-eat meals, fast-food products, industrial bakery products, packaged desserts, and many mass-produced packaged breads or sweetened milk-based drinks (Chen et al., 2020, p. 87; Silva et al., 2021, p. 3). Some industrial meat products, such as hot dogs, chicken nuggets, burgers, fish sticks, and certain sausages, may also be classified as UPFs when they are reconstituted, mechanically modified, or contain multiple additives and industrial ingredients.

3.1.4. Difference between processed foods and ultra-processed foods

A key distinction in the NOVA framework is that not every processed food is ultra-processed. Many traditional processing methods, such as freezing, drying, fermentation, pasteurization, or canning, may improve food safety or shelf life without making the product ultra-processed. Processed foods are generally produced by adding culinary ingredients to minimally processed foods, while the original food matrix remains largely recognizable. In contrast, ultra-processed foods are characterized by extensive industrial formulation, the use of ingredients not commonly found in home kitchens, and the presence of cosmetic additives. This distinction provides the basis for understanding why UPF consumption may be relevant to the risk of obesity, metabolic syndrome, and cardiovascular disease.

3.2. Consumption Patterns and Nutritional Characteristics of Ultra-Processed Foods

3.2.1. Increasing consumption and public health relevance

The global nutrition transition is characterized by a growing contribution of ultra-processed foods to daily energy intake. Driven by high availability, affordability, long shelf life, convenience, and intensive marketing, this trend is observed globally, including in low- and middle-income countries (Baker et al., 2020; Chen et al., 2020; Dicken & Batterham, 2022). The widespread consumption of UPFs is considered an important public health issue, with research indicating that UPFs often dominate diets worldwide and are associated with a range of chronic lifestyle diseases (Smuszkiewicz-Róžański et al., 2024). Consequently,

observational studies have consistently associated higher UPF intake with obesity, type 2 diabetes, cardiovascular disease, and other non-communicable diseases (Chen et al., 2020; Srouf & Touvier, 2021).

3.2.2. Nutritional profile of ultra-processed foods

UPFs typically have an unfavorable nutritional profile, characterized by high energy density and substantial amounts of added sugars, sodium, refined carbohydrates, and unhealthy fats (Srouf & Touvier, 2021). They are generally lower in dietary fiber, vitamins, minerals, and other beneficial bioactive compounds compared with diets based on unprocessed or minimally processed foods (Chen et al., 2020; Steele et al., 2017). Replacing whole foods with UPFs may therefore reduce overall diet quality and contribute to excessive energy intake. Furthermore, industrial processing can alter the food matrix, which may influence digestion, absorption, glycemic regulation, and satiety (Anih et al., 2025; Srouf & Touvier, 2021).

3.2.3. Non-nutritional characteristics of ultra-processed foods

Beyond their nutrient profile, UPFs often contain additives such as emulsifiers, artificial sweeteners, preservatives, flavour enhancers, colourants, and stabilizers, which are used to improve sensory properties, appearance, texture, and shelf life (Srouf & Touvier, 2021). Some studies suggest that selected additives may influence gut microbiota composition, intestinal barrier function, or low-grade inflammation, although human evidence remains limited and evolving (Kaiser et al., 2026; Srouf & Touvier, 2021). Additionally, industrial processing and packaging may introduce contaminants or food-contact chemicals, such as phthalates and bisphenols, which have been discussed as potential contributors to metabolic and cardiovascular risk (Anih et al., 2025; Srouf & Touvier, 2021). However, evidence on these non-nutritional factors is less conclusive than evidence concerning the overall poor nutritional quality and high consumption of UPFs.

3.2.4. Relevance for cardiometabolic outcomes

The combination of high palatability, unfavorable nutritional composition, altered food structure, and exposure to various industrial ingredients provides a plausible rationale for studying UPFs in relation to metabolic and cardiovascular health. These characteristics may contribute to excessive energy intake, poorer diet quality, appetite dysregulation, insulin resistance, inflammation, and other metabolic disturbances. Consequently, UPF consumption is increasingly studied as a dietary factor potentially associated with obesity, metabolic

syndrome, and cardiovascular disease. The following section discusses the biological mechanisms that may explain these associations.

3.3. Biological Mechanisms Linking Ultra-Processed Food Consumption with Cardiometabolic Risk

3.3.1. Excess energy intake and positive energy balance

UPFs are often characterized by high energy density, strong palatability, convenience, and low satiety potential, which may facilitate overconsumption (Babalola et al., 2025; Godsey et al., 2025). By promoting frequent snacking, large portion sizes, and replacement of nutrient-dense whole foods, UPF-rich dietary patterns may contribute to sustained positive energy balance. Over time, this may favor weight gain and increased adiposity, which are important contributors to metabolic syndrome and cardiovascular risk (Singar et al., 2026; Sitasari et al., 2025).

3.3.2. Satiety dysregulation and eating behavior

The industrial formulation of UPFs often results in soft textures and products requiring minimal chewing, which may increase eating rate and weaken physiological satiety responses (Godsey et al., 2025). In addition, liquid calories, refined carbohydrates, and the reduced structural complexity of UPFs may impair energy compensation after meals. These characteristics could partly explain why diets rich in UPFs are associated with higher spontaneous energy intake compared with diets based on minimally processed foods (Rondinella et al., 2025; Singar et al., 2026).

3.3.3. Insulin resistance and impaired glucose homeostasis

High UPF consumption may be linked to impaired glucose metabolism through the frequent presence of refined carbohydrates, added sugars, and high-glycemic products. These factors may contribute to rapid postprandial glucose fluctuations, increased insulin demand, and, over time, reduced insulin sensitivity (Sitasari et al., 2025). Excess adiposity, which may result from chronic positive energy balance, can further contribute to systemic insulin resistance and increase the risk of type 2 diabetes (Babalola et al., 2025; Singar et al., 2026).

3.3.4. Gut microbiota alterations and intestinal barrier function

UPF-rich diets are often low in dietary fiber and may contain additives such as emulsifiers and artificial sweeteners, which have been discussed as potential modulators of gut microbiota composition and intestinal barrier function (Asensi et al., 2023; Rondinella et al., 2025). Reduced fiber intake may decrease microbial diversity and short-chain fatty acid production, while selected additives may influence intestinal permeability and inflammatory signaling. However, much of the evidence on these pathways comes from experimental or preclinical studies, and human evidence remains less conclusive (Godsey et al., 2025; Singar et al., 2026).

3.3.5. Chronic low-grade inflammation and oxidative stress

Several characteristics of UPF-rich diets may contribute to chronic low-grade inflammation and oxidative stress, including poor diet quality, excess adiposity, gut microbiota alterations, high intake of refined sugars and unhealthy fats, and possible exposure to selected contaminants such as bisphenols and phthalates (Babalola et al., 2025; Singar et al., 2026). These processes may be relevant to endothelial dysfunction, insulin resistance, and the development of atherosclerotic changes, thereby providing a possible mechanistic link between UPF consumption and cardiovascular risk (Asensi et al., 2023).

3.3.6. Dyslipidemia, hypertension, and endothelial dysfunction

UPF-rich dietary patterns may also contribute to cardiometabolic risk through adverse effects on lipid metabolism and vascular function. High intakes of refined carbohydrates, added sugars, saturated fats, trans fats, or other industrial fats may be associated with elevated triglycerides, increased LDL cholesterol, and reduced HDL cholesterol (Sitasari et al., 2025). In addition, the high sodium content of many savory UPFs may contribute to increased blood pressure, while inflammation and oxidative stress may impair endothelial function. These mechanisms may partly explain the observed associations between UPF consumption and cardiovascular disease (Babalola et al., 2025; Singar et al., 2026).

Overall, these mechanisms should be interpreted as interrelated rather than isolated pathways. Excess energy intake, adiposity, insulin resistance, gut microbiota alterations, inflammation, oxidative stress, dyslipidemia, hypertension, and endothelial dysfunction may interact and provide biological plausibility for the association between UPF consumption and obesity, metabolic syndrome, and cardiovascular disease.

3.4. Ultra-Processed Food Consumption and Obesity

3.4.1 Association between UPF consumption and body weight

Epidemiological evidence has linked the consumption of ultra-processed foods with higher risk of weight gain and obesity-related outcomes. Prospective cohort studies suggest that individuals with higher UPF intake may have a greater tendency toward body weight increase over time compared with those consuming fewer ultra-processed products (Godsey et al., 2025). Although much of the evidence comes from observational studies, findings reported across different populations support a possible association between UPF-rich dietary patterns and increased adiposity (Srouf & Touvier, 2021). This relationship may partly reflect the displacement of nutrient-dense minimally processed foods, poorer overall diet quality, and higher total energy intake.

3.4.2 UPF consumption and BMI

The association between UPF intake and body mass index has been widely examined in nutritional epidemiology. In adult populations, cross-sectional and longitudinal studies have reported that a higher dietary contribution of UPFs is associated with higher BMI and a greater likelihood of overweight or obesity (Babalola et al., 2025; Sitasari et al., 2025). However, comparisons between studies may be affected by differences in dietary assessment methods, population characteristics, and adjustment for confounding variables. Some evidence also suggests similar associations in adolescents, although adult populations remain the main focus of much of the current literature (Sitasari et al., 2025).

3.4.3 Abdominal obesity and adiposity

Beyond BMI, UPF consumption has also been investigated in relation to abdominal obesity and adiposity measures, including waist circumference and visceral fat accumulation. Abdominal adiposity is clinically relevant because it is closely associated with insulin resistance, metabolic dysfunction, and increased cardiometabolic risk (Singar et al., 2026).

Available evidence suggests that higher UPF intake may be associated with increased waist circumference and a greater likelihood of central obesity (Singar et al., 2026). These findings are important because visceral adiposity may act as an intermediate factor linking dietary patterns with later metabolic and cardiovascular outcomes.

3.4.4 Potential explanations for the UPF–obesity association

The association between UPF consumption and obesity is likely multifactorial. UPFs are often energy-dense, highly palatable, inexpensive, convenient, and available in large portions, which may facilitate excessive energy intake (Godsey et al., 2025). Their soft texture and reduced need for chewing may increase eating rate and weaken satiety responses. In addition, frequent snacking, sugar-sweetened beverages, refined carbohydrates, added fats, and low dietary fiber content may contribute to poorer appetite regulation and reduced dietary quality (Singar et al., 2026). These factors may partly explain why UPF-rich diets are associated with weight gain and adiposity.

3.4.5 Interpretation of current evidence

Overall, current evidence supports a positive association between higher UPF consumption and obesity-related outcomes, including increased body weight, higher BMI, and abdominal adiposity. However, causality should be interpreted cautiously because many studies are observational and may be influenced by residual confounding, self-reported dietary intake, and differences in UPF classification. Further prospective and interventional studies are needed to clarify the strength and direction of this relationship.

3.5. Ultra-Processed Food Consumption and Metabolic Syndrome

3.5.1. Definition and components of metabolic syndrome

Metabolic syndrome represents a cluster of interrelated cardiometabolic abnormalities associated with increased risk of type 2 diabetes and cardiovascular disease. It is commonly defined by the co-occurrence of at least three of five criteria: abdominal obesity, elevated

blood pressure, impaired glucose metabolism or insulin resistance, elevated triglycerides, and reduced high-density lipoprotein cholesterol. These components reflect underlying metabolic dysfunction and often coexist in individuals with excess adiposity and unfavorable dietary patterns.

3.5.2. Association between UPF consumption and metabolic syndrome risk

Epidemiological evidence has linked higher ultra-processed food consumption with increased prevalence and risk of metabolic syndrome. Prospective cohort studies, including the Longitudinal Study of Adult Health, have reported positive associations between higher UPF intake and the incidence of metabolic syndrome (Canhada et al., 2022). Similarly, analyses from the China Health and Nutrition Survey suggest that long-term high consumption of UPFs may be associated with a greater risk of developing metabolic syndrome (Pan et al., 2023). These findings are supported by systematic reviews and meta-analyses reporting a positive association between high UPF intake and metabolic syndrome, although the magnitude of these associations may be influenced by dietary assessment methods, population characteristics, and adjustment for confounding variables (Kinasih & Jannah, 2026; Vitale et al., 2023).

3.5.3. UPF consumption and insulin resistance / impaired glucose metabolism

Habitual intake of UPFs may be associated with insulin resistance and impaired glucose metabolism through several interconnected mechanisms. UPFs often contain refined carbohydrates, added sugars, and high-glycemic ingredients, which may contribute to postprandial glucose fluctuations and increased insulin demand (Aramburú et al., 2024; Monda et al., 2024). In addition, excessive energy intake associated with UPF-rich diets may promote weight gain and abdominal adiposity, both of which are closely related to systemic insulin resistance (Kinasih & Jannah, 2026). Industrial processing and changes in food texture or structure may also influence nutrient bioavailability and glycemic responses, although these mechanisms require further investigation in human studies (Aramburú et al., 2024).

3.5.4. UPF consumption and dyslipidemia

UPF consumption has also been associated with unfavorable lipid profiles, including elevated triglycerides and reduced HDL cholesterol (Vitale et al., 2023). These abnormalities may partly reflect high intake of refined sugars, saturated fats, trans fats, or other industrial fats, together with the displacement of fiber-rich whole foods such as vegetables, legumes, fruits,

and whole grains (Sitasari et al., 2025). A diet low in fiber and rich in refined components may adversely influence lipid metabolism and hepatic fat accumulation, thereby contributing to dyslipidemia in individuals with high UPF consumption (Aramburú et al., 2024).

3.5.5. UPF consumption and hypertension

Several studies have suggested an association between higher UPF intake and elevated blood pressure or hypertension (Barbosa et al., 2022; Rivera et al., 2024; Wang et al., 2022). One potential explanation is the high sodium content of many savory UPFs, which may contribute to blood pressure elevation. Other possible pathways include excess adiposity, systemic low-grade inflammation, endothelial dysfunction, and poorer overall diet quality (Monda et al., 2024; Singar et al., 2026). In addition, diets high in UPFs may displace minimally processed foods rich in potassium and other nutrients involved in blood pressure regulation (Kinasih & Jannah, 2026).

3.5.6. Integrated pathway from UPF intake to metabolic syndrome

Overall, the relationship between ultra-processed food consumption and metabolic syndrome is likely multifactorial. Excessive energy intake, abdominal adiposity, insulin resistance, chronic low-grade inflammation, oxidative stress, dyslipidemia, and hypertension may interact and contribute to metabolic dysfunction. These interconnected pathways provide a plausible explanation for the observed association between UPF-rich dietary patterns and metabolic syndrome. However, because much of the available evidence is observational, further prospective and interventional studies are needed to clarify causality and determine the relative contribution of individual mechanisms.

3.6. Ultra-Processed Food Consumption and Cardiovascular Disease

3.6.1. Association between UPF consumption and overall cardiovascular risk

The consumption of ultra-processed foods has increasingly been investigated as a modifiable dietary factor associated with cardiovascular disease risk. Observational evidence, particularly from large prospective cohort studies, suggests a positive association between higher UPF

intake and the incidence of cardiovascular outcomes (Sitasari et al., 2025; Vitale et al., 2023). Systematic reviews and meta-analyses of prospective cohorts indicate that individuals with the highest UPF consumption may have a higher risk of developing cardiovascular disease compared with those with lower consumption (Singar et al., 2026; Vitale et al., 2023). However, the strength of these associations varies across studies and may be influenced by differences in UPF assessment, population characteristics, lifestyle factors, and adjustment for overall diet quality. Importantly, it remains difficult to fully separate the potential effect of industrial processing from the generally poor nutritional profile of UPF-rich diets (Vitale et al., 2023).

3.6.2. UPF consumption and coronary heart disease

Specific evidence has also linked higher UPF intake with coronary heart disease, including ischemic heart disease and myocardial infarction (Sitasari et al., 2025). These associations may be partly explained by cardiovascular risk factors commonly related to UPF-rich dietary patterns, including dyslipidemia, insulin resistance, hypertension, chronic low-grade inflammation, and endothelial dysfunction (Singar et al., 2026; Vitale et al., 2023). In addition, UPFs may displace nutrient-dense foods such as vegetables, fruits, legumes, and whole grains, which are generally associated with better cardiometabolic health. Therefore, while available evidence suggests a plausible relationship between UPF intake and coronary heart disease, further research is needed to clarify the relative contribution of industrial processing, poor nutrient composition, and displacement of protective dietary components.

3.6.3. UPF consumption and stroke

The association between UPF consumption and stroke appears less clearly established than the association with overall cardiovascular disease or coronary heart disease. Some epidemiological studies suggest a possible link between higher UPF intake and increased risk of stroke, particularly ischemic stroke, but findings are not uniform across all populations (Sitasari et al., 2025; Vitale et al., 2023). Potential mechanisms may include hypertension, vascular inflammation, endothelial dysfunction, insulin resistance, and other metabolic abnormalities (Singar et al., 2026). However, because stroke is a multifactorial outcome, isolating the independent effect of UPF consumption remains challenging. More longitudinal studies are needed to determine whether these associations persist after rigorous adjustment for blood pressure, metabolic health status, and other confounding factors.

3.6.4. UPF consumption and cardiovascular mortality

Evidence concerning the relationship between UPF intake and cardiovascular mortality is growing, but should be interpreted cautiously. Several large prospective studies have reported that high UPF consumption is associated with an increased risk of mortality attributed to cardiovascular causes, distinct from all-cause mortality (Vitale et al., 2023). Nevertheless, determining whether this association reflects the specific effects of ultra-processing, poor diet quality, or broader lifestyle patterns remains complex. Because most available evidence is observational, causality cannot be firmly established, and further research is needed to quantify this risk across populations with different dietary patterns and baseline cardiovascular risk.

3.6.5. Cardiovascular risk factors and possible pathways

The relationship between UPF consumption and cardiovascular disease is likely mediated by several intermediate risk factors. Diets high in UPFs have been associated with obesity, abdominal adiposity, metabolic syndrome, hypertension, dyslipidemia, and impaired glucose metabolism, all of which may contribute to cardiovascular risk (Singar et al., 2026). UPF-rich dietary patterns may also contribute to chronic low-grade inflammation, oxidative stress, and endothelial dysfunction, which are relevant to atherosclerosis and vascular disease (Singar et al., 2026; Vitale et al., 2023). These pathways likely interact rather than operate independently, providing a plausible explanation for the observed associations between UPF consumption and cardiovascular outcomes.

3.6.6. Interpretation of current evidence

Overall, current evidence suggests a positive association between higher UPF intake and cardiovascular disease outcomes. However, establishing causality remains challenging due to the predominantly observational nature of the available research, residual confounding, variability in dietary assessment methods, and differences in the application of the NOVA classification across studies. Future well-designed prospective studies and, where feasible, controlled interventional trials are needed to determine the strength of this relationship and to better distinguish the effects of ultra-processed food consumption from overall diet quality and lifestyle-related factors.

3.7. Strengths, Limitations, and Public Health Implications

3.7.1. Strengths of current evidence

The body of literature regarding ultra-processed food consumption has expanded in recent years, supported by an increasing number of prospective cohort studies, systematic reviews, and meta-analyses. These investigations have shown consistency in associations across a broad spectrum of cardiometabolic outcomes, including obesity, metabolic syndrome, type 2 diabetes, cardiovascular disease, and mortality (Singar et al., 2026; Vitale et al., 2023). The adoption of the NOVA classification system has been particularly important, as it enables researchers to examine the extent of food processing as a distinct dimension of overall diet quality, separate from traditional nutrient-based assessments (Sitasari et al., 2025; Vitale et al., 2023).

3.7.2. Limitations of available studies

Despite these strengths, the current evidence base is constrained by several important limitations. The literature is dominated by observational designs, which complicates the establishment of causal relationships (Vitale et al., 2023). Furthermore, reliance on self-reported dietary intake through food frequency questionnaires—often not originally designed to capture the detailed definitions of the NOVA framework—introduces potential recall bias and misclassification of UPFs (Sitasari et al., 2025). Differences in dietary assessment methods, population characteristics, and cultural eating habits also make it difficult to directly compare results across studies or generalize findings internationally (Sitasari et al., 2025; Vitale et al., 2023).

3.7.3. Difficulty separating processing from nutrient composition

A persistent challenge is distinguishing the independent effect of industrial ultra-processing from the unfavorable nutritional profile commonly associated with UPF-rich diets. These diets are frequently characterized by high energy density, higher content of added sugars, sodium, and unhealthy fats, as well as lower fiber and nutrient density (Singar et al., 2026). In addition, the displacement of minimally processed, nutrient-dense foods such as vegetables, fruits, legumes, and whole grains complicates the attribution of observed health risks. Therefore, determining the relative contribution of processing techniques, nutrient composition, and overall dietary patterns remains an important unresolved issue in the literature (Singar et al., 2026; Vitale et al., 2023).

3.7.4. Public health implications

Given the current evidence, public health strategies aimed at reducing excessive UPF consumption may be relevant for the prevention of cardiometabolic disorders. Such strategies may include promoting dietary patterns based on minimally processed foods, including vegetables, fruits, legumes, whole grains, nuts, and unsweetened beverages. Population-level approaches may involve nutrition education, clear front-of-pack labeling, restrictions on marketing of UPFs to children, and policies aimed at improving access to healthier and affordable foods (Singar et al., 2026). Food reformulation may also help improve the nutritional quality of widely consumed products, although such interventions should be implemented carefully so that they do not reinforce continued reliance on highly processed foods.

3.7.5. Clinical and preventive relevance

In clinical practice, assessment of UPF intake may be a useful component of comprehensive dietary evaluation, particularly in patients with obesity, metabolic syndrome, hypertension, dyslipidemia, insulin resistance, or elevated cardiovascular risk. Rather than treating UPF intake as an isolated risk factor, clinicians and public health professionals may incorporate this assessment into broader dietary counseling aimed at improving overall diet quality and supporting long-term cardiometabolic health (Singar et al., 2026).

Ultimately, while current research provides a reasonable rationale for considering UPF consumption in the context of cardiometabolic health, the limitations of existing studies require cautious interpretation. Future high-quality longitudinal studies, well-designed intervention trials, and mechanistic investigations are needed to clarify the nature of these associations, better assess causality, and guide the development of effective evidence-based prevention strategies.

3.8. Summary

Ultra-processed foods, as categorized by the NOVA classification system, are defined by extensive industrial processing and formulation, frequently incorporating additives, refined ingredients, and substances not typically used in domestic food preparation to enhance palatability and shelf life (Crimarco et al., 2021, p. 81; Vadeveloo et al., 2025). Diets heavily reliant on UPFs are commonly associated with unfavorable nutritional profiles, characterized by high energy density, increased content of added sugars, sodium, and unhealthy fats, coupled with insufficient dietary fiber and essential micronutrients (Shim, 2025; Singar et al., 2026; Vitale et al., 2023).

The potential biological mechanisms underlying the association between UPF intake and cardiometabolic risk are multifactorial. They include increased caloric consumption driven by enhanced palatability, satiety dysregulation, and the development of abdominal adiposity, which may contribute to insulin resistance, chronic low-grade inflammation, oxidative stress, dyslipidemia, hypertension, and endothelial dysfunction (Babalola et al., 2025; Kaiser et al., 2026; Singar et al., 2026). Epidemiological data from prospective cohort studies support a positive association between higher UPF consumption and increased risks of obesity, metabolic syndrome, and cardiovascular disease (Lane et al., 2020; Vitale et al., 2023). However, as the majority of current evidence is observational, causal inferences should be made cautiously, considering potential residual confounding and variations in dietary assessment (Singar et al., 2026; Vitale et al., 2023).

In clinical and public health contexts, assessing UPF intake may supplement comprehensive dietary counseling that prioritizes whole, minimally processed foods (Baltacı & Şengün, 2025; Singar et al., 2026). While product reformulation represents a potential strategy, the primary focus should remain on shifting dietary patterns toward nutrient-dense, minimally processed alternatives (Behrens et al., 2025). Ultimately, further high-quality prospective studies, controlled intervention trials, and mechanistic investigations are required to clarify causality,

elucidate the specific impacts of industrial processing versus nutrient composition, and guide evidence-based prevention strategies.

Table 1. Potential pathways linking ultra-processed food consumption with cardiometabolic outcomes

UPF-related factor	Potential biological or behavioral pathway	Associated cardiometabolic outcome
High energy density and large portion sizes	Excessive caloric consumption	Obesity, metabolic syndrome
High palatability and soft texture	Satiety dysregulation	Obesity
Added sugars and refined carbohydrates	Insulin resistance, abdominal adiposity	Metabolic syndrome, dyslipidemia
High sodium content	Elevated blood pressure	Hypertension
Unhealthy fats and industrial ingredients	Endothelial dysfunction, dyslipidemia	Cardiovascular disease
Low dietary fiber and micronutrient density	Reduced nutrient intake, lower overall diet quality	Cardiovascular disease, metabolic syndrome
Food additives (e.g., emulsifiers, sweeteners)	Gut microbiota alterations, oxidative stress, inflammation	Cardiovascular disease, metabolic syndrome
Displacement of minimally processed foods	Reduced intake of protective nutrients	Cardiometabolic risk
Packaging or processing contaminants	Possible oxidative stress and metabolic disruption	Cardiometabolic risk

Source: (Babalola et al., 2025; Kaiser et al., 2026; Singar et al., 2026)

Abbreviations: UPF, ultra-processed food. The pathways presented in the table are interrelated and should be interpreted as biologically plausible mechanisms rather than definitive causal relationships.

4. Conclusion

Current evidence from nutritional epidemiology suggests a positive association between ultra-processed food consumption and adverse cardiometabolic outcomes, including obesity, metabolic syndrome, and cardiovascular disease (Lane et al., 2020; Vitale et al., 2023). These associations are likely multifactorial and may be partly explained by the unfavorable nutritional profile of UPF-rich diets, characterized by high energy density, excessive intake of added sugars, sodium, and unhealthy fats, and low content of dietary fiber and micronutrients (Kaiser et al., 2026; Shim, 2025; Singar et al., 2026). In addition, industrial processing may alter food structure, while the displacement of minimally processed, nutrient-dense foods may further contribute to poorer overall diet quality and increased cardiometabolic risk (Singar et al., 2026).

Potential biological pathways linking UPF intake with cardiometabolic disorders include excessive energy intake, altered satiety regulation, abdominal adiposity, insulin resistance, chronic low-grade inflammation, oxidative stress, dyslipidemia, hypertension, endothelial dysfunction, and possible gut microbiota alterations (Babalola et al., 2025; Kaiser et al., 2026; Singar et al., 2026). However, causal interpretation remains limited by the predominance of observational studies, residual confounding, differences in dietary assessment methods, and inconsistencies in UPF classification across studies (Singar et al., 2026; Vadiveloo et al., 2025; Vitale et al., 2023).

From a clinical and public health perspective, reducing excessive UPF intake and promoting dietary patterns based on minimally processed, nutrient-dense foods may support long-term cardiometabolic health (Behrens et al., 2025; Singar et al., 2026). UPF consumption should be considered as part of a broader assessment of diet quality rather than as an isolated risk factor. Further prospective studies, controlled intervention trials, and mechanistic research are needed to clarify causality, dose-response relationships, and the relative contribution of industrial processing versus nutrient composition. Such evidence will be important for developing effective dietary recommendations and public health strategies aimed at reducing the burden of cardiometabolic disease.

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