

Food classification according to processing

Food items were initially classified into four groups shown in Table 1. This was accomplished by taking into account, the following three variables from the NHANES recall databases: “Main Food Description”, “Additional Food Description” and “SR Code Description”. Thereafter, the food item classification was modified, if necessary, taking two variables into account: “Combination Food Type” and “Source of food”. Thus, most “Frozen meals” or “Lunchables” or food items consumed in “Restaurant fast food/pizza” or acquired at a “Vending machine”, were classified as ultra-processed foods.

As explained in the Subjects and Methods section, when Food Codes were judged to be a handmade recipe, the classification was applied to the underlying ingredients (SR Codes), to enable a more precise food item classification (1).

It must be noted, however, that SR Codes and their proportions are not necessarily the ingredients and proportions consumed by the participant. One of the reasons is that links between FNDDS 5.0 and SR24 were developed to estimate the nutrient content of a Food Code and not the ingredient intake (2). Furthermore, when assigning SR Codes to a Food Code the individual-specific variable “Modification Code” (“adjustments to predefined recipe ingredients that reflect more closely the food as described by the respondent” (2)) was not taken into account, as manual changes would have had been necessary to do so.

Absence of data or discrepancies regarding degree of processing were solved opting for the lesser degree of processing (conservative criterion), which could have led to a slight underestimation of ultra-processed food consumption.

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We classified homemade recipes with unknown ingredients based on expected principal ingredients, which could slightly underestimate ultra-processed food consumption.

Regarding bread, the classification distinguishes between handmade bread (either homemade or made in restaurants or artisanal bakeries), and industrial bread (made in industrial bakeries or factories), either processed (when manufactured with ingredients used in culinary preparations) or ultra-processed (when manufactured with food substances not used in culinary preparations). In our study, because of the large amount of industrial breads with unknown ingredients (approximately 3.7% of all industrial bread had fully known ingredients) and the very low consumption of processed breads when ingredients were reported (approximately 2.3% of industrial breads were processed), we ended up classifying all industrial bread as ultra-processed foods. This could slightly overestimate ultra-processed food consumption.

Assessing energy and added sugar contents

For some handmade recipes, the sum of the "calorie intake per SR Code" (calculated by us) of all underlying SR Codes did not add up exactly to the "calorie intake per Food Code" (provided by NHANES). In these cases, the "final calorie intake per SR code" was calculated as follows:

$$\text{Final calorie intake per SR code} = \text{NHANES Calorie intake per Food Code} * \left(\frac{\text{Calculated Calorie intake per SR code}}{\sum_{n=1}^{\infty} \text{Calculated Calorie intake per SR Code}} \right)$$

The same was done for added sugars:

$$\text{Final added sugars intake per SR code} = \text{Added sugars intake per Food Code} * \left(\frac{\text{Added sugars intake per SR code}}{\sum_{n=1}^{\infty} \text{Added sugars intake per SR code}} \right)$$

where n = each of the Food Code underlying SR Codes

Supplementary Table 1. NOVA food classification based on the extent and purpose of industrial processing (adapted from 3,4)

Food groups and definition	Examples
<p>1 Unprocessed or minimally processed foods</p> <p>Unprocessed 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, pasteurisation, cooling, freezing, or other processes which do not add substances to the original food. Purpose of minimum processes is to preserve foods and make it possible to store them and, sometimes, also to decrease stages of food preparation (cleaning and removing inedible parts) or facilitate their digestion, or render them more palatable (grinding or fermentation).</p>	<p>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, fruit juices fresh or pasteurized 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.</p>
<p>2 Processed culinary ingredients</p> <p>These are substances extracted from natural foods or from nature itself by processes such as pressing, grinding, crushing, pulverising, and refining. Purpose of processing here is to obtain ingredients used in homes and restaurants kitchens to season and cook natural or minimally processed foods and to create with them varied and enjoyable dishes such as soups and broths, salads, rice and beans dishes, grilled or roasted vegetables and meat, and homemade breads, pies, cakes, and desserts.</p>	<p>Plant oils; coconut and animal fats (including butter and lard); table sugar, maple syrup (100%), molasses and honey; and table salt.</p>
<p>3 Processed foods</p> <p>These are relatively simple products manufactured essentially with the addition of salt or sugar or other substance of common culinary use, such as oil or vinegar, to natural or minimally processed foods. Purpose here is to prolong duration of foods and modify their palatability.</p> <p>If alcoholic beverages should be classified, drinks produced by the fermentation of group 1 food items such as wine, beer and cider will be classified in this group.</p>	<p>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 made of ingredients used in culinary preparations (i.e. wheat flour, yeast, water, salt, butter or sugar).</p>
<p>4 Ultra-processed foods</p> <p>These are food and drink products whose manufacture involves several stages and various processing techniques and ingredients, many of which are used exclusively by industry. Purpose of processing here 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.</p>	<p>Confectionery, soft drinks, sweetened juices and dairy drinks, powders for juices, 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</p>

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If alcoholic beverages should be classified, drinks produced by fermentation of group 1 food items followed by distillation and eventual addition of sugars or other substances, such as rum, whiskey, vodka, gin, and liqueurs, will be classified in this group.

substances not used in culinary preparations such as hydrogenated vegetable fat, whey, emulsifiers, and other additives.

Supplementary Table 2. Percentage of participants with more than 10% of total energy intake from added sugars, by demographic subgroups, according to quintiles of the dietary contribution of ultra-processed foods. US population aged 1+ years (NHANES 2009-2010)

		Quintiles of the dietary contribution of ultra-processed foods (% of total energy intake)				
		1st (n=1,937)	2nd (n=1,888)	3rd (n=1,814)	4th (n=1,779)	5th (n=1,899)
Gender	Men (n=4,634)	24.5	48.6	61.7	78.1	78.5*
	Women (n=4,683)	28.3	51.4	63.7	75.3	85.6*
Age (years)	1 to 5 (n=1,136)	17.0	45.5	61.3	71.0	84.3*
	6 to 11 (n=1,154)	33.1	54.0	76.5	82.4	90.0*
	12 to 19 (n=1,265)	39.9	62.8	66.2	83.0	87.1*
	20 to 39 (n=1,928)	28.8	53.4	64.1	79.7	82.7*
	40 to 59 (n=1,935)	26.0	49.1	59.6	71.7	76.7*
	60 and over (n=1,899)	22.8	43.6	58.6	71.9	71.1*
Race/ethnicity	Mexican American (n=2,064)	28.5	52.8	64.5	79.4	84.7*
	Other Hispanic (n=988)	41.7	59.4	62.2	80.1	85.2*
	Non-Hispanic White (n=3,984)	22.9	47.3	60.1	75.3	80.4*
	Non-Hispanic Black (n=1,726)	33.0	60.3	76.5	82.1	89.0*
	Other Race (including Multi-Racial) (n=555)	25.8	45.0	64.5	73.0	79.2*

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Income to poverty*	0.00–1.30 (n=3,322)	31.1	58.8	72.3	81.0	86.5*
	>1.30–3.50 (n=3,062)	26.4	50.0	67.1	77.4	84.9*
	>3.50 and above (n=2,100)	23.0	46.1	52.0	72.8	75.2*
Educational attainment	<12 years (n=2,669)	32.9	50.6	68.7	76.8	86.4*
	12 years (n=2,136)	29.3	56.2	66.0	81.8	83.7*
	>12 years (n=4,398)	23.4	47.7	59.1	74.2	79.9*

*Significant linear trend across quintiles ($P \leq 0.001$), both in unadjusted and Poisson models adjusted for sex, age group (1-5, 6–11, 12–19, 20–39, 40–59, 60 + years), race/ethnicity (Mexican-American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black and Other Race - Including Multi-Racial-), ratio of family income to poverty (SNAP 0.00–1.30, >1.30–3.50, and >3.50 and over) and educational attainment (<12, 12 years and >12 years).

Online Supplementary Material

References (for Online Supplementary Material).

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3. Moubarac JC, Parra DC, Cannon G, Monteiro CA. Food Classification Systems Based on Food Processing: significance and implications for policies and actions: a systematic literature review and assessment. *Curr Obes Rep* 2014; 3: 256-272.
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