



Ultra-Processed Food and Cardiometabolic Risk: What the Classification Does and Does Not Explain

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Abstract

Applied to the same 5,636 participants, four food processing classifications assigned between 7.9 and 45.9 per cent of intake to the ultra-processed category, with an intraclass correlation of 0.51 between them. They also produced different findings: an association with body mass index emerged under one system and with systolic and diastolic blood pressure under another, in the same people. Within the category, subgroups point in opposite directions. Processed meats, sugar-sweetened beverages and refined grain products are consistently associated with higher cardiometabolic risk, while breakfast cereals, whole-grain breads and some dairy products show neutral or inverse associations. Against that, controlled trials show that diets high in these foods increase energy intake and weight, so something is operating beyond nutrient composition even where the category is a poor guide to it.

Keywords: Ultra-processed food; Food classification; Cardiometabolic risk; NOVA; Nutritional epidemiology

Introduction

Ultra-processed foods account for a substantial share of daily energy intake across high-income countries, and high intake is consistently linked to adverse health outcomes [1,2]. The most widely used definition classifies foods into four groups by extent of processing, with the fourth comprising industrially formulated products made using substances rarely found in home kitchens together with additives [3].

The term nonetheless lacks a universal definition [1,3]. The fourth group is broad, assembling breakfast cereals, packaged breads, plant-based meat alternatives and confectionery under a single heading on the basis of processing extent rather than nutritional composition [3].

This review examines what the classification predicts, where different classifications disagree with one another, whether the category behaves consistently internally, and what remains after those qualifications are applied.

Objective

This review sets out to establish four things from the published literature. First, what the classification systems are and how far they agree when applied to the same people. Second, whether foods grouped together within the ultra-processed category share a direction of association with cardiometabolic outcomes. Third, what experimental rather than observational evidence shows. And fourth, which mechanisms have been proposed that would operate independently of nutrient composition.

Literature Review

What the classification contains: The framework distinguishes minimally processed foods altered only by drying, grinding or pasteurisation; culinary ingredients such as oils, salt and sugar; simply processed items including canned fish and cheese; and industrially formulated products using high-fructose corn syrup, hydrogenated oils, hydrolysed proteins and maltodextrins together with emulsifiers, flavours, sweeteners and colours (Figure 4) [3].

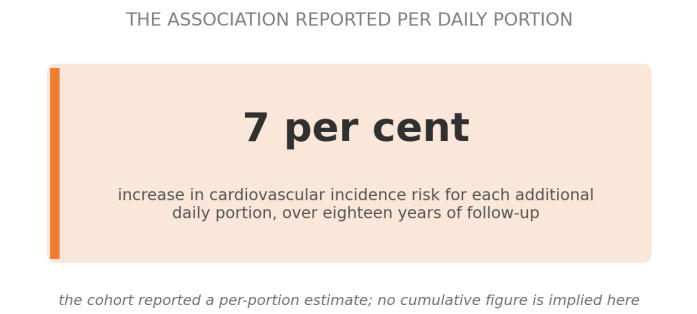


Figure 4: The four groups of the classification [3]

How far the systems agree: Baseline data from 5,636 participants of a Mediterranean diet prevention trial, 48.5 per cent female with a mean age of 65.1 plus or minus 4.9 years and all meeting at least three metabolic syndrome criteria, were classified using four processing-based systems applied to the same 143-item food frequency questionnaire. The highest ultra-processed consumption was obtained with one system at 45.9 per cent and the lowest with another at 7.9 per cent (Figure 2), and the intraclass correlation between the four was 0.51 overall (Figure 3) [4].

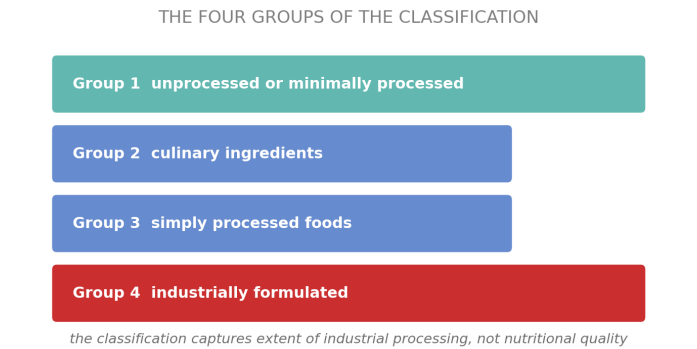


Figure 2: One cohort of 5,636 assessed under four classification systems [4]

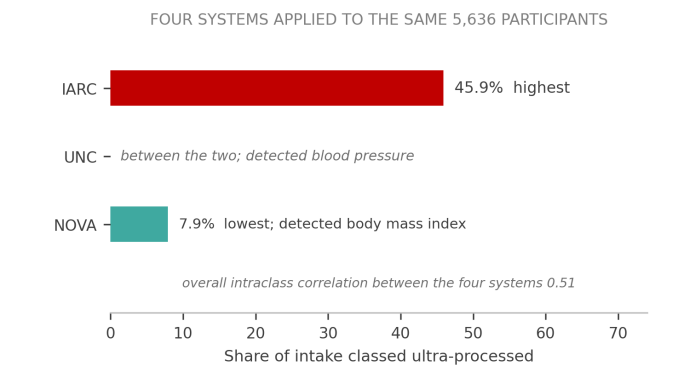


Figure 3: Agreement between the four systems [4]

Different systems, different findings: In the same participants, a direct association between ultra-processed consumption and body mass index was detected using one system ($p = 0.001$), and associations with systolic ($p = 0.018$) and diastolic ($p = 0.042$) blood pressure using another (Figure 6). The investigators concluded that food classification methodologies markedly influenced the association between ultra-processed consumption and cardiometabolic risk markers [4] (Table 1).

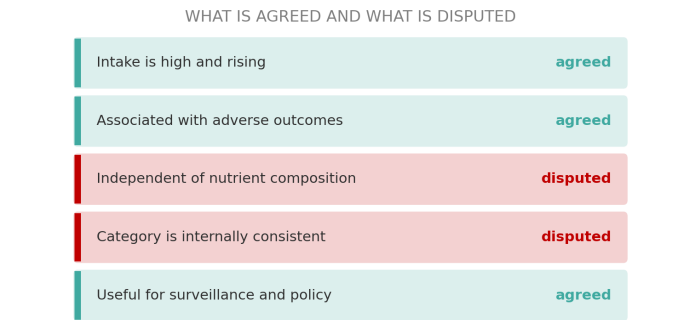


Figure 6: Which system detected which association, in the same participants [4]

Table 1: The same cohort under four classifications, as published [4]

System	Share classed ultra-processed	Association detected
Highest-yielding system	45.9%	— [4]
Lowest-yielding system	7.9%	Body mass index [4]
A third system	Between the two	Blood pressure [4]
Agreement between all four	—	Intraclass correlation 0.51 [4]

The category is internally inconsistent: Foods within the same processing category often differ substantially in nutritional composition, metabolic effects and clinical associations, and recent evidence describes the health associations as highly heterogeneous [5,6]. In several prospective cohorts, processed meats and sugar-sweetened beverages showed consistent positive associations with type 2 diabetes and cardiometabolic disease, while other subgroups including breads and breakfast cereals showed neutral or inverse associations (Figure 1) [5,6].

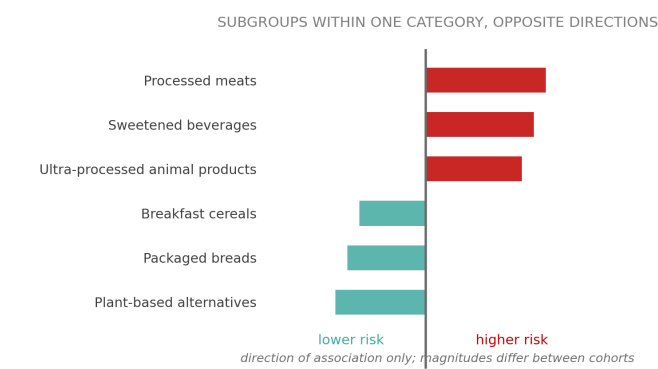


Figure 1: Subgroups within a single processing category [5,6,7]

The same pattern in two large cohorts: In a European cohort, higher consumption of ultra-processed animal-based products and sweetened beverages was associated with greater diabetes risk, while ultra-processed breads, cereals and plant-based alternatives were associated with lower risk estimates [6]. A separate analysis found refined grains, animal-based products and sugar-sweetened beverages linked to higher type 2 diabetes risk, while cereals, dark and whole-grain breads, yogurt and dairy-based desserts were associated with lower risk [7].

The ingredient may matter more than the processing: An analysis in an Australian population reported that ultra-processed foods containing non-refined, high whole-grain ingredients did not contribute to deleterious cardiometabolic associations, despite being technically industrially formulated [8]. The reviewing authors of a professional advisory note that some nutrient-dense foods with ultra-processed characteristics may be neutral or even beneficial [2].

What the definition struggles with: The same advisory observes that developing nutrition guidance and policy on the basis of the classification alone remains challenging, that criteria such as the use of additives for palatability are often subjective, and that despite progress in establishing operational markers of processing, classification remains complex. Policy development is further constrained by limited mechanistic insight and by debate about whether all such foods carry health risks [2].

What experimental evidence shows: Controlled trials show that diets rich in these foods increase energy intake and weight gain [3]. Proposed mechanisms include high energy density, disrupted food matrices, faster eating rates, additives affecting the gut and hyper-palatable formulation (Figure 5) [3]. Observational evidence associates higher intake with obesity, cardiovascular disease, type 2 diabetes and all-cause mortality [3,9] (Table 2).

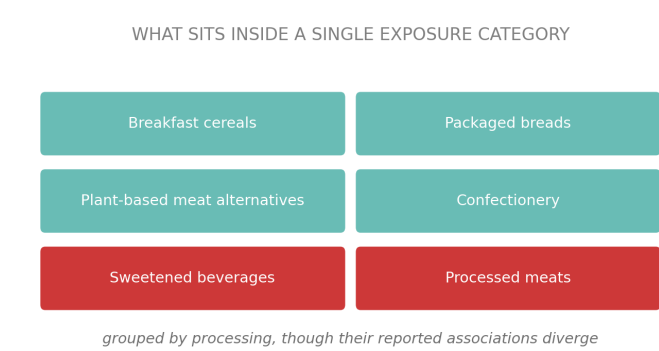


Figure 5: Mechanisms proposed beyond nutrient composition [3]

Table 2: What the classification does and does not support

Table 3: Where the evidence is strong and where the framework is contested

Claim	Status in the reviewed evidence
High intake is associated with harm	Consistent across cohorts [1,2,3]
The category is internally consistent	No; subgroups diverge [5,6,7]
Classifications agree with each other	Poorly; correlation 0.51 [4]
Processing matters beyond nutrients	Supported by controlled trials [3]
The definition supports policy alone	Described as challenging [2]

The controlled trial in detail: An inpatient randomised study of ad libitum intake compared ultra-processed with unprocessed diets matched for presented nutrients and found excess calorie intake and weight gain on the ultra-processed arm [10]. Proposed mechanisms of action for cardiovascular outcomes have been set out separately [17], and the role of diet quality in mediating the association examined directly [28].

The observational base: Large prospective cohorts have reported associations with cardiovascular disease [11] and cancer [12], and systematic review with meta-analysis has pooled health status outcomes [13]. An umbrella review of epidemiological meta-analyses assessed the breadth of reported adverse outcomes [14], and analyses of three large cohorts examined cardiovascular disease [15] and type 2 diabetes [16] respectively. Population-level trends in sales have been related to body mass index trajectories [29], and the nutrition transition described globally and regionally [30]. Intake has been characterised in national survey data in several countries [25,26,31,32], and mediation by body fat examined in normal-weight children [33].

The critique of the framework itself: The originators have addressed the trouble with ultra-processing as a concept [18], and definitional and policy issues have been set out by others [19]. Whether the concept informs dietary guidelines beyond conventional classification has been debated in print by proponents and critics together [20]. How functional the system is has been examined directly [21], with critical perspectives

from food science [22] and analyses of the conceptual challenges in classifying processed food [23]. One group constructed a healthy dietary pattern menu largely from ultra-processed items to test whether the two frameworks can coexist [24], and narrative review has surveyed the outcome literature [27]. Alternative nutrient profiling systems using expanded characteristics have been proposed [34] (Table 3).

Question	What the evidence supports
Do these diets raise intake?	Yes, in a controlled trial [10]
Is the category coherent?	No; subgroups diverge [5,6,7]
Do classifications agree?	Correlation 0.51 [4]
Does the framework support policy alone?	Described as challenging [2,20]
Are alternatives proposed?	Yes, profiling systems [34]

Method

Search strategy: PubMed and the archives of the major nutrition, cardiology and public health journals were searched for studies of food processing classification and cardiometabolic outcomes. Search terms combined ultra-processed food with NOVA, classification, cardiometabolic risk, subgroup heterogeneity and controlled trial. Reference lists of the professional advisory [2] and the four-classification comparison [4] were screened by hand for primary sources.

Eligibility: Studies were included if they reported associations between processing-classified intake and cardiometabolic outcomes, compared classification systems, or examined subgroups within the ultra-processed category. Advisory and position documents are cited for their content and identified as such.

Data extraction and handling: Population, classification system applied, subgroup where reported and the outcome were extracted as published. The classification system is stated alongside every estimate, because the same cohort yields ultra-processed intake of 7.9 or 45.9 per cent depending on the system used and detects different associations accordingly. Where a source reported only the highest and lowest of several systems, intermediate values are described as falling between rather than assigned figures. This review reports published findings and does not constitute dietary guidance for any individual or population. No pooling or re-analysis was performed. Figures 1 to 6 and Tables 1 to 3 reproduce published values only. This is a narrative synthesis of published literature and was not registered as a systematic review.

Concluding Remarks

The most direct test of the classification is what happens when several are applied to one dataset, and the answer is unflattering. Four systems assigned between 7.9 and 45.9 per cent of intake to the ultra-processed category in the same 5,636 people, with an intraclass correlation of 0.51 [4]. Two of them detected associations with different outcomes in the same participants [4]. A category whose membership varies almost sixfold by definition is not measuring one thing.

The internal heterogeneity compounds this and is better documented. Processed meats and sugar-sweetened beverages associate with higher risk; breakfast cereals, whole-grain breads and some dairy products with neutral or lower risk [5,6,7]. Those foods share membership of the fourth group and nothing else that bears on cardiometabolic outcome. An exposure variable that combines them will report an average of opposing effects.

The Australian whole-grain finding sharpens the point. Industrially formulated products built on non-refined, high whole-grain ingredients did not carry the adverse associations [8]. If the harmful signal tracks the ingredient rather than the industrial process, then processing extent is a proxy, and a leaky one.

None of this dismisses the association, and the controlled trial evidence is why. Diets rich in these foods increase energy intake and weight gain under experimental conditions [3]. That is a causal finding about a dietary pattern, and the proposed mechanisms, energy density, disrupted matrix, faster eating rate, palatability, are properties of manufacture rather than of nutrient content [3]. Something real is being detected.

The reconciliation is that two different claims are being conflated. That diets high in ultra-processed food produce excess intake is supported experimentally. That ultra-processed status is a useful classifier of individual products is not, given that subgroups diverge and systems disagree [2,4,5]. The first justifies population-level concern; the second is what a label or a guideline would need, and it is the weaker of the two.

The advisory's own conclusion should be read as written. Guidance based solely on the classification is described as challenging, criteria such as additives for palatability as subjective, and policy as constrained by limited mechanistic insight [2]. Those are the authors of a professional statement on this topic saying that their own framework will not carry a policy on its own.

Three limitations belong with these conclusions. The four-system comparison was conducted in an older population selected for overweight and metabolic syndrome criteria, so agreement between systems might differ in a general population [4]. Subgroup analyses within cohorts were not the primary hypotheses of those studies and carry the usual risks of multiple comparison [6,7]. And the reviewed literature reports direction

of association for subgroups more often than effect size, which limits how far the opposing signals can be weighed against one another [5,6,7].

There is a constructive proposal buried in the critique. One group built a menu meeting conventional dietary guidelines largely from ultra-processed items, which is a direct test of whether the two frameworks conflict [24]. That such a menu can be constructed at all indicates that processing status and nutritional adequacy are separable properties, whatever their correlation in the food supply as actually purchased [2,24].

Alternative approaches exist and are worth naming. Nutrient profiling systems using expanded characteristics have been developed to score healthfulness directly rather than by proxy [34], and analyses examining diet quality as a mediator suggest that much of the association may run through nutritional composition after all [28]. If that is right, the classification is a convenient marker for a poor diet rather than an independent exposure [28,34].

Where this leaves a reader depends on the decision being made. For population surveillance and for describing trends in the food supply, the framework works and is widely used for exactly that [3,30]. For advising an individual which product to put back on the shelf, the subgroup evidence says the category will sometimes give the wrong answer, and the whole-grain finding is the clearest example [7,8].

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Conflict of Interest

The authors declare no competing interests.

Ethics Statement

This article reviews previously published studies only. No new patient data were collected and no participants were recruited, so ethical approval was not required.

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