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Ultra-Processed Foods and Their Impact on Health: A Review

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Abstract
Ultra-processed foods (UPFs) have become increasingly prevalent within contemporary food environments, generating substantial interest regarding their implications for nutritional status and long-term health. UPFs are industrial formulations characterised by extensive processing and the use of ingredients and additives that are uncommon in conventional culinary preparation. This review critically examines the concept and classification of UPFs, their dietary characteristics, associations with major health outcomes, determinants of consumption, and evidence-informed approaches for reducing their intake. Evidence from observational studies, systematic reviews, meta-analyses, umbrella reviews, and controlled feeding research was integrated using a qualitative integrative review approach. Current evidence indicates that higher UPF consumption is consistently associated with obesity, type 2 diabetes, cardiovascular outcomes, mortality, and several other adverse health outcomes. Experimental evidence further indicates that consumption of an ultra-processed dietary pattern can increase energy intake and promote short-term weight gain. However, much of the evidence linking UPFs with chronic disease is observational, and the certainty of evidence varies across outcomes. Consequently, associations should not be interpreted as definitive evidence of causation. UPF consumption is influenced by multiple interacting determinants, including convenience, palatability, affordability, food availability, marketing, time constraints, socioeconomic circumstances, and broader food environments. Strategies to reduce excessive UPF intake should therefore extend beyond individual dietary restriction and incorporate nutrition education, food-label literacy, meal planning, substitution with minimally processed foods, behavioural support, and supportive food-environment and policy measures. Overall, reducing reliance on UPFs may contribute to improved dietary quality, but recommendations should consider nutritional adequacy, cultural acceptability, affordability, and individual circumstances. Further research is required to strengthen causal inference, standardise UPF assessment, evaluate specific UPF subtypes, and determine the health effects of replacing UPFs with minimally processed foods.

1. Introduction

The global food environment has undergone substantial transformation over recent decades, accompanied by increasing availability and consumption of industrially formulated foods. Among these, **ultra-processed foods (UPFs)** have attracted considerable scientific and public health attention because of their high prevalence in contemporary diets and their reported associations with a wide range of adverse health outcomes. UPFs include diverse products such as packaged snacks, sugar-sweetened beverages, confectionery, biscuits, ready-to-eat meals, instant noodles, processed meat products, sweetened breakfast cereals, and other commercially formulated foods. Their increasing dietary contribution has raised concerns regarding the nutritional quality of diets and the broader health consequences of highly processed dietary patterns (Monteiro et al., 2019).

The concept of UPFs is primarily operationalised through the **NOVA food classification system**, which categorises foods according to the nature, extent, and purpose of processing. Within this framework, UPFs constitute the fourth category and are generally characterised as industrial formulations containing substances derived from foods and ingredients rarely used in conventional culinary preparation, together with additives intended to modify taste, texture, appearance, or shelf life. Importantly, **food processing itself should not be equated with poor nutritional quality or adverse health effects**, as processing encompasses a broad spectrum of techniques, many of which can improve food safety, preservation, and accessibility. The distinction between minimally processed, processed, and ultra-processed foods is therefore essential when interpreting the emerging evidence (Monteiro et al., 2019).

Interest in UPFs has intensified because epidemiological evidence increasingly links greater consumption with adverse health outcomes. A comprehensive umbrella review by Lane et al. (2024), incorporating 45 pooled analyses involving approximately 9.9 million participants, reported associations between higher UPF exposure and outcomes spanning cardiometabolic, mental, respiratory, gastrointestinal, cancer, and mortality-related domains. Particularly notable associations were observed for cardiovascular disease-related mortality, type 2 diabetes, obesity, depression, and all-cause mortality. However, the interpretation of these findings requires methodological caution: most of the underlying pooled analyses were assessed as having **low or very low certainty**, and much of the evidence was derived from observational studies. Consequently, associations between UPF consumption and disease outcomes should not automatically be interpreted as evidence of direct causation.

The relationship between UPF consumption and **obesity and type 2 diabetes** is of particular nutritional and clinical importance. Observational evidence has consistently reported positive associations between higher UPF intake and adiposity and diabetes risk, while experimental evidence provides additional insight into possible causal pathways. In a controlled inpatient randomized crossover trial, Hall et al. (2019) found that participants consumed substantially more energy and gained weight during consumption of an ultra-processed diet compared with an unprocessed diet, despite the diets being matched for several nutritional characteristics. Such findings suggest that factors beyond conventional nutrient composition, including food structure, eating rate, palatability, and dietary energy density, may influence energy intake.

UPF consumption is also shaped by a complex interaction of **individual, socioeconomic, behavioural, and environmental determinants**. A systematic review of nationally representative studies found variation in UPF consumption according to age, urbanisation, food insecurity, income, education, socioeconomic circumstances, and geographic region, although the direction and magnitude of associations differed across countries (Dicken et al., 2024). Therefore, reducing UPF intake cannot be considered solely an issue of individual dietary choice; broader food environments and structural determinants must also be considered.

Against this background, the present review critically examines the concept and characteristics of UPFs, synthesises evidence concerning their associations with health outcomes—with particular emphasis on obesity and type 2 diabetes—and considers determinants of their consumption and evidence-informed approaches for reducing intake. **The review aims to integrate nutritional, epidemiological, behavioural, and public health perspectives while maintaining a clear distinction between observed associations and established causal relationships.**

2. Review Methodology

2.1 Review Design

The present paper adopts a **qualitative integrative review** design to synthesise evidence concerning ultra-processed foods (UPFs), their defining characteristics, associations with health outcomes, determinants of consumption, and approaches for reducing dietary exposure. An integrative approach is appropriate because the evidence base encompasses diverse research designs, including observational studies, controlled feeding trials, systematic reviews, meta-analyses, and evidence syntheses. This approach permits integration of findings across nutritional epidemiology, clinical nutrition, behavioural science, and public health while recognising differences in study design and strength of evidence.

The review was guided by the methodological principles of integrative review methodology described by Whittemore and Knafl (2005). The interpretation of evidence was undertaken with particular attention to the distinction between **statistical association and causal inference**, given that a substantial proportion of research on UPFs is observational. Recent umbrella reviews have demonstrated consistent associations between greater UPF exposure and multiple adverse health outcomes, while also identifying substantial variation in the certainty and credibility of the underlying evidence (Dai et al., 2024; Lane et al., 2024).

2.2 Review Objectives

The review was guided by the following objectives:

1. To critically examine the concept, classification, dietary characteristics, and health implications of ultra-processed foods, with particular emphasis on their associations with obesity, type 2 diabetes, and other major health outcomes.
2. To synthesise the evidence on the determinants of ultra-processed food consumption and evaluate evidence-informed individual, behavioural, and food-environment approaches for reducing their intake.

2.3 Literature Search Strategy

Relevant literature was identified through a structured search of major biomedical, nutritional, and multidisciplinary literature sources. Core databases considered for the review included **PubMed/MEDLINE, Scopus, Web of Science, and PsycINFO**, with supplementary identification of relevant literature through reference-list screening and Google Scholar.

Search terms were developed around the principal concepts of the review and included combinations of **"ultra-processed food," "ultra-processed foods," "UPF," "NOVA classification," "food processing," "obesity," "adiposity," "type 2 diabetes," "cardiovascular disease," "health outcomes," "food consumption," "dietary determinants," "food environment," "dietary behaviour,"** and **"reducing ultra-processed food intake."** Boolean operators were used to combine related concepts where appropriate.

Priority was given to systematic reviews, umbrella reviews, meta-analyses, prospective cohort studies, controlled feeding trials, and other studies capable of contributing substantively to the objectives of the review. Recent evidence syntheses were particularly considered because the scientific literature concerning UPFs has expanded rapidly. For example, Lane et al. (2024) synthesised 45 pooled analyses involving approximately 9.9 million participants, while Dai et al. (2024) updated observational meta-analytic evidence across 49 health outcomes.

2.4 Eligibility Criteria

Studies were considered relevant when they addressed at least one of the following domains: **(a)** definition or classification of UPFs; **(b)** nutritional or dietary characteristics of UPFs; **(c)** associations between UPF consumption and health outcomes; **(d)** obesity or type 2 diabetes; **(e)** determinants or patterns of UPF consumption; or **(f)** strategies for reducing UPF intake.

Both original empirical studies and evidence syntheses were considered because different questions within the review require different forms of evidence. Controlled feeding studies were considered particularly informative for examining short-term effects under experimental conditions, whereas prospective cohort studies and meta-analyses were considered important for evaluating longer-term associations at the population level.

Studies focused exclusively on food processing without relevance to the NOVA concept, non-human research, duplicate publications, and publications that did not provide substantive evidence relevant to the review objectives were excluded.

2.5 Study Selection and Data Extraction

Relevant literature was assessed according to its contribution to the review objectives. Information extracted from selected studies included **author and publication year, study design, population or sample characteristics, assessment of UPF exposure, principal health outcomes, major findings, methodological considerations, and implications for nutrition and public health practice**.

Particular attention was given to the method used to quantify UPF consumption because estimates may be expressed as the proportion of total energy intake, weight contribution, frequency of consumption, servings per day, or categories of consumption. Differences in exposure assessment can influence comparisons between studies and contribute to heterogeneity in the evidence base.

2.6 Thematic Synthesis

Evidence was organised thematically according to the two review objectives. The first thematic domain addressed the **conceptualisation and health implications of UPFs**, including the NOVA classification, characteristics of ultra-processing, overall health outcomes, obesity, and type 2 diabetes. The second domain addressed **determinants of consumption and strategies for dietary reduction**, encompassing individual behaviours, socioeconomic circumstances, food environments, food accessibility, nutrition education, dietary substitution, and population-level approaches.

The synthesis was interpretive rather than quantitative. Findings were compared according to consistency, study design, biological or behavioural plausibility, and methodological limitations. Particular caution was applied when interpreting observational associations. This is important because recent umbrella reviews have reported extensive associations between UPF exposure and adverse health outcomes but have also identified low or very low certainty for many pooled estimates (Lane et al., 2024).

2.7 Methodological Considerations

The review distinguishes between **evidence of association and evidence of causation**. Observational evidence can identify population-level relationships between UPF intake and disease risk but may be influenced by residual confounding, measurement error, dietary pattern clustering, reverse causation, and differences in UPF classification. Conversely, controlled feeding studies provide stronger experimental evidence for specific short-term outcomes but generally involve relatively small samples and limited intervention periods.

Accordingly, conclusions in this review are based on the **overall direction, consistency, and methodological strength of the available evidence**, rather than on individual studies alone. This approach is particularly important because UPFs represent a heterogeneous category of foods, and the health effects associated with specific products or dietary patterns may not necessarily be attributable to a single common mechanism.

3. Understanding Ultra-Processed Foods

3.1 Food Processing and Ultra-Processing

Food processing encompasses a broad continuum of techniques used to preserve, transform, improve the safety of, or increase the usability of foods. Consequently, **processing should not be regarded as inherently detrimental to health**. Freezing, drying, pasteurisation, milling, fermentation, and other relatively simple processes may enhance food safety, stability, storage, and availability without fundamentally altering the food's nutritional identity.

The concept of **ultra-processing** represents a more specific category within this broader continuum. The NOVA classification system categorises foods according to the extent and purpose of industrial processing and distinguishes four groups: (1) unprocessed or minimally processed foods, (2) processed culinary ingredients, (3) processed foods, and (4) ultra-processed foods and drinks (Monteiro et al., 2019). The fourth group comprises industrial formulations generally produced through a sequence of processes involving substances derived from foods and ingredients that are rarely used in conventional domestic cooking.

Ultra-processing therefore differs from conventional food processing not merely in the number of processing steps but also in the **nature and purpose of the processes and ingredients employed**. Industrial techniques may include fractionation of foods into their constituent substances, chemical modification, extrusion, moulding, pre-processing and reassembly. Formulations may also contain additives intended primarily to modify sensory characteristics, including colours, flavours, flavour enhancers, emulsifiers, sweeteners and thickeners (Monteiro et al., 2019).

3.2 NOVA Classification of Foods

The NOVA system provides a conceptual framework for distinguishing foods according to processing characteristics. **Group 1** includes unprocessed or minimally processed foods such as fruits, vegetables, legumes, whole grains, eggs, milk, meat, fish, and nuts. Processing in this group is generally undertaken to preserve foods, improve palatability, or facilitate storage and preparation.

Group 2 comprises processed culinary ingredients, including oils, fats, sugar, salt, and other substances obtained from Group 1 foods or natural sources. These ingredients are generally used in the preparation and seasoning of foods rather than consumed independently.

Group 3 consists of processed foods produced by adding culinary ingredients such as salt, sugar, or oil to relatively simple foods. Examples include canned vegetables, fruits preserved in syrup, and some traditionally prepared cheeses.

Group 4, comprising UPFs, consists predominantly of industrial formulations manufactured using multiple processing techniques and ingredients that are uncommon in conventional kitchens. Examples include packaged sweet and savoury snacks, confectionery, sugar-sweetened beverages, mass-produced breads and pastries, ready-to-eat or ready-to-heat meals, instant noodles, reconstituted meat products, and some formulated dairy or plant-based beverages (Monteiro et al., 2019).

The classification is based primarily on **processing characteristics rather than a single nutrient criterion**. Thus, two products may have similar amounts of fat, sugar, or sodium but belong to different NOVA categories because of differences in their ingredients, formulation, and processing. This distinction is important when interpreting research on UPFs because the category is heterogeneous and encompasses products with substantially different nutritional compositions.

3.3 Characteristics of Ultra-Processed Foods

Several characteristics commonly distinguish UPFs from minimally processed and traditionally processed foods. First, they frequently contain combinations of refined ingredients, including modified starches, protein isolates, hydrogenated or interesterified oils, syrups, and other industrially derived substances. Second, cosmetic additives may be used to reproduce or intensify desirable sensory properties. Third, many UPFs are formulated to have a long shelf life, require little or no preparation, and provide convenient consumption.

These characteristics may influence dietary behaviour independently of conventional nutrient composition. Industrial formulation can modify **texture, palatability, energy density, eating rate, portion characteristics, and sensory appeal**, potentially affecting food intake. Evidence from nutritional research has consequently shifted attention from a purely nutrient-centred interpretation of diet towards consideration of food structure, formulation, and the overall dietary context.

UPFs also tend to have characteristics that facilitate their incorporation into modern food environments. Research examining their energy density, nutrient density, and monetary cost has reported that UPFs tend to be more energy-dense, less nutrient-dense, and less costly per unit of energy than minimally processed foods (Gupta et al., 2019). These characteristics may contribute to their widespread consumption, particularly when convenience, affordability, and time constraints influence food selection.

3.4 Common Examples of Ultra-Processed Foods

UPFs constitute a heterogeneous group and should not be regarded as a single type of food. Common examples include sugar-sweetened and artificially sweetened soft drinks, packaged savoury snacks, confectionery, biscuits, cakes, pastries, mass-produced packaged breads, sweetened breakfast products, instant soups and noodles, ready-to-eat or ready-to-heat meals, reconstituted meat products, and various commercially formulated spreads and beverages (Monteiro et al., 2019).

The heterogeneity of this category is relevant to health interpretation. A diet containing several different UPFs may differ considerably in total energy intake, fibre content, sodium, free sugars, saturated fat, protein quality, and micronutrient content. Therefore, associations between overall UPF consumption and health outcomes should not necessarily be interpreted as evidence that every individual UPF has an equivalent health effect.

3.5 Nutritional and Structural Characteristics

The nutritional profile of UPFs frequently differs from that of minimally processed foods. In comparative analyses, UPFs have generally demonstrated greater energy density and lower nutrient density, although substantial variation exists between products (Gupta et al., 2019). Many UPFs also contain relatively high amounts of refined carbohydrates, free sugars, sodium, or certain fats while providing comparatively limited dietary fibre and micronutrients.

However, attributing health effects exclusively to these nutrient characteristics may be insufficient. The **physical structure of food and degree of industrial formulation** may influence eating behaviour, satiety, energy intake, and metabolic responses. The distinction is particularly relevant because UPF exposure represents a dietary pattern rather than an isolated nutrient exposure. Consequently, associations observed in epidemiological studies may reflect a combination of nutritional composition, food structure, dietary displacement, eating behaviour, and broader lifestyle characteristics.

3.6 Identification of Ultra-Processed Foods from Food Labels

Food labels provide a practical means of identifying many UPFs, although classification requires consideration of the complete ingredient list rather than relying solely on front-of-pack claims or individual nutrients. Monteiro et al. (2019) proposed examining ingredient lists for substances that are rarely used in conventional kitchens, such as protein isolates, modified starches, hydrogenated oils, and certain syrups, as well as additive classes primarily used to alter sensory characteristics.

A practical limitation is that ingredient terminology and formulation practices vary between countries and products. Therefore, **the presence of a single additive should not automatically be interpreted as proof that a product is nutritionally harmful**. Rather, identification should be undertaken within the broader NOVA framework, considering the overall formulation and purpose of industrial processing.

From a nutrition perspective, the ability to recognise UPFs is relevant to dietary counselling and food literacy. Nevertheless, classification should complement rather than replace assessment of the **overall dietary pattern, nutritional adequacy, cultural context, affordability, and individual dietary requirements**.

4. Ultra-Processed Foods and Health

4.1 Overall Health Outcomes

Growing epidemiological evidence indicates that higher consumption of ultra-processed foods (UPFs) is associated with a broad range of adverse health outcomes. In an umbrella review of epidemiological meta-analyses, Lane et al. (2024) identified associations between greater UPF exposure and outcomes involving cardiometabolic health, mental health, respiratory health, gastrointestinal health, cancer, and mortality. The strongest evidence included associations with cardiovascular disease-related mortality, type 2 diabetes, anxiety, and common mental disorders, while highly suggestive evidence was reported for all-cause mortality, depression, obesity, and several other outcomes. However, the certainty of evidence varied considerably, with most pooled analyses rated as low or very low certainty. Therefore, these findings indicate a consistent epidemiological signal but do not establish that UPF consumption independently causes all observed outcomes.

An updated umbrella review similarly reported associations between higher UPF intake and several adverse health outcomes, including obesity, cardiovascular disease, type 2 diabetes, and mortality (Dai et al., 2024). Differences in study populations, dietary assessment methods, definitions of UPF exposure, and adjustment for potential confounders contribute to heterogeneity across the evidence base. Furthermore, individuals with high UPF consumption may differ from those with lower consumption in other dietary and lifestyle characteristics, making complete separation of the effects of UPFs from the overall dietary pattern challenging.

4.2 Cardiovascular Health

Cardiovascular disease represents an important area of concern because UPFs may contribute to several established cardiometabolic risk pathways. Many UPFs contain substantial amounts of sodium, free sugars, saturated fats, and refined carbohydrates, while often providing relatively little fibre and micronutrient diversity. High consumption may consequently be associated with an overall dietary pattern that is less favourable for cardiovascular health.

Epidemiological evidence has reported associations between greater UPF consumption and cardiovascular disease incidence and mortality (Lane et al., 2024). However, the observed relationship is unlikely to be attributable to a single nutritional component. The dietary displacement of minimally processed foods, higher energy intake, and characteristics of industrial food formulation may operate concurrently. Accordingly, UPF exposure should be considered within the context of total dietary quality and food patterns rather than as an isolated dietary risk factor.

4.3 Cancer

Cancer has also emerged as an important outcome in research examining UPF consumption. Lane et al. I

(2024) reported associations between UPF exposure and several cancer-related outcomes within the epidemiological literature. Nevertheless, interpretation requires caution because cancer is a multifactorial outcome influenced by genetic, metabolic, behavioural, environmental, and lifestyle factors.

Potential explanations for observed associations include poorer overall dietary quality, higher energy intake and adiposity, exposure to certain food constituents or processing-related compounds, and displacement of protective foods such as fruits, vegetables, legumes, and whole grains. These mechanisms remain an area of active investigation, and evidence linking UPF consumption directly to specific carcinogenic pathways remains less definitive than the broader epidemiological associations.

4.4 Mental Health

The relationship between UPFs and mental health has received increasing attention. Higher consumption has been associated with anxiety, depression, and common mental disorders in observational evidence synthesised by Lane et al. (2024). The reported associations are biologically plausible through several pathways, including dietary quality, metabolic health, inflammation, and potential interactions between diet and gut–brain signalling.

However, the direction of association is difficult to establish from observational studies alone. Psychological distress may itself influence food choice, including greater reliance on convenient, highly palatable foods. Consequently, **reverse causation and residual confounding** represent important considerations when interpreting associations between UPF consumption and mental health outcomes.

4.5 Gastrointestinal and Respiratory Health

UPF consumption has also been examined in relation to gastrointestinal and respiratory outcomes. Epidemiological evidence included in recent umbrella reviews indicates associations with certain gastrointestinal and respiratory conditions, although the strength and certainty of evidence differ substantially across outcomes (Lane et al., 2024).

Potential explanations include differences in dietary fibre intake, food matrix disruption, overall dietary diversity, metabolic health, and exposure to multiple food additives. Nevertheless, these mechanisms should currently be regarded as hypotheses requiring further investigation rather than established explanations for the observed epidemiological relationships.

4.6 Mortality and Overall Disease Burden

One of the most consequential findings in the UPF literature concerns **all-cause and cause-specific mortality**. Lane et al. (2024) identified highly suggestive evidence linking greater UPF exposure with all-cause mortality and convincing evidence for cardiovascular disease-related mortality. Barbaresko et al. (2025) also reported associations between UPF consumption and several major health outcomes, including all-cause mortality, cardiovascular outcomes, type 2 diabetes, and colorectal cancer.

These findings suggest that UPF consumption may represent an important marker of dietary and health risk at the population level. Nevertheless, mortality associations are particularly vulnerable to confounding because high UPF consumption may cluster with smoking, physical inactivity, socioeconomic disadvantage, obesity, and other health-related behaviours. Thus, the available evidence supports concern regarding high UPF exposure but does not justify interpreting UPF consumption as an independent cause of mortality without qualification.

4.7 Interpretation of the Evidence

The current evidence supports a **consistent association between higher UPF consumption and multiple adverse health outcomes**, but the strength of evidence is not uniform. A critical interpretation requires consideration of study design, exposure measurement, outcome definition, confounding, and the certainty of pooled estimates.

Observational studies are valuable for examining long-term dietary exposures in large populations but cannot completely eliminate confounding or establish causality. Experimental evidence provides stronger support for specific causal pathways but remains comparatively limited in duration and scope. Therefore, the health implications of UPFs should be interpreted using a **hierarchy of evidence**, with conclusions based on convergence across epidemiological, experimental, and mechanistic research rather than on individual associations.

Importantly, UPFs represent a heterogeneous category. The health implications of different UPF subtypes may vary according to their nutritional composition, processing characteristics, food matrix, additives, and position within the overall dietary pattern. Consequently, reducing UPF exposure should not be interpreted simply as eliminating all commercially processed foods; rather, emphasis should be placed on improving overall dietary quality and increasing consumption of minimally processed and nutritionally valuable foods.

5. Ultra-Processed Foods, Obesity and Type 2 Diabetes

5.1 Ultra-Processed Foods and Energy Intake

One of the principal hypotheses linking ultra-processed food (UPF) consumption with obesity is that these foods may facilitate **higher energy intake**. UPFs are frequently characterised by high palatability, relatively high energy density, soft or modified textures, and ease of consumption. These characteristics may influence eating rate, appetite regulation, portion consumption, and subsequent energy intake.

Experimental evidence provides important support for this relationship. In an inpatient randomised controlled crossover trial, Hall et al. (2019) compared ultra-processed and unprocessed diets in weight-stable adults. Although the diets were matched for several nutritional characteristics, participants consumed substantially more energy during the ultra-processed diet and experienced greater weight gain. The findings suggest that differences in food formulation and structure may influence energy intake beyond conventional nutrient composition alone.

However, the findings should be interpreted within the limitations of the experimental design. The intervention was short in duration and conducted under highly controlled inpatient conditions. Therefore, while the study provides evidence that an ultra-processed dietary pattern can increase energy intake under controlled conditions, its findings cannot independently establish the long-term effects of UPF consumption across diverse populations.

5.2 Ultra-Processed Foods and Obesity

The association between UPF consumption and obesity has been consistently reported in prospective observational research. Higher exposure to UPFs has been associated with greater risk of overweight, obesity, and abdominal adiposity in population-based studies and evidence syntheses (Lane et al., 2024). These relationships are biologically plausible because frequent consumption of energy-dense, highly palatable foods may promote positive energy balance over time.

The relationship may also operate through **dietary displacement**. A diet high in UPFs may reduce the relative contribution of fruits, vegetables, legumes, whole grains, nuts, and other minimally processed foods. Consequently, the association between UPFs and obesity may reflect both the characteristics of the foods consumed and the nutritional quality of foods displaced from the diet.

Importantly, obesity itself may influence dietary behaviour. Individuals with existing overweight or obesity may modify their diets, experience changes in appetite or food preferences, or differ in healthseeking behaviour. Such factors can introduce reverse causation into observational studies. Therefore, the observed association between UPF consumption and obesity should be interpreted as evidence of a relationship rather than definitive proof that UPFs independently cause obesity.

5.3 Possible Mechanisms Linking UPFs With Adiposity

Several mechanisms have been proposed to explain the relationship between UPFs and adiposity. One pathway involves **increased energy intake**, as demonstrated experimentally by Hall et al. (2019). Rapid consumption, high palatability, and altered food texture may reduce the time available for physiological satiety signals to influence food intake.

A second mechanism relates to **energy density and dietary composition**. Many UPFs contain substantial amounts of refined carbohydrates, added sugars, or fats while providing relatively low amounts of dietary fibre. Such characteristics can increase energy intake without producing proportional increases in dietary volume.

A third possibility concerns the **food matrix and degree of structural modification**. Industrial processing can substantially alter the physical characteristics of foods, potentially influencing digestion, absorption, satiety, and eating behaviour. In addition, additives and other components of industrial formulations have been proposed as possible contributors to metabolic effects, although the relative importance of individual additives remains uncertain.

These mechanisms should not be interpreted as mutually exclusive. UPF consumption represents a complex exposure involving food composition, physical structure, sensory properties, eating behaviour, and the broader dietary pattern. Consequently, the relationship between UPFs and obesity is likely to involve multiple interacting pathways rather than a single biological mechanism.

5.4 Ultra-Processed Foods and Type 2 Diabetes

Type 2 diabetes (T2D) is another major metabolic outcome associated with higher UPF consumption. Prospective epidemiological studies have generally reported a positive relationship between greater UPF exposure and subsequent risk of T2D. An updated systematic review and meta-analysis by Souza et al. (2025), including 14 prospective cohort studies and 692,508 participants, reported a higher risk of diabetes among individuals with the greatest UPF consumption compared with those with the lowest consumption. However, the authors rated the certainty of evidence as **very low**, highlighting important limitations in the available literature.

Similarly, dose-response evidence has indicated that increasing UPF consumption is associated with progressively higher T2D risk. Such findings are consistent with the possibility that frequent consumption of UPFs contributes to metabolic deterioration through increased energy intake, adiposity, poorer dietary quality, and metabolic effects associated with specific dietary components.

Nevertheless, the relationship should not be reduced to the presence of individual nutrients such as sugar or fat. UPF consumption frequently occurs as part of a broader dietary pattern characterised by lower intake of minimally processed foods and greater consumption of energy-dense products. This makes it difficult to determine how much of the observed diabetes risk is attributable specifically to the degree of processing versus the nutritional and behavioural characteristics accompanying high UPF consumption.

5.5 Possible Pathways Linking UPFs With Diabetes

Several pathways may contribute to the observed association between UPF consumption and T2D. **Excess energy intake and subsequent adiposity** represent an important pathway because obesity is a major established risk factor for insulin resistance and T2D. The experimental findings of Hall et al. (2019) are relevant in this context because increased energy intake and weight gain occurred during the ultra-processed dietary intervention.

Poor overall dietary quality may constitute another pathway. Diets dominated by UPFs may contain greater amounts of refined carbohydrates, free sugars, sodium, and certain fats while providing less fibre and dietary diversity. These characteristics may adversely influence metabolic health when consumed frequently over prolonged periods.

Other mechanisms under investigation include alterations in appetite regulation, gastrointestinal processes, food structure, inflammatory pathways, and interactions between dietary components and the gut microbiome. However, evidence concerning specific biological mechanisms remains heterogeneous, and individual additives or processing-related components cannot presently be assumed to account for the overall epidemiological association.

5.6 Strength and Limitations of the Evidence

The evidence linking UPFs with obesity and T2D is substantial but requires careful interpretation. **Observational studies provide evidence of long-term population-level associations**, whereas controlled feeding studies offer stronger experimental evidence for specific short-term outcomes. The convergence of these approaches strengthens the overall scientific rationale for investigating UPFs, but important uncertainties remain.

A major limitation is the heterogeneity of UPFs themselves. Products classified within the same NOVA category can differ substantially in nutritional composition, ingredients, food structure, and potential metabolic effects. In addition, methods used to assess UPF consumption differ across studies, including dietary recalls, food-frequency questionnaires, dietary records, and national food databases. Misclassification of exposure may therefore affect the magnitude of observed associations.

Residual confounding is another important concern. High UPF consumption may coexist with lower physical activity, smoking, socioeconomic disadvantage, poorer sleep, and other dietary behaviours. Although epidemiological studies attempt to adjust for such factors, complete control is rarely possible.

Overall, the evidence supports a **consistent association between higher UPF consumption and obesity and T2D**, with experimental evidence providing additional support for increased energy intake and short-term weight gain. However, the available evidence does not justify treating all UPFs as equally harmful or attributing observed disease risk exclusively to the degree of processing. Future research should therefore examine specific UPF subtypes, food characteristics, dose-response relationships, and the effects of replacing UPFs with nutritionally superior alternatives.

6. Determinants of Ultra-Processed Food Consumption

Ultra-processed food (UPF) consumption is shaped by a complex interaction of individual preferences, socioeconomic circumstances, food availability, and the broader food environment. Therefore, dietary reliance on UPFs should not be interpreted solely as a consequence of individual choice. Understanding these determinants is important for developing interventions that are both nutritionally appropriate and feasible within diverse social and economic contexts.

6.1 Convenience and Time Constraints

Convenience is a major characteristic of many UPFs. Ready-to-eat and ready-to-heat products require comparatively little preparation and can therefore accommodate individuals experiencing time constraints related to employment, education, commuting, childcare, or other responsibilities. The availability of inexpensive foods requiring minimal preparation may increase their attractiveness within increasingly time-constrained lifestyles.

The convenience of UPFs may also extend beyond preparation time. Their long shelf life, portability, standardised portions, and widespread availability facilitate consumption outside conventional meal settings. Consequently, the modern food environment can make UPFs an easily accessible option when time, cooking facilities, or food preparation skills are limited.

6.2 Palatability and Sensory Appeal

UPFs are frequently formulated to provide desirable sensory characteristics, including pronounced sweetness, saltiness, flavour, aroma, and texture. Such characteristics may increase acceptability and influence food choice. Highly palatable foods can facilitate repeated consumption and may contribute to greater energy intake when consumed frequently.

The controlled feeding study by Hall et al. (2019) is relevant to this issue. Participants consumed more energy during the ultra-processed dietary condition despite similarities between the diets in several conventional nutritional characteristics. Although the study does not establish that palatability alone explains the difference, it supports the broader hypothesis that food formulation and eating characteristics may influence energy intake.

6.3 Affordability and Economic Factors

Economic considerations can substantially influence food selection. UPFs are often available across a wide range of price points and may provide inexpensive sources of energy. Their long shelf life and convenience can further increase their practical value for households managing restricted food budgets.

However, the relationship between socioeconomic status and UPF consumption is not uniform across populations. Dicken et al. (2024), in a systematic review of nationally representative studies from 32 countries, found that associations between UPF intake and income, education, and socioeconomic status varied across settings. This variation indicates that economic determinants should be interpreted within specific national and food-system contexts rather than assuming a universal relationship between lower socioeconomic position and greater UPF consumption.

6.4 Marketing and the Food Environment

Food marketing can influence consumer awareness, preferences, purchasing behaviour, and perceived product value. UPFs are widely represented in commercial food environments, including supermarkets, convenience stores, restaurants, vending outlets, and digital platforms. Repeated exposure to promotional messages may normalise frequent consumption, particularly among children and adolescents.

The influence of marketing is particularly relevant because food choice does not occur in isolation. Product placement, price promotions, availability, packaging, branding, and advertising may collectively shape the range of foods that consumers encounter and ultimately select. Consequently, strategies directed exclusively at individual knowledge may have limited effectiveness when healthier alternatives are less accessible or less convenient.

6.5 Urbanisation and Lifestyle Changes

Urbanisation and changes in household and occupational structures may alter dietary practices by increasing dependence on commercially prepared and packaged foods. Longer commuting times, changing work patterns, smaller households, and reduced time available for food preparation may create conditions in which convenience becomes an important determinant of food choice.

Dicken et al. (2024) identified younger age and urbanisation among sociodemographic characteristics associated with higher UPF intake in several study populations. Nevertheless, these relationships were not universal, reinforcing the importance of considering cultural, economic, and food-system differences.

6.6 Food Insecurity and Socioeconomic Vulnerability

Food insecurity introduces additional complexity to the relationship between UPF consumption and health. Individuals experiencing uncertainty regarding adequate food access may prioritise foods that are inexpensive, energy-dense, readily available, and have a long shelf life. Under such circumstances, recommending substantial reductions in UPFs without addressing affordability and food access may be impractical.

Dicken et al. (2024) identified food insecurity as one of the sociodemographic factors associated with UPF consumption across the literature, although the direction and magnitude of associations varied between settings. This evidence supports an **equity-oriented approach** in which dietary interventions recognise economic constraints rather than attributing consumption patterns solely to insufficient nutrition knowledge.

6.7 Availability and Accessibility

The physical food environment strongly influences dietary opportunities. UPFs are frequently available in supermarkets, small retail outlets, institutional settings, transport hubs, and online food-delivery systems. High availability can reduce the practical effort required to purchase and consume these products.

Conversely, access to fresh and minimally processed foods may be constrained by geographic location, price, seasonality, transportation, cooking facilities, or local food infrastructure. Thus, improving dietary quality requires consideration of both **reducing exposure to less desirable food environments and increasing access to affordable, convenient alternatives**.

6.8 Children's and Adolescents' Exposure

Children and adolescents represent an important population because dietary habits and food preferences develop during early life. Frequent exposure to highly marketed, convenient, and palatable UPFs may contribute to the establishment of habitual consumption patterns. Younger consumers may also have limited autonomy over food purchasing and preparation, making household and environmental factors particularly influential.

The determinants identified in population-based research, including age, urbanisation, socioeconomic circumstances, and food availability, indicate that interventions targeting younger populations should extend beyond individual nutrition education (Dicken et al., 2024). Family practices, school food environments, marketing exposure, and availability of nutritious alternatives are relevant components of a comprehensive prevention strategy.

6.9 Integrated Interpretation

The determinants of UPF consumption are therefore **multilevel and interrelated**. Convenience may interact with time constraints; affordability may interact with food insecurity; marketing may interact with product availability; and individual preferences may be shaped by repeated environmental exposure. This complexity suggests that reducing UPF intake through nutrition education alone is unlikely to address all underlying drivers.

Effective approaches should consequently combine **individual dietary skills with supportive food environments**, while recognising differences in socioeconomic circumstances and cultural food practices. Such an approach is consistent with the evidence that determinants of UPF consumption vary substantially across populations (Dicken et al., 2024).

7. Practical Approaches to Reduce Ultra-Processed Food Intake

Reducing ultra-processed food (UPF) consumption requires a **multilevel approach** that addresses individual dietary behaviour as well as the social and food environments in which food choices occur. Because UPFs constitute a heterogeneous category, the objective should not be interpreted as indiscriminate elimination of all processed foods. Rather, emphasis should be placed on improving overall dietary quality through greater consumption of minimally processed foods and appropriate substitution of frequently consumed UPFs with nutritionally adequate alternatives.

7.1 Individual Dietary Strategies

At the individual level, dietary modification can begin with identification of frequently consumed UPFs and assessment of the circumstances in which they are selected. Rather than recommending abrupt dietary restriction, practical counselling can focus on **gradual reduction and substitution**. For example, sugar-sweetened beverages may be replaced with water or unsweetened beverages, packaged snacks with fruits or nuts, and highly processed ready-to-eat meals with meals based on minimally processed ingredients.

Such approaches are more consistent with sustainable dietary behaviour because they address what individuals can realistically incorporate into their existing routines. Nutrition counselling should consider dietary preferences, cultural practices, food availability, affordability, cooking facilities, and individual nutritional requirements.

7.2 Food-Label Literacy

Improving consumers' ability to interpret ingredient lists may support informed food selection. UPFs can frequently be recognised through the presence of industrially derived ingredients and additives that are uncommon in conventional culinary preparation (Monteiro et al., 2019). Nutrition education can therefore teach individuals to examine the **overall ingredient list and formulation** rather than relying exclusively on front-of-pack claims such as “natural,” “light,” or “healthy.”

However, label-based education should be presented as a tool for food literacy rather than as a substitute for comprehensive dietary assessment. The presence of an individual additive does not, by itself, establish that a food is harmful. Interpretation should remain consistent with the broader NOVA classification framework.

7.3 Increasing Consumption of Minimally Processed Foods

A practical strategy for reducing UPF exposure is to increase the relative contribution of minimally processed foods within the diet. Fruits, vegetables, pulses, whole grains, nuts, seeds, eggs, and other minimally processed foods can form the foundation of meals while reducing reliance on highly formulated products.

This approach has an important advantage over restriction alone: it focuses on **dietary substitution and improvement of food quality**. Increasing the availability and consumption of minimally processed foods may simultaneously increase dietary fibre, micronutrient diversity, and food variety while reducing the proportion of energy derived from UPFs.

7.4 Meal Planning and Home Food Preparation

Meal planning and food preparation can reduce dependence on convenience foods, particularly when lack of time is an important determinant of UPF consumption. Preparing meals in advance, maintaining basic minimally processed ingredients at home, and developing simple cooking routines can increase the feasibility of healthier choices.

However, recommendations for home preparation should remain realistic. Time constraints, employment patterns, household responsibilities, cooking skills, and access to kitchen facilities differ substantially between individuals and households. Consequently, nutrition counselling should emphasise **feasible preparation strategies rather than idealised dietary practices**.

7.5 Substitution Rather Than Simple Restriction

Evidence-informed dietary counselling should emphasise **replacement of frequently consumed UPFs with nutritionally preferable alternatives** rather than focusing exclusively on prohibition. This distinction is important because simple restriction may be difficult to sustain if individuals lack convenient alternatives.

For example, replacing packaged sweet snacks with fruit and unsweetened yoghurt, replacing highly processed breakfast products with oats or other minimally processed cereals, and replacing sugar-sweetened beverages with water can reduce UPF exposure while maintaining familiar eating occasions. The appropriate substitution should depend on dietary needs, cultural acceptability, affordability, and availability.

7.6 Nutrition Counselling and Behavioural Strategies

Nutrition professionals can contribute by translating evidence concerning UPFs into practical dietary recommendations. Counselling may incorporate **goal setting, self-monitoring, problem solving, dietary planning, and behavioural feedback** to support gradual dietary change.

An important principle is to avoid an excessively restrictive approach. Because UPFs are embedded within contemporary food systems and are consumed for multiple reasons, including convenience and affordability, counselling should identify the individual's specific consumption drivers. Personalised interventions may therefore be more appropriate than uniform recommendations.

7.7 Family and Community Approaches

Food choices are strongly influenced by household practices and social environments. Family-based strategies can include joint meal planning, increasing availability of minimally processed foods at home, involving children in food preparation, and reducing routine availability of highly processed snacks and sugar-sweetened beverages.

Community-level interventions may complement individual counselling by improving access to affordable nutritious foods and strengthening food and nutrition literacy. Such approaches are particularly relevant where economic or environmental barriers constrain individual choice.

7.8 Food-Environment and Policy-Level Strategies

Individual interventions alone cannot fully address the structural determinants of UPF consumption. Food-environment strategies may include improving availability and affordability of minimally processed foods, strengthening nutrition education, regulating inappropriate food marketing, particularly to children, and improving the transparency and interpretability of food information.

The need for such approaches is supported by evidence demonstrating that UPF consumption varies according to sociodemographic and environmental circumstances (Dicken et al., 2024). Interventions should therefore be designed to avoid widening dietary inequalities. Policies that increase the cost or reduce the availability of UPFs without simultaneously improving access to affordable nutritious alternatives may disproportionately affect economically vulnerable populations.

7.9 Integrated Approach to Dietary Reduction

Taken together, the evidence supports a **hierarchical and context-sensitive approach** to reducing UPF intake:

Assessment of current intake → Identification of consumption determinants → Nutrition education and label literacy → Substitution with minimally processed foods → Behavioural support → Supportive family and community environments → Food-system and policy interventions.

The most appropriate strategy will vary according to individual circumstances and the characteristics of the surrounding food environment. Importantly, reducing UPF intake should be integrated into the broader objective of achieving a **nutritionally adequate, culturally appropriate, affordable, and sustainable dietary pattern**, rather than being treated as an isolated dietary target.

8. Discussion

The evidence reviewed indicates that ultra-processed food (UPF) consumption is an important characteristic of contemporary food environments and is consistently associated with several adverse health outcomes. However, the interpretation of this evidence requires consideration of the heterogeneity of UPFs, differences in exposure assessment, and the predominance of observational research. The findings therefore support a cautious interpretation in which high UPF consumption is considered a **marker and possible contributor to poorer health**, rather than an independent cause of all associated diseases.

8.1 Ultra-Processed Foods Within Contemporary Dietary Patterns

The increasing contribution of UPFs to dietary intake reflects broader changes in food systems, including greater availability of ready-to-consume products, commercialisation of food preparation, and increasing demand for convenience. The NOVA framework has contributed to the recognition that the health characteristics of foods cannot always be captured adequately by nutrient composition alone (Monteiro et al., 2019).

Nevertheless, the NOVA classification has also generated scientific debate because UPFs encompass a highly heterogeneous group of products. Foods classified within the same category may differ substantially in nutrient composition, food matrix, ingredients, and dietary role. Consequently, the health implications of UPFs should not be interpreted as uniform across all products.

8.2 Relationship With Obesity and Type 2 Diabetes

The relationship between UPF consumption and obesity is supported by both observational and experimental evidence. Population-based studies generally report higher adiposity among individuals with greater UPF consumption, while the controlled feeding trial by Hall et al. (2019) demonstrated increased energy intake and weight gain during an ultra-processed dietary intervention.

The evidence concerning type 2 diabetes is similarly consistent in direction. Prospective cohort studies and meta-analyses generally indicate higher diabetes risk among individuals consuming greater amounts of UPFs (Souza et al., 2025). However, the certainty of this evidence remains an important consideration. The association may reflect multiple interacting pathways, including excess energy intake, increased adiposity, dietary displacement, and poorer overall dietary quality.

Thus, the evidence supports reducing excessive reliance on UPFs as part of broader dietary improvement, but it does not support attributing diabetes risk to processing alone.

8.3 Health Equity and Food Choice

An important implication of the evidence is that UPF consumption cannot be understood exclusively as an individual behavioural problem. Convenience, affordability, availability, time constraints, marketing, and socioeconomic circumstances can substantially influence dietary choices. Dicken et al. (2024) demonstrated considerable variation in the sociodemographic determinants of UPF consumption across countries.

This finding has implications for nutrition practice. Recommendations to “avoid UPFs” may be difficult to implement when individuals have limited time, financial resources, cooking facilities, or access to affordable minimally processed foods. Consequently, effective interventions should provide **realistic substitutions and practical dietary skills** rather than relying solely on restrictive messages.

8.4 Implications for Nutrition and Public Health Practice

Nutrition professionals should focus on improving overall dietary quality while helping individuals identify foods that contribute substantially to their UPF exposure. Dietary counselling can incorporate label literacy, meal planning, food preparation skills, substitution strategies, and gradual reduction of frequently consumed UPFs.

At the population level, individual counselling should be complemented by food-environment interventions. Improving access to affordable minimally processed foods, supporting nutrition literacy, and creating healthier institutional and community food environments may facilitate sustained dietary change.

8.5 Interpretation of Causality

A central issue in the UPF literature is the distinction between **association and causation**. The large body of observational evidence provides consistent evidence that higher UPF consumption is associated with adverse health outcomes. However, observational research remains susceptible to confounding, measurement error, and reverse causation. Lane et al. (2024) highlighted this limitation by showing that although associations were widespread across health outcomes, the certainty of evidence was low or very low for most pooled analyses.

Experimental evidence provides a complementary perspective. Hall et al. (2019) demonstrated that an ultra-processed diet increased energy intake and body weight under controlled conditions, supporting the possibility of a causal effect on energy balance. Nevertheless, the short duration and controlled setting limit direct extrapolation to long-term disease outcomes.

Therefore, the most scientifically appropriate interpretation is that **higher UPF consumption is consistently associated with poorer health outcomes, while evidence for specific causal mechanisms and long-term disease effects continues to develop**.

8.6 Overall Interpretation

Taken together, the evidence supports a dietary approach that prioritises minimally processed foods while reducing excessive dependence on UPFs. Such an approach should not be based on the assumption that every processed product is harmful or that complete elimination of UPFs is necessary or feasible for all individuals.

The more appropriate public health objective is to improve the **overall quality, nutritional adequacy, accessibility, and sustainability of dietary patterns**. Future research should increasingly move beyond examining total UPF exposure alone and investigate the effects of specific UPF subtypes, replacement foods, food-processing characteristics, and population-specific determinants.

9. Research Gaps and Future Directions

Despite the growing body of evidence linking ultra-processed food (UPF) consumption with adverse health outcomes, several important research gaps remain. A major limitation is the predominance of **observational evidence**, which limits definitive causal interpretation. Although controlled feeding research has demonstrated effects of an ultra-processed dietary pattern on energy intake and short-term weight gain (Hall et al., 2019), longer-duration controlled studies are required to determine whether these effects translate into sustained changes in adiposity, glycaemic regulation, cardiovascular risk, and disease incidence.

9.1 Need for Improved Assessment of UPF Exposure

Future studies should improve the measurement and classification of UPF consumption. Dietary assessment methods vary considerably between studies, and differences in food composition databases and classification procedures may result in exposure misclassification. Standardised approaches would improve comparability across populations and countries.

In addition, the heterogeneity of UPFs warrants greater attention. Products within the same NOVA category can differ substantially in nutrient composition, food matrix, additives, and dietary role. Research examining **specific UPF subtypes and their replacement with minimally processed alternatives** may therefore provide more clinically meaningful information than analyses based exclusively on total UPF intake.

9.2 Strengthening Causal Evidence

Future research should integrate prospective cohorts, controlled feeding trials, mechanistic investigations, and well-designed intervention studies. Studies should also examine potential mediating pathways, including energy intake, adiposity, metabolic dysfunction, dietary fibre intake, eating rate, food structure, and other biological mechanisms.

Greater emphasis should be placed on **substitution analyses**, determining whether replacing UPFs with minimally processed foods produces measurable improvements in health outcomes. Such evidence would have direct relevance for dietary recommendations because the health effect of reducing a food depends partly on what replaces it.

9.3 Population-Specific and Food-Environment Research

Further research is also needed to understand how socioeconomic conditions, food insecurity, urbanisation, cultural dietary practices, marketing, and food accessibility influence UPF consumption. Evidence indicates substantial cross-country variation in sociodemographic determinants (Dicken et al., 2024). Therefore, interventions should be evaluated within specific cultural and food-system contexts rather than assuming that a single strategy will be equally effective across populations.

10. Strengths and Limitations

A major strength of this review is its **multidimensional approach**, integrating evidence on UPF classification, health outcomes, obesity, type 2 diabetes, determinants of consumption, and dietary reduction strategies. The review also distinguishes observational associations from experimental evidence, thereby avoiding an assumption of causality where the evidence does not support it.

However, several limitations should be recognised. The review is an integrative synthesis rather than a formal systematic review with quantitative meta-analysis; consequently, it does not provide a pooled effect estimate of its own. Considerable heterogeneity exists among studies in the definition and measurement of UPF exposure, populations studied, outcomes assessed, and degree of adjustment for confounding. Furthermore, the evidence base is predominantly observational, and therefore residual confounding and reverse causation cannot be completely excluded. These limitations should be considered when interpreting the conclusions.

11. Conclusion

Ultra-processed foods constitute a substantial component of contemporary food environments and are increasingly recognised as an important factor in nutritional epidemiology and public health. Higher UPF consumption is consistently **associated with obesity, type 2 diabetes, cardiovascular outcomes,**

mortality, and several other adverse health outcomes, although the certainty of evidence varies across outcomes.

Experimental evidence strengthens the interpretation that ultra-processed dietary patterns can promote increased energy intake and weight gain, while observational evidence provides information regarding longer-term disease associations. Nevertheless, the heterogeneity of UPFs and limitations of observational research require cautious interpretation.

Reducing excessive reliance on UPFs should therefore form part of a broader strategy to improve dietary quality through greater consumption of minimally processed foods, practical dietary substitution, nutrition education, and supportive food environments. Future research should prioritise stronger causal evidence, standardised assessment of UPF exposure, subtype-specific analyses, and interventions that are **effective, affordable, culturally appropriate, and equitable**.

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