Ultraprocessed Foods and CVD
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In the past several decades, consumption of ultraprocessed foods has significantly risen across the globe. According to food surveys in Europe, the United States, Canada, New Zealand, and South American countries, ultraprocessed foods make up between 22% and 58% of typical total energy intake.¹

Ultraprocessed foods have been associated with an increase in heart disease risk and mortality, as well as negative impacts on blood pressure, cholesterol, blood sugar levels, BMI, and metabolic syndrome.

This continuing education course explores foods that are classified as ultraprocessed, food processing methods that are utilized during the creation of ultraprocessed foods, and ultraprocessed foods’ impact on specific risks factors for CVD, including high blood pressure, high cholesterol, and obesity, as well as overall CVD.

Classifications of Processing
The main classification system in the United States for ultraprocessed food is the NOVA classification scale. The NOVA classification scale consists of four classifications that group food based on its extent of processing.

Group 1 is termed “unprocessed or minimally processed foods,” which includes various edible parts of plants—such as fruits, seeds, leaves, stems, and roots—as well as animal products, fungi, algae, and spring or tap water. This category also includes certain parts of these foods that were removed or altered but are still in a minimally processed state—for instance, drying, powdering, squeezing, crushing, freezing, or pasteurizing. Group 1 does not include any foods that have added salt, sugars, oils, or fats. Examples of group 1 foods include fresh, squeezed or dried fruit, quinoa, meat, poultry, fish, avocados, eggs, fresh or powdered milk, and fresh herbs.²

Group 2 is termed “processed culinary ingredients,” which includes byproducts of foods obtained from group 1 foods by industrial processes such as extracting, refining, or pressing. Group 2 can include culinary additives that extend a product’s shelf life. Examples of group 2 foods include vegetable oils extracted from seeds and nuts such as olive oil and sunflower oil, butter from milk, sugar and molasses from cane and beet, and table salt with added drying agents or iodized salt.²
Group 3 is termed “processed foods,” which includes food products that have salt, oil, sugar, or other group 2 ingredients added and are processed through preservation methods such as canning, bottling, or nonalcoholic fermentation (such as in the production of breads and cheeses). Some examples of group 3 foods are canned vegetables, salted nuts and seeds, smoked meats and fish, canned fish, freshly made unpackaged breads, and fresh cheeses.  

Group 4, “ultraprocessed foods,” are food products primarily made through a combination of industrial processes that use equipment to process the food and introduce additives normally not found in foods in their natural state. Ultraprocessing can incorporate sources of energy and food substances that are not used in typical culinary preparations, and these foods are often sold in packaging that includes plastic and other synthetic materials.

Ultraprocessed foods include sugars, oils, fats, and salt, as well as substances seldom used in culinary preparations such as casein, lactose, whey, gluten, hydrogenated oils, interesterified oils, soy protein isolate, maltodextrin, and high-fructose corn syrup. The purpose of ultraprocessing is to manufacture profitable products using low-cost ingredients, increasing palatability and shelf life. Examples of ultraprocessed foods include carbonated soft drinks, candies, ice cream, mass-produced packaged breads, margarines and spreads, energy bars, instant sauces, pastries, cakes, ready-to-heat products, burgers, hot dogs, sausages, infant formulas, and meal replacement shakes.  

This NOVA scale classification system enables researchers to use consistent definitions when exploring the energy density and nutrient profiles of ultraprocessed vs non-ultraprocessed foods and their respective associations with disease.  

It is also important to clarify the difference between ultraprocessed and processed foods. Processing involves any element of human processing, such as dicing, cutting, or chopping; for instance, taking carrots and cutting them into baby carrots would make baby carrots a processed food. Conversely, ultraprocessed foods involve the use of additives and advanced technology to manipulate natural foods into more shelf stable or convenient products, as described by the NOVA classifications.  

The classification system is not always black and white; the production techniques and ingredients of each food should be assessed individually to determine the processing classification. For example, based on varying processing techniques and ingredients, some energy bars, hummus, and yogurts may fall into group 3 classification, while others may fall into group 4. Additionally, ultraprocessed classification does not indicate equal nutritional value between items in this category. For example, an ultraprocessed yogurt contains healthful nutrients, such as magnesium and potassium, whereas sugar-sweetened beverages do not.  

Possible Mechanisms  
There are many potential reasons why ultraprocessed foods appear to negatively impact cardiovascular health. If someone’s diet comprises 25% to 60% ultraprocessed foods, they likely consume fewer cardioprotective foods such as fruits, vegetables, beans, legumes, whole grains, and lean protein in their natural states. Many ultraprocessed foods are low in healthful nutrients and also contain high amounts of sodium, calories, fats, and sugars, which, in
excess, can increase risk of heart disease. In addition, ultraprocessing methods also can cause various byproducts to form; this may contribute to the association observed with increased risk of CVD, explored in the next section.

Advanced glycation end products (AGEs) are among the byproducts formed by ultraprocessing methods. AGEs are the result of a nonenzymatic reaction among proteins, lipids, and glucose. Research shows that excess AGEs may lead to inflammation, oxidative stress, and progression of atherosclerosis. Studies have also demonstrated an association between excess AGE consumption and heart failure prevalence, particularly diastolic heart failure. In the carbohydrate category, AGE levels were highest per gram in ultraprocessed foods that utilized dry, high heat. This includes foods such as crackers, chips, and cookies.

Acrylamide is another byproduct associated with higher risk of heart disease due to its ability to increase LDL cholesterol levels and inflammatory markers, particularly high-sensitivity C-reactive protein, which is an independent risk factor of heart disease. Acrylamide is found in potato chips, French fries, biscuits and crackers, crisp breads, corn chips, soft breads, and coffee, the latter in small amounts.

Acrolein is another byproduct formed during ultraprocessing methods that has a negative impact on cardiovascular health. Both in vitro and in vivo studies have suggested that heart tissues are sensitive to toxic effects of acrolein, such as production of free oxygen radical stress in the heart, platelet activation, and endothelial dysfunction. It is formed during the burning of gasoline, diesel fuels, woods, and plastics, and has been used in the creation of organic chemicals and as a biocide in agricultural and water supply systems. Acrolein's mechanisms have not been thoroughly assessed due to analytical difficulties, but it’s thought to be formed when fats are overheated and tends to be found in grilled sausages, caramel candies, roasted coffee, and fried foods.

Another byproduct found in ultraprocessed foods are sodium nitrites, which are typically added to processed meats—such as bacon, luncheon meats, and jerky—for color and to prolong shelf life. Nitrites and their byproduct, peroxynitrite, have been shown to cause hardening and narrowing of the arteries, promoting atherosclerosis and potentially leading to heart disease and endothelial damage. High-nitrite foods tend to be rather high in sodium, which is well known to negatively impact blood pressure and blood vessel health and promote arterial stiffness.

Ultraprocessed foods may also be contaminated by packaging materials such as bisphenol A, commonly known as BPA, which has been associated with increased risk of high blood pressure and coronary artery disease. In a study by Bae and colleagues, higher exposure to BPA was associated with a 27% greater likelihood of having either systolic blood pressure >140 mm Hg or diastolic blood pressure >90 mm Hg.

**Mortality and Overall CVD Risk**

The NutriNet-Santé study included 105,159 individuals aged 18 years or older and followed up with them within an average of five years to see the impact of ultraprocessed foods and CVD. Participants’ food intake was analyzed based on three nonconsecutive validated 24-hour...
dietary recalls at baseline and every six months thereafter, which were randomly taken over two weeks in combination of weekdays and weekends. Their reports were compared with the NOVA classification system, with analysis conducted by RDs. The study showed that for every 10% increase in ultraprocessed foods intake, the risk of heart disease increased by 12%.\textsuperscript{13}

In another large study by Rico-Campà and colleagues, 19,899 individuals between 20 and 91 years of age were followed up with every two years for 15 years to fill out a validated 136-item food frequency questionnaire, and their food intake was analyzed according to the NOVA classification system. More than four servings of ultraprocessed foods a day was associated with an increased risk of all-cause mortality by 62% and of CVD mortality by 57%.\textsuperscript{14}

In a meta-analysis and systematic review, unprocessed red meat, processed meat, and total meat consumption were compared with incident coronary heart disease and stroke. Unprocessed red meat was defined as unprocessed beef, hamburgers, lamb, pork, or game, but did not include chicken, fish, or eggs. Processed meat was defined as any meat that used preservation methods, such as bacon, salami, sausages, hot dogs, or processed deli or luncheon meats. Total meat was the combined intake of unprocessed red meat and processed meats. Consumption of unprocessed red meat was not associated with coronary heart disease; however, processed meats were. For each 50-g serving per day of processed meat, risk of coronary heart disease increased by 42%. Total meat consumption was also associated with a 27% increased risk of coronary heart disease, though this relationship wasn’t statistically significant.\textsuperscript{15}

Research shows that consumption of sugar-sweetened beverages leads to an increased risk of all-cause and CVD mortality. In a study by Malik and colleagues, a dose-dependent relationship was seen between sugar-sweetened beverage consumption and all-cause mortality in more than 118,000 women and men. When compared with individuals who drank sugar-sweetened beverages less than once per month, those who drank them one to four times per month had 1% higher risk, two to six times per week had a 6% higher risk, one to two times per day had a 14% higher risk, and two or more per day had a 21% higher risk. The risk for all causes was driven by deaths from CVD. When comparing consumption of individuals who had sugar-sweetened beverages two or more times a day with those who had infrequent consumption, there was a 31% increased risk of death from coronary vascular disease alone.\textsuperscript{16}

A prospective analysis by Yang and colleagues of National Health and Nutrition Examination Survey data found that that those who consumed seven or more 12-oz servings of sugar-sweetened beverages per week had 29% higher risk of CVD mortality compared with those who consumed one serving or less per week.\textsuperscript{17}

**Ultraprocessed Foods and CVD Risk Factors**

There are many factors that increase the risk of heart disease. The following section focuses on the impact of ultraprocessed foods on specific risk factors, including blood pressure, cholesterol, and obesity.
**Blood Pressure**

In the Seguimiento Universidad de Navarra Project, 14,790 Spanish adult university graduates who were free of high blood pressure at baseline were assessed for an average of nine years to analyze their ultraprocessed food consumption, using the NOVA classification system, and any development of hypertension over this period. Those who consumed the highest amount of ultraprocessed foods had a 21% increased risk of developing hypertension compared with those who consumed the least, after adjusting for sex, age, physical activity, hours of TV watching, BMI, smoking status, analgesic use, following a special diet at baseline, family history of hypertension, hypercholesterolemia, alcohol consumption, total energy intake, olive oil intake, and consumption of fruits and vegetables. Those with a higher intake of ultraprocessed foods consumed more salt, saturated fat, and sugars, with a lower intake of fiber, which may have contributed to the development of hypertension.\(^\text{18}\)

Sugar-sweetened beverage consumption and incidence of high blood pressure was also assessed in several studies. In a dose-response meta-analysis, Xi and colleagues looked at six prospective studies that included 240,726 adults and found that the relative risk for developing hypertension was 8% for every additional serving of sugar-sweetened beverage.\(^\text{19}\)

A systematic review and meta-analysis by Jayalath and colleagues of six prospective cohort studies found that sugar-sweetened beverage consumption increased the risk of high blood pressure by 12% in individuals who drink sugar-sweetened beverages. The dose-response analysis is comparable to that of Xi and colleagues, where every additional sugar-sweetened beverage consumed per day was associated with increased risk of hypertension by around 8%.\(^\text{20}\)

Ultraprocessed vs unprocessed red meats and incidence of high blood pressure has been assessed in several studies. In a study by Lajous and colleagues, 44,616 women who were disease-free at baseline were observed over 15 years to assess their ultraprocessed vs processed meat consumption and possible development of high blood pressure. Their diets were assessed via a 208-item self-administered questionnaire that included 11 categories of frequency to choose from. Beef, pork, veal, sheep, or horse were classified as unprocessed red meats. Sausage, salami, bacon, and ham were defined as processed red meats, although the NOVA classification system, which would characterize them as ultraprocessed, was not utilized in this study. Women who consumed five or more 50-g servings per week of ultraprocessed meats demonstrated a 17% increased risk of high blood pressure compared with women who had less than one serving per week. High unprocessed meat intake was not associated with high blood pressure development.\(^\text{21}\)

**Obesity**

In a meta-analysis and systemic review of 14 studies, including one cohort and 13 cross-sectional studies, ultraprocessed food consumption was associated with a pooled 26% increased risk of obesity.\(^\text{22}\)

In a study by Rauber and colleagues of 6,143 adults, ultraprocessed food consumption was evaluated alongside BMI and waist circumference. Each participant recorded a four-day food diary, with their food intake classified by the NOVA system. Compared with the lowest level of
ultraprocessed food consumption—less than 35% or daily energy intake—the greatest consumption of ultraprocessed foods, more than 73% daily energy intake, was associated with higher BMI by about 1.66 kg/m², larger waist circumference by roughly 3.56 cm, and a 90% increased risk of obesity. Every 10% increase in consumption of ultraprocessed foods was linked to increases of 0.38 kg/m² for BMI, 0.87 cm for waist circumference, and 18% for obesity risk. These findings were significant in both men and women.  

In a crossover study by Hall and colleagues, 20 adults resided in a metabolic clinical research unit for 28 days and were randomly assigned to either an unprocessed or ultraprocessed diet for the first two weeks, followed by the alternative diet for another two weeks. Meals that met these two criteria based on the NOVA classification scale were provided. Each group was given three meals daily and instructed to consume ad libitum. Both groups were offered 5,435 kcal per day in snacks and meals. While consuming the ultraprocessed diet, individuals gained about 0.6 to 1.2 kg and voluntarily consumed an additional 400 to 600 kcal, with a noted increase of calories from carbohydrates of 230 to 320 kcal per day. Additionally, the ultraprocessed diet was associated with an individual increase of body fat mass by about 0.3 to 0.5 kg, while body fat mass decreased by 0.2 to 0.4 kg when participants were on the unprocessed diet. Weight was lost during the unprocessed diet, suggesting that high consumption of ultraprocessed foods is associated with weight gain and limiting intake may be an effective strategy for obesity prevention.

In a study by da Costa Louzada and colleagues, 30,243 children from Brazil who were 10 years of age or older had their 24-hour food records evaluated and characterized by degree of food processing. Results found that ultraprocessed foods made up about 30% of their average total energy intake. Those with the highest ultraprocessed food consumption had a higher BMI by about 0.94 kg/m² and a 98% increased risk of obesity, suggesting that ultraprocessed food intake is a significant contributor to the obesity epidemic in Brazil. The ultraprocessed foods were mostly from candies, cookies, sugar-sweetened beverages, and ready-made dishes.

In a cross-sectional analysis of data by Denova-Gutiérrez and colleagues, sugar-sweetened beverage intake and BMI were assessed in 1,055 children aged 10 to 19. Those who consumed three servings of sugar-sweetened beverages had twice the risk of proportionally excess body fat compared with those who consumed less than one sugar-sweetened beverage per day. Each serving of sugar-sweetened beverage consumed was associated with a greater BMI by a median of 0.33 kg/m².

Another study, by Micha and colleagues, found every 8-oz serving of sugar-sweetened beverage was associated with a 23% higher BMI and 26% increased risk of coronary heart disease with adjustment for BMI. There is established research that sugar-sweetened beverage consumption is associated with increased BMI and body weight; however, even when adjusted for BMI, these studies showed an increased risk of all-cause and CVD mortality. This suggests risk can be independent of BMI, and targets a suboptimal intake of nutrient intake such as excess sodium, low omega-3 fatty acids, high trans fat, low fruits and vegetables, and low polyunsaturated fat to increased risk of deaths due to CVD.
**Cholesterol**

In a study by Hoffman and colleagues, the dietary data of 308 children in low-income Brazilian families were assessed at ages 3 and 6 via two 24-hour recalls and compared with the NOVA classification system. Higher ultraprocessed food intake was associated with an 8.51-mg/dL increase in total cholesterol at age 3 and a 9.69-mg/dL increase in triglyceride levels at age 6.28

In the Framingham Heart Study, which included 6,039 middle-aged adults, those who consumed one or more soft drinks a day had a 25% increased risk of hypertriglyceridemia and 32% increased risk of low HDL cholesterol.29 Similarly, in the Multi-Ethnic Study of Atherosclerosis, those who consumed at least one sugar-sweetened beverage daily had a 4% increased risk of high triglycerides and 5% increased risk of low HDL cholesterol.30

There are limited studies that extrapolate the relationship between ultraprocessed food intake and lipids in adults alone; however, there are studies that look at ultraprocessed food consumption and risk of metabolic syndrome.

**Metabolic Syndrome**

In a cross-sectional study of 6,385 adults by Steele and colleagues, individuals' blood tests and at least one 24-hour dietary recall were assessed for a relationship between ultraprocessed food consumption and metabolic syndrome. Every 10% increase in ultraprocessed food intake was associated with a 4% increase in incidence of metabolic syndrome. Daily dietary intake comprising more than 71% ultraprocessed foods was associated with a 28% increased risk of metabolic syndrome compared with intake of less than 40% ultraprocessed foods per day.31

In a meta-analysis of observational studies, processed red meat consumption was assessed in relationship to risk of metabolic syndrome. Sixteen studies that included 76,111 individuals were evaluated, and results showed that the highest intake of processed meat increased risk of metabolic syndrome by 35%. Interestingly, consumption of pooled meat categories increased metabolic syndrome prevalence by 14%, indicating that the processing had a larger negative impact on incidence of metabolic syndrome.32

In the Framingham Heart Study, consuming one or more soft drinks per day was associated with a 48% greater risk of metabolic syndrome compared with those who consumed less than one drink per day. Specifically, consuming at least one sugar-sweetened beverage per day was associated with greater risk of obesity by 31%, waist circumference by 30%, risk of impaired fasting blood sugar levels by 25%, blood pressure by 18%, high triglyceride levels by 25%, and low HDL cholesterol by 32%.29

In a study by Tavares and colleagues, 210 adolescents between 12 and 19 years of age were assessed for metabolic syndrome based on their ultraprocessed food consumption as reported in a semiquantitative food frequency questionnaire. Consumption of ultraprocessed foods at the second-highest quartile or more was associated with almost 2.5 times increased prevalence of metabolic syndrome, with the most frequent diagnostic criteria being low HDL levels, elevated blood sugar levels, and increased waist circumference.33
Putting It Into Practice
Given the growing body of literature supporting an association between ultraprocessed foods and CVD and its risk factors, it is imperative that RDs work alongside clients to help them reduce their ultraprocessed food consumption when appropriate. It is important that RDs recognize which foods are considered ultraprocessed and help their clients understand this term so they can make informed decisions. Using motivational interviewing tactics, nutrition professionals can involve their patients in the process of shifting towards more healthful choices.

Nutrition professionals should inquire why certain ultraprocessed foods are being chosen so factors including culture, affordability, and accessibility are taken into account when considering alternative options that fit clients’ needs. If individuals mostly or only have access to ultraprocessed foods, dietitians can work with them to identify ultraprocessed options that have higher nutritional value, as well as connect them with food access resources in their community.

For families consuming high amounts of ultraprocessed foods for affordability or convenience, RDs can work with them to find similar easy-to-prepare and affordable food ideas to help them transition to a less processed eating pattern and long-term implementation of more healthful eating habits. If they consume ready-to-eat meals because they do not have time to cook, nutrition professionals can work with them on meal planning and prep strategies, as well as quick cooking techniques, to help with time management.

Reducing intake of ultraprocessed foods can be more effective when undertaken gradually. Nutrition professionals can start by assessing how frequently their clients consume ultraprocessed foods and titrate back slowly. If they consume five sugar-sweetened beverages a day, scaling back gradually may help clients more easily transition than if they attempt to eliminate a food or beverage overnight. Offering them alternatives to sugar-sweetened beverages such as lemon water, seltzer water, or unsweetened tea that they initially sweeten themselves also may help them transition more successfully. Clients can gradually reduce the sweetness so their palate adapts to a less sweet and eventually unsweetened flavor profile.

It is also important to remember that everything that comes in a package is not considered ultraprocessed. Bagged or canned beans, precut carrots, and shelf-stable milk are healthful choices that are convenient and can contribute nutrients to one’s diet. Additionally, ultraprocessed foods may be a necessary and beneficial part of an individual’s lifestyle. For example, military personnel stationed in areas without access to fresh foods or elite athletes undergoing long training periods benefit from ultraprocessed, shelf-stable foods that have been developed to deliver specific nutrition in these situations.

Lastly, the NOVA classification system categorizes based only on processing level, not nutritional value, so RDs should be aware of the potential nutritional variation between foods within the same category and work to help clients choose the most nutritious options when possible.
Nutrition professionals should recognize each person’s lifestyle when reducing ultraprocessed foods and create realistic expectations to choose more healthful alternatives within the individual’s financial, cultural, and personal parameters.

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References


Quiz

1. According to food surveys from Europe, the United States, Canada, New Zealand, and South American countries, what percentage of total energy intake do ultraprocessed foods comprise?
   A. 6% to 18%
   B. 10% to 20%
   C. 22% to 58%
   D. 55% to 74%

2. Which group from the NOVA classification scale does olive oil fall into?
   A. Group 1
   B. Group 2
   C. Group 3
   D. Group 4

3. Which of the following groups consists of only ultraprocessed foods?
   A. Energy bars, ice cream, ready-to-eat meals
   B. Yogurt, olives, tomato sauce
   C. Energy bars, palm oil, tomato paste
   D. Pickles, oats, ice cream

4. Which of the following substances are produced by ultraprocessing methods?
   A. Nitrites, nitrates, liquid smoke
   B. Bisphenol A, nitrates, acrylamide
   C. Salt, sugar, carbohydrates
   D. High-fructose corn syrup, trans fat, nitrates

5. What effect do advanced glycation end products have on health?
   A. Increase progression of atherosclerosis
   B. Lower HDL levels
   C. Increase weight directly
   D. Suppress appetite

6. Higher exposure to bisphenol A was associated with a 27% greater chance of having which condition?
   A. High LDL cholesterol
   B. High blood sugar levels
   C. High BMI
   D. High blood pressure
7. In a meta-analysis, intake of ultraprocessed red meat was associated with how much greater risk of metabolic syndrome compared with unprocessed red meat?
A. 17%
B. 21%
C. 35%
D. 42%

8. In a randomized crossover study of 20 individuals, consumption of an ultraprocessed diet for two weeks vs an unprocessed diet for two weeks was associated with which of the following?
A. Increased body weight
B. Increased body fat mass
C. Increased body weight and body fat mass
D. There was no difference between the two groups.

9. Which food may contain acrylamide?
A. Ice cream
B. Biscuits
C. Energy bars
D. Canned pineapple

10. In a study by da Costa Louzada and colleagues, children who consumed the most ultraprocessed food demonstrated what percentage increase in risk of obesity?
A. 35%
B. 42%
C. 59%
D. 98%