**Nordic Nutrition Recommendations 2022** - **Ultra-processed foods**

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**Abstract**

Ultra-processed foods, which are industrially manufactured, ready-to-eat/heat formulations that are largely devoid of whole foods, are increasingly consumed worldwide and have been linked to several health challenges relevant for the Nordic and Baltic countries, including obesity, cardiovascular disease, type 2 diabetes, cancers, depression and premature mortality*.* The aim of this chapter is to describe the totality of the available evidence regarding ultra-processed foods in relation to health-related outcomes as a basis for setting Food-Based Dietary Guidelines (FBDGs) for the Nordic Nutrition Recommendations 2022 (NNR2022). Systematic literature searches were conducted to identify high-quality systematic reviews, meta-analyses, randomized controlled trials (RCT) and prospective cohort studies examining the association between ultra-processed food intake and non-communicable diseases or mortality. A total of eight systematic reviews (including 2 meta-analyses) and 25 original research studies were included in the chapter review. While limited in number, carefully conducted prospective cohort studies consistently found that higher consumption of ultra-processed foods is associated with increased risk of weight gain, obesity, CVD, and all-cause mortality. The strongest evidence is observed in relation to weight gain and obesity, as this association is supported by both epidemiological studies and a well conducted RCT. The current evidence is also suggestive of an association between ultra-processed foods and type 2 diabetes, hypertension, cancer and depression, however the limited number of studies and subjects investigated preclude strong conclusions. Additional prospective cohort studies and experimental studies in diverse populations and settings are warranted. Nevertheless, the current evidence is sufficiently strong to justify the inclusion of FBDGs to limit the consumption of ultra-processed foods.

**Introduction**

Diets and food supplies worldwide are increasingly based on ultra-processed foods, which are industrially manufactured, ready-to-eat/heat formulations that are largely devoid of whole foods.1,2 The role of industrial food processing in relation to human health has historically been neglected in nutrition research, dietary guidelines and national and international policies.3 Recently, however, there is a rapidly growing scientific interest in ultra-processed foods as accumulating evidence links its consumption to poor diet quality and chronic disease outcomes.3,4

The concept of ultra-processed foods was first suggested by Monteiro et al in 2010, as part of the NOVA classification of food processing level. NOVA classifies foods into four mutually exclusive groups based on the extent and purpose if the industrial processing they have undergone (**Table 1**): (1) ‘unprocessed or minimally processed foods’ including fresh, dry or frozen fruits or vegetables, grains, legumes, meat, fish and milk; (2) ‘processed culinary ingredients’ including table sugar, oils, fats, salt, and other constituents extracted from foods or from nature, and used in kitchens to make culinary preparations; (3)‘processed foods’ including foods such as canned fish and vegetables, simple breads and artisanal cheeses which are manufactured by only adding salt, sugar, oil or other processed culinary ingredients to unprocessed or minimally processed foods; and (4) ‘ultra-processed foods’, which are industrial formulations made with no or minimal whole foods. In contrast to processed foods, which are whole foods preserved by traditional techniques such as canning or pickling, the production of ultra-processed foods involves a number of novel processing techniques (e.g. extrusion), ingredients (e.g. modified starches, protein isolates) and additives (e.g. emulsifiers, artificial flavors) of exclusive industrial use.1 Examples of ultra-processed foods include soft drinks, salty snack foods, fast foods and candy.1 Many foods that are marketed and perceived as healthy, such as industrially produced breads, breakfast cereals, flavored yogurts, reduced-calorie/low-fat products, and products ‘enriched’ with beneficial nutrients, are in fact ultra-processed.1

Food processing level has emerged as a novel dimension of diet quality and ultra-processed foods are increasingly scrutinized as a potential driver of the current global epidemics of diet-related chronic diseases.3 Epidemiological studies have consistently found that diets with a higher proportion of ultra-processed foods have less favorable nutrient profiles than diets containing less ultra-processed foods.5-13 Specifically, diets higher in ultra-processed foods are generally higher in total energy, total fat, saturated fat, trans fat, added/free sugars and sodium while providing less protein, fiber and several essential vitamins and minerals.3 Furthermore, greater intakes of ultra-processed foods have been linked to increased risk of several chronic diseases including risk of obesity, diabetes, hypertension, dyslipidaemia, cardiovascular diseases, and all-cause mortality in several large cohort studies.3,4

In response to the current evidence, some countries have recently implemented public health policies to decrease the consumption of ultra-processed foods.14-16 For example, Brazil15 and Israel16 have developed food-based dietary guidelines dissuading ultra-processed food consumption, and Chile14 has implemented strict food-marketing and front-of-package labelling legislation. Nevertheless, the topic has so far not been addressed in the Nordic Nutrition Recommendations. The aim of this chapter is to describe the totality of the available evidence regarding ultra-processed foods in relation to health-related outcomes as a basis for setting Food-Based Dietary Guidelines (FBDGs) for the Nordic Nutrition Recommendations 2022 (NNR2022).

**Table 1.** NOVA food classification based on the extent and purpose of industrial processing. Modified with permission from Martinez-Steele at al. 2016.12

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| Food groups and definitions | Examples |
| 1. Unprocessed or minimally processed foodsUnprocessed foods are those obtained directly from plants or animals (such as green leaves and fruits, or eggs and milk) and purchased for consumption without having undergone any alteration following their removal from nature. Minimally processed foods are natural foods that have been submitted to cleaning, removal of inedible or unwanted parts, fractioning, grinding, drying, fermentation, pasteurization, cooling, freezing, or other processes which do not add substances to the original food. The purpose of minimum processes is to preserve and store foods; decrease stages of food preparation (cleaning and removing inedible parts); facilitate digestion or increase palatability (e.g. grinding or fermentation). | Natural, packaged, cut, chilled or frozen vegetables, fruits, potatoes, cassava, and other roots and tubers; bulk or packaged white, parboiled and wholegrain rice; whole or separated corn; grains of wheat and other cereals that are dried, polished, or ground as grits or flour; dried or fresh pasta made from wheat flour and water; all types of beans; lentils, chickpeas, and other legumes; dried fruits, fresh or pasteurized fruit juices without added sugar or other substances; nuts, peanuts, and other oilseeds without salt or sugar; fresh and dried mushrooms and other fungi; fresh and dried herbs and spices; fresh, frozen, dried beef, pork, poultry and other meat and fish; pasteurized, ‘long-life’ and powdered milk; fresh and dried eggs, yoghurt without sugar; and tea, herbal infusions, coffee, and tap, spring and mineral water. |
| 2. Processed culinary ingredientsSubstances extracted from natural foods or from nature itself by processes such as pressing, grinding, crushing, pulverizing, and refining. The purpose is to obtain ingredients to season and cook natural or minimally processed foods. | Plant oils; coconut and animal fats (including butter and lard); table sugar, maple syrup (100%), molasses and honey; and table salt. |
| 3. Processed foodsSimple products manufactured with the addition of processed culinary ingredients, to natural or minimally processed foods. This group also includes alcoholic drinks produced by the fermentation of unprocessed/minimally processed foods.The purpose of processing is to prolong duration and modify the palatability of foods.  | Canned and bottled vegetables, legumes or fruits; salted nuts or seeds; salted, smoked or cured meat or fish; canned sardine and tuna; cheeses, and breads and baked goods made of only ingredients used in culinary preparations (i.e. wheat flour, yeast, water, salt, butter or sugar), wine, beer and cider. |
| 4. Ultra-processed foodsFood and drink products whose manufacture involves several stages and various processing techniques and ingredients, many of which are used exclusively by industry. This group also includes drinks produced by fermentation of minimally processed food items followed by distillation and eventual addition of sugars or other substances, such as rum, whiskey, vodka, gin, and liqueurs.The purpose of processing is to create durable, accessible, convenient, and highly palatable, ready-to-drink, ready-to-eat, or ready-to-heat products typically consumed as snacks or desserts or as fast meals, which replace dishes prepared from scratch.  | Confectionery, soft drinks, sweetened juices and dairy drinks, powdered fruit drinks, sausages, chicken and fish nuggets or sticks and other pre-prepared frozen dishes, dried products such as cake mix, powdered soup, instant noodles, ready-seasonings, and an infinity of new products including packaged snacks, morning cereals, cereal bars, and ‘energy’ drinks. Sugar substitutes, sweeteners and all syrups (excluding 100% maple syrup). Breads and baked goods become ultra-processed products when, in addition to wheat flour, yeast, water, and salt, their ingredients include substances nut used in culinary preparations such as hydrogenated vegetable fat, whey, emulsifiers, and other additives. |

**Methods**

The current review of the available evidence related to ultra-processed foods and non-communicable diseases was conducted in accordance with the protocol developed within the NNR2022. The protocol is available in the publication *“The Nordic Nutrition Recommendations 2022 – Principles and methodologies“* and on the NNR2022 website.17 All sources of evidence considered in this chapter adhere to the eligibility criteria determined by the NNR2022 project.17

The Population, Intervention (or exposure), Comparator, Outcome(s), Timing, Setting, Study design (PI/ECOTSS) statement defining the review topic is presented in **Table 2**. The NNR2022 project conducted an initial scoping review, which identified two qualified systematic reviews on the relevant topic.3,18 Qualified systematic reviews are defined as high-quality, peer-reviewed systematic reviews from leading international food and health organizations or national food and health authorities. Given that the current topic is a rapidly growing area of research, the authors conducted additional literature searches on MEDLINE to identify recently published high-quality systematic reviews, meta-analyses, randomized controlled trials (RCTs) and prospective cohort studies examining the association between ultra-processed food intake and non-communicable diseases or mortality. The following search terms were used “ultra-processed[title] AND food\*[MeSH Terms]) AND ("2011"[Date - Publication] : "3000"[Date - Publication]) AND humans[Filter]”, “Ultra-processed food AND systematic review[Filter]” and “ultra-processed food AND meta-analysis[Filter]”. The main literature search was performed on April 12th, 2021. An updated search was performed on August 1st, 2022. The literature search yielded a total of 158 original research articles and 13 systematic reviews (including 2 meta-analyses), of which 125 original studies and 7 systematic reviews were deemed irrelevant based on the title and abstract. Full-text articles of 33 original studies and 6 systematic reviews were screened for eligibility, of which 14 original studies were excluded (13 due to wrong study design, 1 due to not presenting multivariable adjusted risk estimates). Six additional original research studies were identified by manually searching the bibliographies of the included studies. All titles, abstracts and full text-articles were screened independently by the two chapter-authors. Conflicts were resolved by discussion. In total, the current review included two qualified systematic reviews,3,18 6 systematic reviews (including 2 meta-analyses)4,19-23 and 25 original research studies.24-48 Reviews and meta-analyses based on cross-sectional studies were only considered if there were no other studies at all in that specific area.

**Table 2.** PI/ECOTSS statement defining the review topic of the current chapter.

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| **Population** | **Intervention or Exposure** | **Comparators** | **Outcomes** | **Timing** | **Setting** | **Study design** |
| All groups:PregnantChildrenAdolescentsAdults | Degree of ultra-processed foods in the diet | No/low intake vs high intake of UPFs | Non communicable diseasesMortality | 0 – 20 years | General population | Prospective studies, RCTs, Meta-analyses, Systematic reviews |

**Dietary intake in Nordic and Baltic countries**

*To be expanded and completed when data re food intakes are available*

The concept of ultra-processed foods is rather new and is not specifically addressed by national surveys of dietary intake in the Nordic and Baltic countries. However, the limited available data indicate that consumption is high, although not as high as in certain high-income countries, including the US, Canada and the UK.

Only a few studies in the peer-review literature provide consumption estimates for Nordic countries. Data from household budget surveys in 19 European countries indicate that ultra-processed foods account for 26% of the diet by weight, on average.49 Among the Nordic and Baltic countries included in the study, the average proportion of ultra-processed foods in the diet was 26% in Lithuania, 33% in Latvia, 37% in Norway and 41% in Finland.49 In a recent analysis of food frequency questionnaire data, Borge et al. found that ultra-processed foods provided on 32% of the total energy consumption in a sample of almost 78 000 pregnant women form the Norwegian Mother, Father and Child cohort.44 An analysis of sales data from food retailers reported that UPF represented 59% of purchased items and 49% of the expenditure in Norway in 2013.50 In Sweden, the annual per capita consumption of ultra-processed foods increased from 125 kg in 1960 (20% of total diet by weight) to 302 kg in 2010 (38% of total diet by weight).51

Details regarding the consumption of specific ultra-processed foods can be found in other chapters; SSB (chapter xx), ASB (chapter xx), processed meat (chapter xx), margarine (chapter xx), breakfast cereals (chapter xx), bread (chapter xx), savory snacks (chapter xx), sweets (chapter xx), yoghurts (chapter xx), ready-to-eat meals (chapter xx), fast food (chapter xx).

**Health outcomes relevant for Nordic and Baltic countries**

*To be completed when relevant background chapter are available*

While the concept of ultra-processed food is relatively new, its consumption has already been related to a number of health challenges relevant for the Nordic and Baltic countries. The chapter review shows good quality studies on obesity (chapter xx), cardiovascular diseases (chapter xx), hypertension (chapter xx), type 2 diabetes (chapter xx), cancers (chapter xx), mental health (chapter xx), and total mortality (chapter xx).

**Mechanisms**

Processing may alter a food’s health potential by removing beneficial nutrients and naturally-occurring bioactive components, introducing non-beneficial nutrients and food additives, and modifying the physical structure of the food matrix.52,53 The biological pathways through which ultra-processed foods may influence chronic disease outcomes, such as obesity, cancer, hypertension, type 2 diabetes, cardiovascular disease and depression are not yet fully understood, but the current evidence suggest several hypothesized mechanisms.

Firstly, ultra-processed foods may contribute to chronic diseases through their poor nutritional profile and by displacing nutritious and health-promoting minimally processed foods such as fruits, vegetables, whole grains, meat and fish from the diet.3,54 Furthermore, ultra-processed foods are generally more hypercaloric and less satiating than minimally processed foods and may therefore facilitate excessive energy intakes.55 It is also hypothesized that the convenience, omnipresence, affordability, large portion sizes, and persuasive marketing of ultra-processed foods promote poor dietary habits, snacking and over-eating, which in turn may lead to increased energy intake and weight gain.54 Notably, a recent randomized controlled trial demonstrated that an ultra-processed diet (81 percent of total energy from ultra-processed foods) increased ad libitum energy intake by ~500kcal/day compared to a minimally processed diet with a similar nutrient profile.24 In addition, two recent meta-analyses of observational studies found a direct association between consumption of ultra-processed foods and overweight.4,19

Second, processing can alter the physical structure of the food matrix, with potential implications for nutrient bioaccessibility, absorption kinetics and the gut microbiota profile.53,56,57 The large share of acellular nutrients in ultra-processed foods and consequent high nutrient availability in the small intestine may promote an inflammatory gut microbiota.56,57 Ultra-processed foods are generally low in dietary fiber, which provide substrate for microbial fermentation. Western-style diets that are low fiber while high in sugar and fat are associated with a distinct and less diverse microbiotic profile compared to diets rich in minimally-processed plant foods (44). Low-fiber diets may also shift the gut microbial metabolism toward the utilization of proteins and host mucins, resulting in degradation of the intestinal mucus layer and increased susceptibility to chronic inflammatory diseases (44, 45).

Third, additives in ultra-processed foods may influence biological systems and health outcomes. For example, artificial sweeteners 58 and emulsifiers59 may disrupt gut microbiota integrity and promote a pro-inflammatory status and metabolic dysregulation. The frequent use of phosphate salts in industrial food processing may lead to excessive phosphorous intakes, which can disrupt the hormonal regulation of extra-cellular phosphate and promote arterial calcification, cause oxidative stress of the endothelial cells and impair endothelial function.60

Fourth, extensive heat treatment and extruding during processing may lead to the formation of contaminants. For example, advanced glycation end products, which have been linked to increased oxidative stress and inflammation61; acrolein62 and acrylamide63, which have been linked to insulin resistance and polycyclic aromatic hydrocarbons, which have been associated with diabetes.64 Furthermore, industrial partial oil hydrogenation may lead to the creation of trans-fatty acids, which are linked to cardiovascular disease and diabetes.65,66

Finally, limited epidemiologic data support that ultra-processed intake is associated with increased exposure to endocrine-disrupting chemicals and phthalates used in industrial plastic packaging.67 For example, bisphenol A (BPA) has been shown to promote insulin resistance, oxidative stress, inflammation, adipogenesis and pancreatic beta-cell dysfunction by binding to estrogen-related receptors.68 While bisphenol A is banned for use in food packaging in many countries, it is often replaced by similar components such as bisphenol S, which also has endocrine-disrupting properties.67

In summary, ultra-processed foods may contribute to metabolic disturbances and inflammatory processes, which are present in obesity, cardiometabolic diseases, cancer and depression.

**Food-Based Dietary Guidelines**

*Adults*

Obesity. One American RCT24 and four high-quality prospective cohort studies conducted in Spain,25,26 France27 and Brazil28 examined the association between ultra-processed food intake and weight gain or excess adiposity. In a rigorously conducted in-patient randomized cross-over trial by the US National Institute of Health, participants (N=20) gained on average 0.9 ± 0.3 kg, primarily in fat mass, when receiving an ad libitum ultra-processed diet (83% energy from ultra-processed foods) for 14 consecutive days.24 In contrast, participants lost 0.9 ± 0.3 kg when receiving an ad libitum minimally processed diet for 14 days. The two diets were matched for presented calories, energy density, macronutrients, sugar, sodium, and fiber. The findings provide strong evidence that a diet high in ultra-processed food increases short-term energy intake and promotes weight gain.

Likewise, prospective analyses in the NutriNet-Santé cohort (N=110,260), the Seguimiento de Navarra study (SUN; N=8,451), the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil; N=4,527) and the PREDIMED-Plus cohort (N=1,485) demonstrated a direct association between ultra-processed food intake and incident overweight/obesity,26,28 incident obesity,27,28 and greater age-related visceral and overall adiposity accumulation.25

Meta-analytic pooling of the results from the SUN and ELSA-Brasil studies demonstrated a 23% greater risk of overweight/obesity in the highest vs. lowest consumption quartile (RR 1.23, 95 % CI 1.11, 1.36).4

CVD. Four high-quality prospective cohort studies conducted in the United States,29,30 France31 and Italy32 with sample sizes ranging from 3,003 to 105,159 adults, assessed the association between ultra-processed foods and cardiovascular disease (CVD) incidence (N=2) and/or mortality (N=4). A direct dose-response association was observed in all studies assessing CVD incidence and all except one study evaluating CVD mortality.30

Meta-analytic pooling of three and two studies, respectively, indicated that the highest intake of ultra-processed food was significantly associated with a 29% increased risk of CVD incidence and/or CVD mortality (RR 1.29, 95 % CI 1.12, 1.48) and 34% increased risk of cerebrovascular disease incidence and/or cerebrovascular disease mortality (RR 1.34, 95 % CI 1.07, 1.68).4

Cardiometabolic conditions. Higher intake of ultra-processed foods was associated with a greater risk of incident type 2 diabetes (HR: 1.15, 95%CI, 1.06-1.25 per absolute increment of 10% UPF) in the NutriNet-Santé cohort (N=104,707; mean follow-up 6 years)33 and of incident hypertension (OR:1.23, 95% CI: 1.06-1.44 for tertile 3 vs. 1) in the ELSA-Brasil study (N=8,754, mean follow-up 4 years).34

A meta-analysis of two cross-sectional studies including 1113 participants, indicated a direct association in relation to metabolic syndrome (OR 1.79, 95 % CI: 1.10, 2.90), while a null association was observed in relation to hypertension.4 The association between ultra-processed foods and metabolic syndrome has not yet been examined in prospective analyses.

Cancer. The association between ultra-processed food intake and cancer has so far only been evaluated in one study. In the prospective NutriNet-Santé cohort (N=104,980; mean follow-up: 5.0 years), ultra-processed food intake was associated with higher risk of overall cancer (HR for a 10% absolute increment in ultra-processed food proportion: 1.12, 95%CI: 1.06, 1.18) and breast cancer (HR: 1.11, 95%CI: 1.02, 1.22), but not of prostate cancer or colorectal cancer.35

Depression. A greater intake of ultra-processed foods was associated with higher risk of incident depression in two high-quality prospective cohort studies, conducted in Spain (N=14,907)36 and France (N=26,730),37 with a mean follow-up of 10.3 and 5.4 years, respectively. Meta-analytic pooling of the two studies indicated a significant association between intake of UPF associated and depression (RR: 1.20, 95 % CI 1.03, 1.40 for quartile 4 vs. 1).4

Mortality. A total of six high-quality prospective cohort studies conducted in the United States,29,30 Spain,38,39 France40 and Italy32, with sample sizes ranging from 3,003 to 22 810 adults, evaluated all-cause mortality in relation to ultra-processed food intake. A direct association was observed in four studies,30,32,38,39 while two studies29,40 did not find a significant association. Meta-analytic pooling of five of the above studies involving 111 056 subjects and 4687 deaths indicated that the highest intake of ultra-processed foods was associated with a 25% increased risk of all-cause mortality (RR 1.25, 95 % CI 1.14, 1.37).4

Other health outcomes. Ultra-processed food intake was associated with higher risk of incident frailty (quartile 4 vs 1, OR: 3.67, 95%CI: 2.00–6.73) in the Spanish Seniors-ENRICA Cohort Study (N=1,822 adults aged >59 years, mean follow-up: 3.5 years).41

Ultra-processed food consumption was not associated with incident inflammatory bowel disease in the NutriNet-Santé cohort (N=105,832) during a mean follow-up of 2.3 years.42

*Pregnancy*

Evidence regarding the impact of ultra-processed food in pregnancy is limited and currently only addressed by two prospective cohort studies. Greater maternal intake of ultra-processed foods during pregnancy was associated with greater gestational weight gain and adiposity of the neonate among a small sample of American women (N=45).43 In the Norwegian Mother, Father and Child Cohort Study, greater maternal intake of ultra-processed during pregnancy was associated with increased ADHD symptoms in the offspring (N=37,787), but not with the child’s relative risk of ADHD diagnosis at age 8 (N=77,768).44

*Children and adolescents*

A total of four prospective cohort studies on ultra-processed food consumption and chronic disease outcomes in children were identified.45-48 All studies were conducted in Brazil and three studies were based on the same small cohort of 3-4 year-old children of low socioeconomic status (N=345).46-48 Greater intake of ultra-processed food at age 3 years was associated with higher levels of total cholesterol and triglycerides at age 6 years, higher increase in total cholesterol and LDL cholesterol from age 3-4 to 7-8 years, and greater waist circumference at age 8 years.46-48 No association was observed between intake at 3 years of age and BMI, waist to height ratio, sum of skinfolds, glucose, insulin or HOMA-IR, HDL-cholesterol, non-HDL cholesterol, triglycerides at ages 6-8 years.46-48 There was no association between ultra-processed food intake at 6 years and wheeze, asthma or severe asthma at age 11 among Brazilian children in the 2004 Pelotas Birth Cohort Study (N=2,190).45

A systematic review published in 2018 evaluated the available literature on the association between groups of ultra-processed foods (such as snacks, fast foods, junk foods and convenience foods) or specific ultra-processed foods (soft drinks/sweetened beverages, sweets, chocolate and ready-to-eat cereals) in relation to body fat during childhood and adolescence. Of the included studies (15 cohort studies, 6 cross-sectional studies, 5 intervention studies), 14 studies reported a direct association, 2 studies found an inverse association and 10 studies did not identify a significant association between ultra-processed food intake and body fat.23

*Summary & limitations of the current evidence*

While limited in number, carefully conducted prospective cohort studies consistently found that higher consumption of ultra-processed foods is associated with increased risk of weight gain, obesity, CVD, and all-cause mortality. The strongest evidence is observed in relation to weight gain and obesity, as this association is supported by both epidemiological studies and a well conducted RCT.

Of note, the observed associations largely remained significant despite adjustment for nutrient intakes and indicators of diet quality, suggesting that the nutritional composition of ultra-processed foods alone does not explain the excess disease risk associated with their consumption. The vast majority of the included cohort studies had good methodological quality, with large sample sizes, adequate follow-up time, and high participation rates, which strengthens the current evidence base.

The current evidence is also suggestive of an association between ultra-processed foods and type 2 diabetes, hypertension, cancer and depression, however the very limited number of studies and subjects investigated preclude strong conclusions.

Some limitations of the current literature should be noted. First, because of the observational nature of the vast majority of studies, residual or unmeasured confounding is possible and causality cannot be established. Second, the investigated studies assessed ultra-processed food intake through food frequency questionnaires, food records and 24-h recalls, which are not specifically designed to collect data regarding ultra-processed foods as defined by the NOVA classification. This may have led to over- or underestimation of ultra-processed food intake. Third, studies utilized a wide range of exposure measures (e.g. % of total energy intake, % of total food weight, grams per day, servings per day), limiting comparability of the results across investigations. Fourth, studies were primarily conducted in a limited number of countries (United States, France, Spain and Brazil) and cohorts, which may limit the generalizability of the results due to national differences in food supplies, health status and culinary traditions. Only one study44 was conducted in a Nordic population. Fifth, not all studies adjusted for total energy intake in multivariable models, thus introducing a possible limitation in the interpretation of the results. However, this aspect is not necessarily a study limitation as total energy intake can be a mediator, rather than a confounder, of the association between ultra-processed food intake and health outcomes.

*Data gaps for future research*

Additional well-conducted cohort studies in diverse populations and settings are needed, particularly in relation to type 2 diabetes, hypertension, cancer and depression. If ethically feasible, experimental studies should be conducted to examine potential causal association between ultra-processed food intake and health outcomes, using biomarkers or intermediary outcomes (e.g. blood pressure, blood lipids) where possible. Furthermore, investigations in children and pregnant women are lacking for all health outcomes and should be prioritized. Preferably, studies should use dietary assessment tools that have been validated for collecting data regarding ultra-processed food intake. Further research is also warranted to clarify the biological mechanisms through which ultra-processed foods may influence health outcomes, and the proportional harm associated with the nutritional composition, food additives, physical structure and other attributes of ultra-processed foods. Understanding how ultra-processing changes whole foods and through which pathways these foods affect health is a prerequisite for eliminating harmful processing techniques and ingredients and identify ‘optimal’ levels of processing. The effects of ultra-processed foods on the gut microbiota and microbiota-host interactions constitute an area of special scientific interest, given the accumulating evidence regarding the role of the gut microbiome in cardiometabolic health and diet-disease relationships.

**Integration**

*To be completed when relevant background chapter are available*

**Advice for setting Food-Based Dietary Guidelines**

The available evidence consistently shows a strong association between ultra-processed food intake and multiple chronic health outcomes of relevance to the Nordic countries, including obesity, CVD and premature death. While further research is warranted, the current evidence is sufficiently strong to justify the inclusion of FBDGs to limit the consumption of ultra-processed foods. The recommendations should clearly state that it is advisable to limit the consumption of ultra-processed foods and to choose less processed foods within each food group. In this sense, this advice will both enhance and complement the overall FBDGs. Diets high in ultra-processed foods are less likely to adhere to the overall NNR2022 as they tend to be nutritiously unbalanced3, and limiting ultra-processed foods will facilitate better options within each food group discussed in the NNR2022. We recommend the following FBDGs:

1. Limit the consumption of ultra-processed foods.
2. Choose less processed form of foods within each food group when possible.
3. Cook at home and choose freshly prepared foods when eating out.

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