

The effects of ultra-processed foods on human health: a review of the current evidence and implications for public health

Abstract

The global food system has undergone a profound transformation over recent decades, marked by a rapid increase in the production and consumption of ultra-processed foods (UPFs). These products, typically characterized by extensive industrial processing, poor nutritional quality, and the inclusion of multiple additives, have become a dominant component of modern diets worldwide. Growing concerns have emerged regarding their potential adverse effects on human health and their broader implications for public health. This review critically examines the current body of scientific evidence linking ultra-processed food consumption to health outcomes, with an emphasis on biological mechanisms, epidemiological findings, and public health relevance. The review synthesizes findings from observational studies, cohort analyses, and meta-analyses that explore associations between UPF intake and a range of health conditions, including obesity, type 2 diabetes, cardiovascular disease, cancer, and mental health disorders. Proposed mechanisms of harm such as metabolic dysregulation, chronic low-grade inflammation, altered gut microbiota, and exposure to food additives and contaminants are also discussed. In addition, the review highlights global consumption trends and identifies populations that may be particularly vulnerable to the health impacts of UPFs. The evidence suggests a consistent and concerning relationship between high consumption of ultra-processed foods and adverse health outcomes. These findings underscore the need for effective public health interventions, including regulatory policies, dietary guidelines, and consumer education strategies. Addressing existing research gaps and strengthening evidence-based policies will be essential to mitigating the growing health burden associated with ultra-processed foods.

Keywords: ultra-processed foods, human health, metabolic diseases, public health nutrition, and dietary patterns

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Introduction

The global food environment has undergone a profound transformation over recent decades, characterized by the rapid expansion of industrial food processing and the increasing dominance of ultra-processed foods (UPFs) in modern diets. UPFs are industrial formulations typically composed of refined ingredients, additives, and minimal whole-food content, designed to enhance palatability, convenience, and shelf stability.^{1,2} The NOVA classification system has been widely adopted to categorize foods based on the extent and purpose of processing, identifying UPFs as a distinct group with potential implications for diet quality and health.² Population-level dietary analyses indicate that UPFs contribute a substantial and growing proportion of total energy intake in many countries, particularly in high-income settings, where they increasingly displace minimally processed foods.³ This global dietary shift has raised significant concerns regarding the long-term health consequences associated with widespread UPF consumption.

A substantial body of epidemiological evidence has emerged linking high intake of UPFs to adverse health outcomes. Systematic reviews and meta-analyses of observational studies consistently report positive associations between UPF consumption and increased risks of obesity, type 2 diabetes, cardiovascular disease, cancer, and all-cause mortality.^{4,5} Prospective cohort studies, including large population-

based investigations, have demonstrated dose-response relationships between UPF intake and cardiovascular disease incidence, reinforcing concerns about their cardiometabolic effects.⁶ More recently, an umbrella review incorporating updated meta-analyses confirmed that higher UPF consumption is associated with a broad range of adverse health outcomes, with moderate to high certainty for several disease endpoints.⁷ Collectively, these findings suggest that UPFs may represent a significant dietary risk factor at the population level.

The potential health effects of UPFs are thought to extend beyond their unfavorable nutrient profiles. UPFs are typically energy-dense and high in added sugars, sodium, and unhealthy fats, while being low in dietary fiber and essential micronutrients, characteristics that can promote excessive energy intake and metabolic dysfunction.^{3,5} Experimental evidence further supports these associations; a randomized controlled feeding trial demonstrated that diets rich in UPFs led to increased calorie intake and weight gain compared with minimally processed diets, even when macronutrient composition was matched.⁸ In addition, mechanistic studies suggest that processing-related components, including food additives and altered food matrices, may disrupt gut microbiota composition, impair intestinal barrier function, and promote chronic low-grade inflammation—pathways implicated in metabolic and cardiovascular disease.^{9,10} These findings highlight the multifactorial nature of UPF-related health risks.

Despite the growing evidence base, important methodological and conceptual challenges remain. Most studies examining UPFs and health outcomes are observational, limiting causal inference and leaving findings susceptible to residual confounding and dietary measurement error.^{4,7} Variability in dietary assessment methods and differences in how UPFs are operationalized within the NOVA framework may also contribute to heterogeneity in reported associations.^{1,2} Furthermore, while associations are consistent across many outcomes, the strength of evidence varies, and uncertainties remain regarding the relative contributions of nutrient composition versus processing-related factors.^{5,9} Addressing these challenges is essential for refining public health recommendations and advancing understanding of the role of UPFs in chronic disease etiology.

This review aims to provide a comprehensive and critical synthesis of the current evidence on the effects of ultra-processed foods on human health and to examine their implications for public health. It begins by clarifying the definition and classification of ultra-processed foods and describing global trends in their consumption. The review then evaluates the nutritional and chemical characteristics that distinguish ultra-processed foods from less processed alternatives, including both nutrient composition and processing-related features. Proposed biological mechanisms linking ultra-processed food consumption to adverse health outcomes are examined to provide mechanistic context for epidemiological findings. Evidence linking ultra-processed foods to major health outcomes such as obesity, metabolic disorders, cardiovascular disease, cancer, and mental health conditions is synthesized, with attention to the consistency, strength, and limitations of existing studies. Finally, the review discusses public health implications, including disease burden, vulnerable populations, and policy-relevant considerations, and identifies key research gaps and future directions to support evidence-based dietary guidance and food system interventions.

Definition and global trends of ultra-processed foods

Ultra-processed foods (UPFs) are most commonly defined using the NOVA food classification system, which categorizes foods according to the nature, extent, and purpose of industrial processing rather than nutrient composition alone.² Within this framework, UPFs are industrial formulations made largely or entirely from substances derived from foods, such as refined starches, sugars, oils, and protein isolates, combined with additives including flavorings, colorings, emulsifiers, and preservatives. These products are designed to be ready-to-consume, hyper-palatable, and highly profitable, while often containing little or no intact whole food.¹¹ Unlike minimally processed or traditionally processed foods, UPFs are characterized by processing techniques that fundamentally alter food matrices, with implications for satiety, digestion, and metabolic responses.⁹ Global consumption of UPFs has increased rapidly over the past three decades, reflecting profound changes in food systems driven by urbanization, globalization, and the expansion of transnational food corporations. National dietary surveys consistently show that UPFs account for more than 50% of total daily energy intake in several high-income countries, including the United States, the United Kingdom, and Canada.^{11,12} This trend is closely linked to aggressive food marketing, widespread availability, and the convenience of ready-to-eat products, particularly in urban settings. The displacement of traditional diets rich in minimally processed foods by UPFs has been identified as a defining feature of the global nutrition transition.¹³

In low- and middle-income countries, UPF consumption is increasing at an accelerated pace, often alongside persistent

undernutrition and rising obesity rates. Studies from Latin America, Asia, and parts of Africa demonstrate rapid growth in UPF sales and intake, particularly among younger populations and urban households.^{11,13} This dual burden of malnutrition characterized by the coexistence of micronutrient deficiencies and diet-related non-communicable diseases-poses significant challenges for public health systems. Socioeconomic factors such as income growth, time constraints, and changing social norms further reinforce reliance on ultra-processed products.¹² Importantly, global trends in UPF consumption are not uniform and reflect complex interactions between policy environments, food industry practices, and cultural dietary patterns. Countries that have implemented stronger food policies such as front-of-pack labeling, marketing restrictions, and dietary guidelines emphasizing minimally processed foods have shown slower growth or stabilization of UPF consumption.¹² Conversely, weak regulatory frameworks and trade liberalization have facilitated the rapid penetration of ultra-processed products in emerging markets. Understanding these global and regional trends is critical for interpreting epidemiological evidence and for designing effective interventions aimed at reducing population-level exposure to ultra-processed foods (Figure 1).

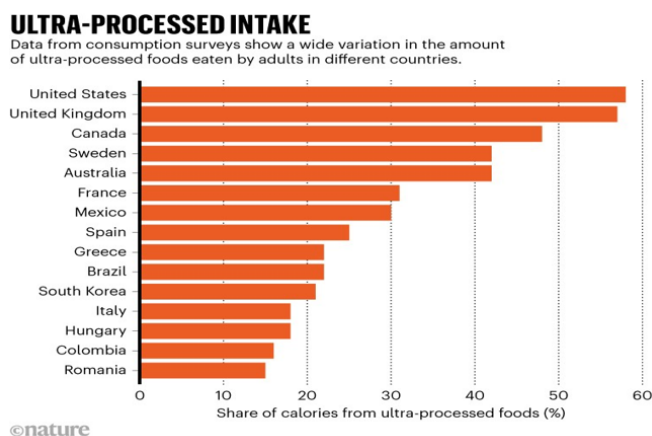


Figure 1 Ultra processed food intake. This figure shows the proportion of total dietary consumption in each country that comes from ultra-processed foods, indicating the relative exposure of populations to these products and potential associated health risks.

Source: Fleming³⁹

Nutritional and chemical characteristics

Ultra-processed foods (UPFs) are distinguished not only by their industrial origin but also by their unique nutritional and chemical characteristics, which contribute to poor diet quality and potential health risks. Studies indicate that UPFs are typically high in added sugars, refined carbohydrates, sodium, and unhealthy fats, while providing low levels of fiber, vitamins, and minerals.^{14,15} In particular, diets with high UPF intake often displace minimally processed foods such as fruits, vegetables, legumes, and whole grains, resulting in reduced overall nutrient density and compromised dietary quality.^{14,15} This pattern has been consistently observed across populations, including vegetarian cohorts in the UK, where a higher proportion of UPFs in the diet was strongly associated with lower intakes of essential nutrients.¹⁵ Beyond macronutrient imbalances, UPFs are frequently formulated with a variety of industrial additives designed to improve flavor, texture, shelf life, and visual appeal.

A recent analysis of the UK food supply demonstrated that emulsifiers, thickeners, stabilizers, and flavor enhancers are widespread

across ultra-processed products, with many items containing multiple additives.¹⁶ Emulsifiers such as lecithin, mono- and diglycerides, and carrageenan are particularly prevalent, especially in bakery, dessert, and dairy products, and have been implicated in modifying satiety responses and gut microbiota composition.¹⁶ The inclusion of these additives underscores the complex formulation of UPFs and their potential to influence health through mechanisms beyond nutrient content.

Industrial processing techniques further introduce neo-formed compounds and chemical contaminants that are not present in minimally processed foods. High-temperature processes like extrusion, frying, and baking can generate advanced glycation end-products, acrylamide, and other potentially toxic compounds.¹⁷ Additionally, chemicals from packaging, including bisphenols and phthalates, can migrate into food during storage, raising concerns about endocrine disruption and metabolic effects.¹⁸ These compounds, though present in small quantities, are ubiquitous across UPFs and are emerging as relevant factors in diet-related chronic disease risk.

Emerging evidence also links UPF consumption to adverse changes in gut microbiota composition and metabolomic profiles, providing insight into mechanistic pathways of harm. A metabolomic study of older Mediterranean adults at high cardiovascular risk showed that higher UPF intake was associated with reduced levels of beneficial microbial metabolites, alterations in lipid profiles, and increased inflammatory markers, suggesting systemic metabolic effects beyond nutrient deficiency.¹⁹ These findings highlight the interplay between poor nutritional quality, additives, processing-derived compounds, and microbiome-mediated effects as potential contributors to UPF-related health outcomes. Collectively, the nutritional and chemical characteristics of UPFs including poor macronutrient balance, presence of multiple industrial additives, formation of neo-formed compounds, and their impact on biological pathways underscore their potential to adversely affect health. Understanding these features is critical for interpreting epidemiological evidence linking UPFs to chronic diseases and for informing public health strategies aimed at improving diet quality at the population level (Table 1).

Table 1 Key nutritional and chemical characteristics of common ultra-processed food categories

UPF Category	Key nutrients/additives	Sources
Bakery Products	High added sugar; sodium present; contains emulsifiers and stabilizers	Sandall et al. ¹⁶ ; Torquato et al. ¹⁵
Ready-to-eat Meals	High sodium; added fats; contains stabilizers	Chen et al. ¹⁴ ; Touvier et al. ¹⁷
Sugary Beverages	High added sugar; colorants present	Chen et al. ¹⁴ ; Torquato et al. ¹⁵
Dairy-Based Desserts	Added sugar; emulsifiers; stabilizers	Atzeni et al. ¹⁹ ; Sandall et al. ¹⁶
Snack Foods (Chips, etc.)	Added fats; sodium; preservatives	Bambridge-Sutton. ¹⁸ ; Touvier et al. ¹⁷

Biological mechanisms of harm

The adverse health effects associated with ultra-processed food (UPF) consumption extend beyond poor nutrient quality and involve complex biological mechanisms, including gut microbiota dysbiosis, impaired gut barrier function, and chronic inflammation. UPFs are typically low in dietary fiber and high in refined sugars, saturated fats, and industrial additives such as emulsifiers, which collectively disrupt the composition and diversity of gut microbial communities. Dysbiosis reduces the abundance of beneficial bacteria and increases pro-inflammatory taxa, contributing to intestinal barrier dysfunction and systemic exposure to microbial products, such as lipopolysaccharides, which activate inflammatory pathways.^{20–22} Industrial additives commonly found in UPFs, including emulsifiers and thickeners, have been shown to directly modulate gut microbial activity. Preclinical and in vitro studies indicate that substances like polysorbate-80 and carboxymethylcellulose can alter microbial gene expression, reduce short-chain fatty acid (SCFA) production, and promote pro-inflammatory profiles, independently of nutrient content.^{20,22} Reduced SCFA concentrations, particularly butyrate, compromise mucosal integrity, impair energy homeostasis, and promote low-grade systemic inflammation, thereby creating a biologically plausible link between UPF intake and metabolic disturbances.^{20,21}

UPFs also influence metabolic signaling and energy regulation. Their high energy density, palatability, and rapid consumption patterns can lead to positive energy balance, adiposity, and activation of reward pathways, further exacerbating metabolic stress.^{17,18} Chronic low-grade inflammation, triggered by nutrient imbalance and additive-induced microbiota changes, contributes to insulin resistance, dyslipidemia, and cardiometabolic risk.^{17,22} The interaction between UPFs, gut microbiota, and the immune system is also critical. Altered microbial profiles and compromised barrier function can stimulate mucosal immune activation, increasing cytokine production and potentially exacerbating inflammatory bowel disease

(IBD) activity in susceptible individuals. Dietary constituents such as emulsifiers, maltodextrin, and excess salt are implicated in epithelial barrier disruption and immune dysregulation in both preclinical and clinical studies.^{22,23} In summary, the biological mechanisms through which UPFs exert harmful effects are multifactorial, involving gut dysbiosis, barrier dysfunction, immune activation, metabolic signaling disturbances, and chronic inflammation. These interrelated pathways provide a mechanistic basis for the epidemiological associations observed between UPF consumption and cardiometabolic and gastrointestinal diseases, underscoring the importance of limiting UPF intake in population-level dietary strategies (Figure 2).

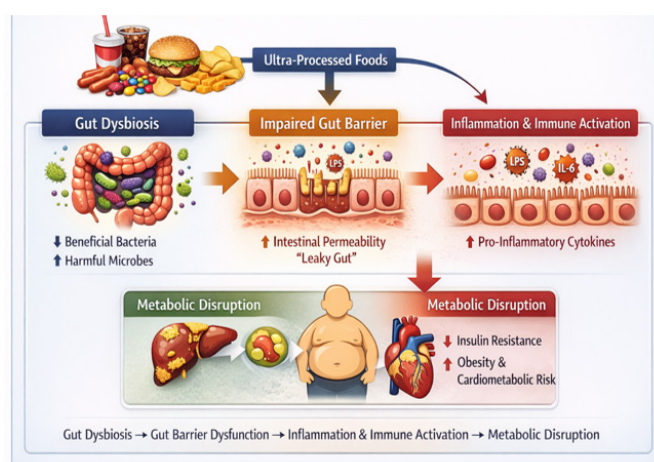


Figure 2 Mechanistic pathways of ultra-processed food effects on gut and metabolism. The figure illustrates how consumption of ultra-processed foods can disrupt gut microbiota, impair intestinal barrier function, trigger immune activation, and contribute to metabolic dysregulation and increased disease risk.

Evidence linking ultra-processed foods to health outcomes

Ultra-processed foods (UPFs) have become a predominant component of modern diets worldwide, raising concerns about their potential impacts on human health. Unlike minimally processed foods, UPFs are often energy-dense, nutrient-poor, and contain additives, preservatives, and other industrial ingredients that may affect physiological processes beyond basic nutrition. The section examines associations with metabolic disorders, cardiovascular disease, cancer, mental health, and other emerging health risks, highlighting findings from recent observational studies, systematic reviews, and large cohort analyses. By focusing on individual outcomes, this section aims to clarify the scope and magnitude of health risks attributed to UPFs, providing an evidence-based foundation for public health recommendations and policy interventions. Figure 3, provides a qualitative synthesis of the relative strength of associations reported across epidemiological studies examining high ultra-processed food intake and selected health outcomes.

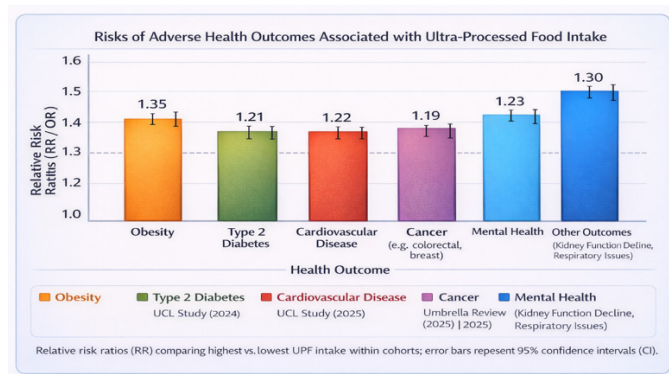


Figure 3 Relative risk of selected health outcomes associated with high ultra-processed food consumption. Bars represent approximate relative risk or odds ratio ranges reported in observational and meta-analytic studies comparing high versus low ultra-processed food consumption across major health outcomes.

Obesity and weight gain

Ultra-processed food (UPF) consumption is strongly linked to increased adiposity and obesity. Prospective cohort studies and systematic reviews have consistently found positive associations between higher UPF intake and both general and abdominal obesity. A systematic review of prospective studies reported substantial agreement that UPF consumption is associated with increased incidence of general and abdominal obesity, with higher odds observed in individuals with the greatest intake compared with the lowest intake groups. The review also found UPFs contribute to features of metabolic dysregulation, including increased waist circumference and impaired glucose homeostasis.²⁴ Additionally, cross-sectional research in Shanghai found that high UPF consumption was associated with a significantly higher risk of abdominal obesity, independent of other lifestyle factors. This provides further real-world evidence of the contribution of UPFs to obesity risk.²⁵

Type 2 Diabetes

Emerging evidence specifically links UPF consumption to an increased risk of developing type 2 diabetes. Large international cohort studies indicate that each 10% increase in the proportion of dietary energy from UPFs is associated with a 17% higher risk of incident type 2 diabetes, even after adjusting for major confounders such

as physical activity and body mass index.²⁶ Moreover, substitution modeling from the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort suggests that replacing UPFs with less-processed or minimally processed foods could reduce diabetes risk, highlighting the potential for dietary modification to mitigate risk.²⁷

Cardiovascular disease and mortality

Recent large-scale analyses have linked UPF consumption with multiple cardiovascular outcomes and mortality. A systematic review of 41 prospective cohort studies involving more than 8 million adults found that each additional 100 g per day of UPFs was associated with higher risks of hypertension, cardiovascular events, and all-cause mortality, alongside other conditions such as digestive diseases and cancer.²⁸ Longitudinal research from the Whitehall II cohort similarly observed that trajectories of higher UPF intake over a decade were related to increased risk of both fatal and non-fatal cardiovascular disease as well as all-cause mortality, reinforcing the strength of the association across diverse populations.²⁹

Cancer incidence

Evidence suggests high UPF consumption is associated with an elevated risk of certain cancers. Observational studies and meta-analyses show positive associations between UPF intake and overall cancer risk, with particular concerns for colorectal and breast cancers, even after adjustment for obesity and lifestyle factors. For example, systematic meta-analysis data indicate convincing associations between UPF intake and multiple chronic conditions including some cancers.⁷ Recent population studies also report that diets high in UPFs correlate with greater risk of precursor lesions such as colon polyps in younger adults, which are known risk markers for colorectal cancer, underscoring the importance of early dietary patterns in long-term carcinogenesis.

Digestive health and other outcomes

There is increasing evidence linking UPF consumption with adverse digestive outcomes and broader health effects. A systematic review of meta-analyses identified kidney function decline and respiratory issues such as wheezing in children and adolescents as outcomes with convincing evidence of association with high UPF intake, suggesting that the impact of UPFs spans multiple organ systems.⁷ Randomized controlled and community-based intervention trials, though limited in number, indicate that reducing UPF intake can improve intermediate health markers within weeks to months, supporting recommendations for dietary change to decrease chronic disease risk.³⁰

Public health implications

The rapid global increase in ultra-processed food (UPF) consumption represents a major public health concern due to its strong association with diet-related noncommunicable diseases (NCDs). In many high-income countries, UPFs contribute more than 50% of total daily energy intake, while consumption is rising sharply in low- and middle-income countries as a result of urbanization, globalization of food systems, and aggressive food marketing.^{2,31} This widespread dietary shift coincides with escalating rates of obesity, type 2 diabetes, cardiovascular disease, and premature mortality, placing increasing strain on already burdened healthcare systems.¹⁷

Evidence from large umbrella reviews and pooled analyses demonstrates that high UPF consumption is consistently associated with a broad spectrum of adverse health outcomes at the population level. A comprehensive synthesis of meta-analyses reported

associations between UPF intake and more than 30 health outcomes, including cardiometabolic disease, depression, anxiety, respiratory disorders, and all-cause mortality, with particularly strong evidence for cardiovascular mortality and type 2 diabetes.³² These findings suggest that UPFs contribute to disease burden through multiple pathways, reinforcing their relevance as a population-level risk factor rather than an isolated dietary concern.¹⁷

The public health burden of UPF consumption is also shaped by social and economic inequalities. Higher intake of UPFs is disproportionately observed among individuals with lower socioeconomic status, limited access to fresh foods, and greater exposure to food marketing, contributing to widening health disparities.³³ Recent population-based studies indicate that high UPF consumption is associated with poorer health-related quality of life, particularly among women and socioeconomically disadvantaged groups, highlighting the intersection between dietary patterns and social determinants of health (Figure 4).³⁴

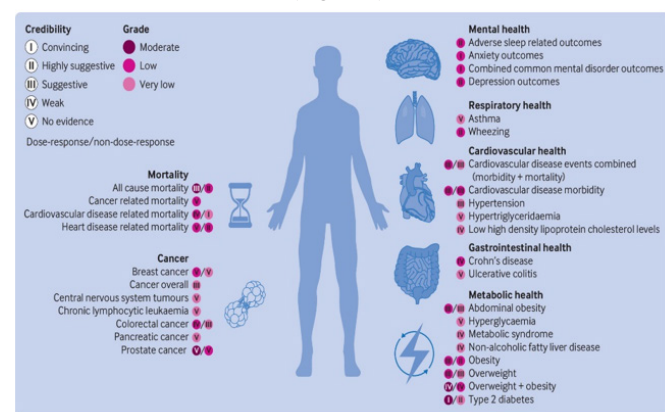


Figure 4 Credibility and GRADE ratings of associations between higher ultra-processed food intake and adverse health outcomes. This figure illustrates the credibility of evidence and GRADE ratings for the associations between higher consumption of ultra-processed foods and various adverse health outcomes, showing the strength and reliability of the reported links.

Source: Lane et al.³²

Beyond individual health effects, UPF consumption has important implications for preventable mortality. International modeling studies suggest that a substantial proportion of premature deaths could be avoided through reductions in UPF intake, with a clear dose-response relationship observed between the proportion of UPFs in the diet and mortality risk.³⁵ These findings underscore the potential population-wide benefits of dietary interventions targeting food processing rather than isolated nutrients or caloric intake alone.³²

In response to the growing body of evidence, public health authorities are increasingly calling for regulatory and policy action. In 2025, the World Health Organization initiated the development of formal guidelines on UPF consumption, reflecting global recognition of their role in diet-related NCDs.³¹ Proposed strategies include front-of-pack warning labels, restrictions on marketing to children, fiscal measures such as taxation, reformulation incentives, and policies that promote access to minimally processed foods within schools and public institutions.¹⁷ Collectively, these approaches emphasize the need for structural interventions that reshape food environments and support healthier dietary choices at the population level (Table 2).

Policy, prevention, and future directions

The increasing evidence linking ultra-processed foods (UPFs) to adverse health outcomes has led public health experts to advocate for regulatory and systemic interventions rather than relying solely on individual behavior change.³⁶ Focusing only on nutrient reduction, such as lowering sugar or fat, without addressing the broader issue of processing and marketing, is insufficient to reduce population-level UPF consumption.³⁶ Global health authorities are responding by developing evidence-based guidance specific to UPFs. In 2025, the World Health Organization issued a call for experts to create guidelines on UPF consumption, emphasizing the need to complement existing dietary guidance on macronutrients and overall healthy eating.³¹ These guidelines aim to support policymakers in crafting interventions that reduce UPF exposure and prevent diet-related noncommunicable diseases.³¹ Effective policy strategies recommended by experts include front-of-pack labeling, advertising restrictions, especially targeting children, and fiscal measures such as taxation of UPFs to promote healthier alternatives.³⁷ These approaches seek to create healthier food environments, shifting the market toward minimally processed foods and improving population dietary patterns.³⁷

Table 2 Public health implications of high ultra-processed food consumption

Public health domain	Key implications	Affected populations	Policy relevance
Disease Burden	Increased NCD prevalence and premature mortality	General population	Priority for NCD prevention
Health Inequities	Higher exposure among low-SES groups	Vulnerable populations	Equity-focused nutrition policies
Healthcare Systems	Rising long-term treatment costs	National health systems	Cost-containment strategies
Food Environments	Dominance of UPFs in retail and schools	Children and adolescents	Marketing and school food regulation
Policy Response	Need for multi-sectoral action	Governments and regulators	Fiscal, labeling, and reformulation tools

Several countries have implemented innovative policies targeting UPFs. For instance, Brazil's national school feeding program mandates that at least 90% of foods served in schools be fresh or minimally processed by 2026, representing a large-scale structural intervention to improve dietary quality in institutional settings (The Lancet, 2025). Other measures under discussion include restricting UPF shelf space in retail, banning UPF sales in hospitals, and expanding taxes beyond sugar-sweetened beverages to other ultra-processed categories.³⁷ Despite progress, barriers to effective regulation remain significant, including food industry influence through lobbying, marketing, and research partnerships, which can slow policy implementation.³⁶

Future research and policy development should prioritize establishing globally accepted definitions and metrics for UPFs, evaluating structural interventions such as taxes and labeling, and integrating UPF reduction into broader nutrition and sustainability policies. Coordinated efforts are essential to reduce population-level UPF exposure and mitigate diet-related disease burdens.^{31,36,40}

Conclusion

Ultra-processed foods (UPFs) are increasingly recognized as a major contributor to diet-related noncommunicable diseases,

including obesity, cardiovascular disease, type 2 diabetes, and certain cancers. Mechanistic evidence shows that UPFs can disrupt metabolism, promote inflammation, and alter gut microbiota, while also displacing nutrient-rich foods from the diet. Beyond individual health, UPFs create broader public health challenges, including increased healthcare costs and amplified health inequities, especially among children, adolescents, and socioeconomically disadvantaged populations. Evidence indicates that multilevel interventions including fiscal policies, front-of-pack labeling, marketing restrictions, and school-based programs are needed to reduce population-level UPF consumption. Future research should focus on refining UPF definitions, evaluating policy effectiveness, and addressing commercial influences on diet. In conclusion, reducing UPF intake through coordinated policy, public awareness, and structural interventions is essential to mitigate health risks and promote sustainable, equitable improvements in population health.

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Conflicts of interest

The authors declared that there are no conflicts of interest.

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