Published in final edited form as:

Nutr Today. 2020 ; 55(2): 75–81. doi:10.1097/nt.0000000000000400.

An Overlap Between "Ultraprocessed" Foods and the Preexisting Nutrient Rich Foods Index?

Adam Drewnowski[1], **Shilpi Gupta**[1], **Nicole Darmon**[2]

[1]Center for Public Health Nutrition, University of Washington, Box 353410, Seattle, WA 98195, USA

[2]MOISA, INRA, Univ Montpellier, CIRAD, CIHEAM-IAMM, Montpellier SupAgro, Montpellier, France

Abstract

The category of "ultra-processed" foods in the NOVA food classification scheme is ostensibly based on industrial processing. We compared NOVA category assignments with the pre-existing family of Nutrient Rich Food (NRF) indices, first developed in 2005. NRF $_{n.3}$ indices are composed of two subscores; the positive NRn based on protein, fiber, and n vitamins and minerals, and the negative LIM subscore based on saturated fat, added sugar, and sodium. The 378 foods that were components of the widely used Fred Hutchinson Cancer Center food frequency questionnaire were assigned to NOVA categories and scored using multiple NRF indices. Contrary to published claims, NOVA was largely based on the foods' content of saturated fat, added sugars, and sodium. There were strong similarities between NOVA categories and NRF scores that were largely driven by the foods' content of fat, sugar, and salt. Nutrient density increased NRF scores but had less impact on NOVA categories. As a result, the NOVA scheme misclassified some nutrient-rich foods. Both NOVA categories and $NRF_{9.3}$ scores were strongly affected by the amounts of saturated fat, added sugars, and sodium. Ultra-processed foods and culinary ingredients received lower $NRF_{n.3}$ scores. We conclude that the arbitrary NOVA classification scheme adds little to the pre-existing nutrient profiling models. The purported links between NOVA categories and health outcomes could have been obtained using pre-existing $NRF_{n.3}$ nutrient density metrics.

Keywords

Food frequency questionnaire (FFQ); NOVA classification; energy density; nutrient density; ultra-processed foods

Introduction

The 2005 Dietary Guidelines for Americans recommended that consumers replace energy-dense foods in their diets with more nutrient-dense options. However, at the time the concept of nutrient density was not yet fully defined [1]. In many cases, healthful foods were defined

*Correspondence: adamdrew@uw.edu; Tel.: +1-206-543-1730.

by the absence of fat, sugar, and sodium—rather than by the presence of protein, fiber, or any vitamins or minerals that they might contain [1–3]. The new science of nutrient profiling (NP) was an early attempt to capture the overall nutrient density of foods, based on their nutrient content relative to calories [4].

The Naturally Nutrient Rich score (NNR), and the Nutrient Density Score (NDS) were developed in 2004 [1] at approximately the same time as the British Food Standards Agency-Office of Communications (FSA-Ofcom) model [5] and the Unilever Choices model [6]. Initially based on protein, fiber, vitamins and minerals, both the NNR and NDS models soon incorporated nutrients to limit: saturated fat, added sugar, and sodium [7]. The SAIN,LIM [8] and Nutrient Rich Foods ($NRF_{n.3}$) models shared the same negative LIM subscore, composed of nutrients to limit: saturated fat, added sugar and sodium [3]. Multiple NP methods, including the $NRF_{9.3}$ model [9–14], are commonly used to assess nutrient density of individual foods [11], composite meals [14] and the total diet [15]. Dietary nutrient density, established using the NRF method, has been linked with long-term health outcomes [12].

Unlike NP models, the NOVA food classification scheme introduced in 2009 did not rely on nutrients and did not include a mathematical algorithm for grading or classifying foods [16]. The NOVA authors' first claim was that foods and nutrients mattered less than did industrial processing [16]. The NOVA scheme distinguished a priori between foods that were "unprocessed", "processed", or "ultra-processed", and culinary ingredients. The purpose of "ultra-processing" alleged by the NOVA creators was to produce purportedly hyper-palatable foods with longer shelf life and "quasi-addictive" properties [17]. A practical way suggested to identify "ultra-processed" foods was to scan ingredient lists for chemical and nonnutritive substances that were not used in normal cooking, such as high-fructose corn syrup, hydrogenated oils, hydrolyzed proteins, flavors, flavor enhancers, colors, emulsifiers, emulsifying salts, sweeteners, thickeners, and antifoaming, bulking, carbonating, foaming, gelling and glazing agents [18]. These ingredients were viewed as being equal in importance in their potential adverse effects to fats, sugars and salt added during preparation [19].

The NOVA scheme criteria for category assignment have been criticized as both inconsistent and incompatible with food science [20–23]. The criteria have also evolved in an arbitrary fashion. In the most recent iteration [24], foods that have gone through industrial processes such as removal of inedible or unwanted parts, drying, powdering, squeezing, crushing, grinding, fractioning, steaming, poaching, boiling, roasting, and pasteurization, chilling, freezing, placing in containers, vacuum packaging, and non-alcoholic fermentation were still viewed as "unprocessed". The main proviso for exempting them was that these methods did not add salt, sugar, oils or fats or other food substances to the original food. By contrast, both "processed" and "ultra-processed" foods were increasingly being defined in NOVA by the presence of fat, sugar, and salt added during preparation [17].

The ever-changing NOVA definitions seem to have come full circle [25]. Despite earlier insistence on the harm of food processing [16–19, 25, 26], the assignment of foods into the "ultra-processed" category seems now to be based on fat, sugar, and salt. If so, then

we would expect to see an overlap between NOVA categories and the pre-existing nutrient profiling models that had long included the foods' content of saturated fat, added sugar and salt.

Methods

The Fred Hutchinson FFQ component food items

The Fred Hutchinson semiquantitative food frequency questionnaire (FFQ) is built around 384 component foods, of which 378 have energy density >10kcal/100g. To avoid dividing by zero, unsweetened tea, coffee, and diet beveragages with low energy density < 10kcal/100g were removed from the current analysis. Details of the FFQ methodology have been published before[27]. The FFQ instrument developed by the Fred Hutchinson Cancer Research Center (FHCRC) has been used in the Women's Health Initiative[28, 29] and many other large studies on diets and health[30, 31]. These same FFQ component foods had been used before in the initial development of the NRF models [8].

NOVA food processing categories

The FFQ component foods were aggregated into 4 NOVA categories: "unprocessed", "processed", "ultra-processed", and culinary ingredients, using published classification schemes [16]. Based on NOVA publication from year 2016 [17], "unprocessed" foods were defined as fresh, dry, or frozen foods, such as fruits, vegetables, or fresh meats that had been subjected to minimal or no processing. Those included fresh meat, fruit (including freshly squeezed juice), milk and plain yogurt, vegetables, eggs, legumes, fish and other seafood, and unsalted nuts and seeds. Both coffee and tea were deemed to be "unprocessed". Breads were deemed to be "unprocessed" if simple, containing fewer than 5 ingredients and either homemade or not sold in a bag. In the 2016 NOVA version, Group 1 foods included fresh, squeezed, chilled, frozen, or dried fruits and leafy and root vegetables; grains such as brown, parboiled or white rice, corn cob or kernel, wheat berry or grain; legumes such as beans of all types, lentils, chickpeas; starchy roots and tubers such as potatoes and cassava. In the NOVA scheme, the most desirable foods were those that were fresh and minimally processed and were prepared, seasoned and cooked from scratch during ordinary culinary preparations at home.

Culinary ingredients were sugar (including high fructose corn syrup), animal fats (butter, lard) and vegetable oils, salt and vinegar. "Processed" foods were manufactured by adding culinary ingredients (fat, sugar, salt) to "unprocessed" foods. Those foods included cheese, ham, salted, smoked, or canned meat or fish, pickled vegetables, salted or sugared nuts, beer and wine. These relatively simple products were made by adding sugar, oil, salt or other group 2 substances to group 1 foods.

"Ultra-processed" foods were defined as industrial creations, which contained ingredients, chemicals and non-nutritive substances not found in home cooking [16], in addition to fat, sugar and salt. Based on NOVA descriptions from a 2016 publication [17], "ultra-processed" foods included industrial breads (refined and whole grain), ready-to-eat breakfast cereals, cakes, sweet snacks, and pizza, French fries, soft drinks (sodas and fruit drinks, regular and

diet), ice cream, and frozen meals and soups. However, the NOVA criteria seem to be in a constant state of evolution. Published studies have varied in how foods were assigned to different NOVA categories [20].

The NOVA criteria were applied to the 378 FFQ component foods, aggregated into 7 MyPyramid food groups, a classification comparable to the current MyPlate. The FFQ specifies which foods are fresh, frozen, or canned and which are commercially available or prepared at home. In the NOVA scheme, “unprocessed” foods included fresh, dry or frozen fruits and vegetables, packaged grains and pulses, grits, flakes, or flours, fresh or dry pasta made from flour and water, fresh eggs, fresh or frozen meat or fish and fresh or pasteurized milk. Tea and coffee were “unprocessed”. Following published guidelines, mass-produced whole grain breads, commercial sweetened yogurts, commercial fruit juices, and ready to eat cereals all were assigned to the ultra-processed category.

Nutrient profiling (NP) models

Energy density is defined as calories per gram [32]. Nutrient density is typically defined as nutrients per calorie or nutrients per gram [33]. The NRF algorithm is based on the ratio of nutrients to calories. Higher $NRF_{n.3}$ scores indicate a higher nutrient density.

Whereas the number (n) of nutrients to encourage can vary, the number of nutrients to limit referred to as LIM has been limited to just three (saturated fats, added sugar and sodium) [3]. The final NRF score was the sum of percent daily values for *n* nutrients to encourage minus the sum of percent maximum recommended values for 3 nutrients to limit. All daily values were calculated per 100 kcal and were capped at 100% for positive nutrients.

Table 1 summarizes nutrient reference amounts from the Food and Drug Administration (FDA) that were the basis of percent daily value calculations [34]. The pre-existing NP models [35] have included protein, fiber, vitamins and minerals, monounsaturated fats and essential fatty acids. As shown in Table 2, the number of nutrients varied from 2 to 10 [2].

Statistical Analysis

Means (SD) were computed for each NRF score across NOVA categories. For analytical purposes, a list of 378 FFQ component foods were used after excluding 6 low energy density food items with missing NRF values. Kappa statistic was computed across 2 groups of NRF scores (created by median-split) and 2 NOVA categories (category 1 - unprocessed and processed; category 2 – ultra-processed and culinary ingredient). Spearman correlation was also computed between quartiles of $NRF_{n.3}$ and NOVA categories. Descriptive statistics was performed to examine the distribution of FFQ food items by NOVA categories across tertiles of NRF scores. The distribution of NOVA categories and MyPyramid food groups was also examined by $NRF_{9.3}$ and LIM per 100kcal. All statistical analyses were conducted using SPSS 22 statistical software and Microsoft Excel (2016)[36]. Level of significance was $p < 0.01$.

Results

Table 3 shows the relation between the four NOVA categories and the LIM score (per 100 kcal). “Ultra-processed” foods and culinary ingredients, that is foods high in fat, sugar, and salt, received the highest and least favorable LIM scores. The Kappa value was 0.50 and Spearman correlation was 0.55. Also shown in Table 3 are Kappa statistics and Spearman correlations between NOVA categories and multiple NRF scores. For all NP models, NOVA categories and $NRF_{n.3}$ scores were correlated with each other.

Figure 1 (multiple panels) shows tertiles of selected $NRF_{n.3}$ scores plotted against NOVA categories. “Ultra-processed” foods and “culinary ingredients” were combined. Again, NOVA category assignments were adequately captured by tertiles of NRF scores.

Discussion

The NOVA classification appears to be based largely on fats, sugar, and salt. This is contrary to published claims but not altogether surprising, given that the “ultra-processed” foods are increasingly being defined not so much by industrial processing but by the presence of “culinary ingredients” fat, sugar, and salt. However, the role of these nutrients to limit is not fully acknowledged in the accompanying NOVA literature. Instead, food processing is given as the ostensible reason why “processed” and “ultraprocessed” foods have low nutritional value [16].

The Dietary Guidelines for Americans have long referred to saturated fat, added sugars, and sodium as the nutrients to limit. The LIM subscore, and its equivalents are a long-standing component of multiple nutrient profiling systems. The adverse health effects of diets excessively high in fat, sugar, and salt are well-known. Yet in a 2009 article [16], Monteiro claimed that the issue was not food, nor nutrients, as much as food processing. As the present analyses show, the issue is about nutrients to limit and has been all along.

The relation between NOVA categories and multiple $NRF_{n.3}$ scores in the present analyses was largely driven by the LIM subscore, based on saturated fat, added sugar and sodium. First, fresh meat and fish, dairy products, low energy density grains (oatmeal), potatoes, legumes, and fresh produce were deemed to be “unprocessed” and also received high NRF scores. As in past NP studies, fresh meat, seafood and fruits and vegetables had low LIM values and high NRF9.3 scores.

By contrast, refined grains, fats, sweets, and desserts had higher and more unfavorable LIM values and lower NRF9.3 scores. Here the arbitrariness of the NOVA categorization made for some mismatches. “Ultra-processed” foods were mostly fats and sweets but the category also included fortified ready-to-eat cereals, as well as beans and nuts (in the form listed in the FFQ). Both food groups were scored as nutrient- rich by the NRF algorithm.

The inconsistency and arbitrariness of the NOVA scheme have been noted before [20, 22, 37]. For example, commercially baked bread has been classed as ultra-processed whereas the same bread was considered unprocessed when home-made [20]. Furthermore, the NOVA definitions have shifted with time [20]. In some cases, it was noted, the definition of

food processing was too ambiguous to be useful [37]. Another study found low agreement between coders for assigning foods to NOVA processing categories [22].

Although “ultra-processed” foods were described at times as being energy-dense, high in saturated fat, added sugar, and salt and poor sources of protein, dietary fiber, and micronutrients [17, 38], it was never explicitly acknowledged that these were also the fundamental components of several pre-existing NP systems. The so-called “ultra-processed” foods had been identified in prior NP research as being low-cost, energy-dense and nutrient-poor [16, 21, 39–42]. The NOVA literature makes no mention of the extensive prior work on nutrient profiling methods by others. It also makes no mention of food cost. Energy-dense foods of low nutritional value generally cost less per calorie [7, 40]. In past studies, fresh meat, poultry and fish, and fresh produce had higher energy costs ($/kcal) and higher $NRF_{9.3}$ scores. By contrast, energy-dense refined grains, fats, and sweets had lower $NRF_{9.3}$ scores and much lower energy costs ($/kcal) [7, 27, 39, 40]. At least two published studies have noted that the NOVA “ultraprocessed” foods were energy dense and had lower cost per calorie of energy. One clinical study reporting that ‘ultra-processed” foods induced overeating and weight gain [51] also noted that the weekly cost for ingredients to prepare 2,000 kcal/day of ultra-processed meals was estimated to be $106 versus $151 for the unprocessed meals as calculated using the cost of ingredients obtained from a local branch of a large supermarket chain [51]. Excess energy intake was attributed to the high energy density of “ultraprocessed” foods, but not to “ultraprocessed” beverages [43, 44]. Recent studies have pointed to links between NOVA categories and metabolic syndrome [45, 46], cancer [47] and all-cause mortality [24, 48, 49]. Arguably, the same results could have been obtained with low cost energy dense foods scoring low on multiple NP models had been used.

Shifting emphasis in scoring systems from the nutrient content of foods to methods of food preparation can have unintended consequences. Based on current reports, some countries plan to use the NOVA categories for their dietary guidelines or goals. For example, dietary guidelines in Brazil recommend limiting consumption of processed food and avoiding ultra-processed foods altogether. The French national plan for nutrition and health 2018–2022 aims to reduce the consumption of “ultra-processed foods” by 20%. The NOVA emphasis on foods that are fresh, natural, and home-made ought to be examined in the light of the United Nations Sustainable Development Goal 5 on achieving gender equity [50]. Empowering women and girls to assume their place in the political and economic worlds is said to benefit humanity at large [50]. An unintended consequence of following the NOVA ukases might be to ensure that women leave the labor market and stay at home in order to cook those “freshly prepared dishes and meals”. Furthermore, cooking at home may not always promote better nutrition; that would depend on the quality and cost of the primary ingredients. The demonstrated gap in price per calorie between unprocessed and “ultraprocessed” foods is another cause for concern.

The present study had limitations. First, it was based on a market basket of 378 FFQ foods (after removing food items with missing values) and not on all the foods in the What We Eat in America dataset. Second, the study was based on foods and not total diets. However, the results of NOVA studies for diets are also inconsistent. On one hand, studies have

reported linking the consumption of ultra-processed foods with adverse health outcomes, including obesity[45], hypertension[46], cancer[47], and all-cause mortality[48]. On the other hand, studies conducted in the US, United Kingdom, France, Brazil, and Canada show that the nutritionally meaningful changes were seen for sugars and fiber but not for total fat, saturated fat, and sodium[25, 41, 51–53]. There are other studies which fail to show any link between body mass index and consumption of “ultra-processed” foods[47, 54].

Conclusion

The similarity between the NOVA scheme and the pre-existing nutrient profiling models has been noted before [40, 55]. Despite assurances to the contrary, and in the absence of any consistent or reproducible algorithm [10], the NOVA scheme appears to be based in large part on the food’s content of saturated fat, added sugar, and salt. The same nutrients to limit had been included in many pre-existing NP models. Repurposing published ideas without attribution and for political ends can only be viewed as a questionable research practice. It is therefore surprising that the NOVA scheme was recently endorsed by the Food and Agriculture Organization of the United Nations [24].

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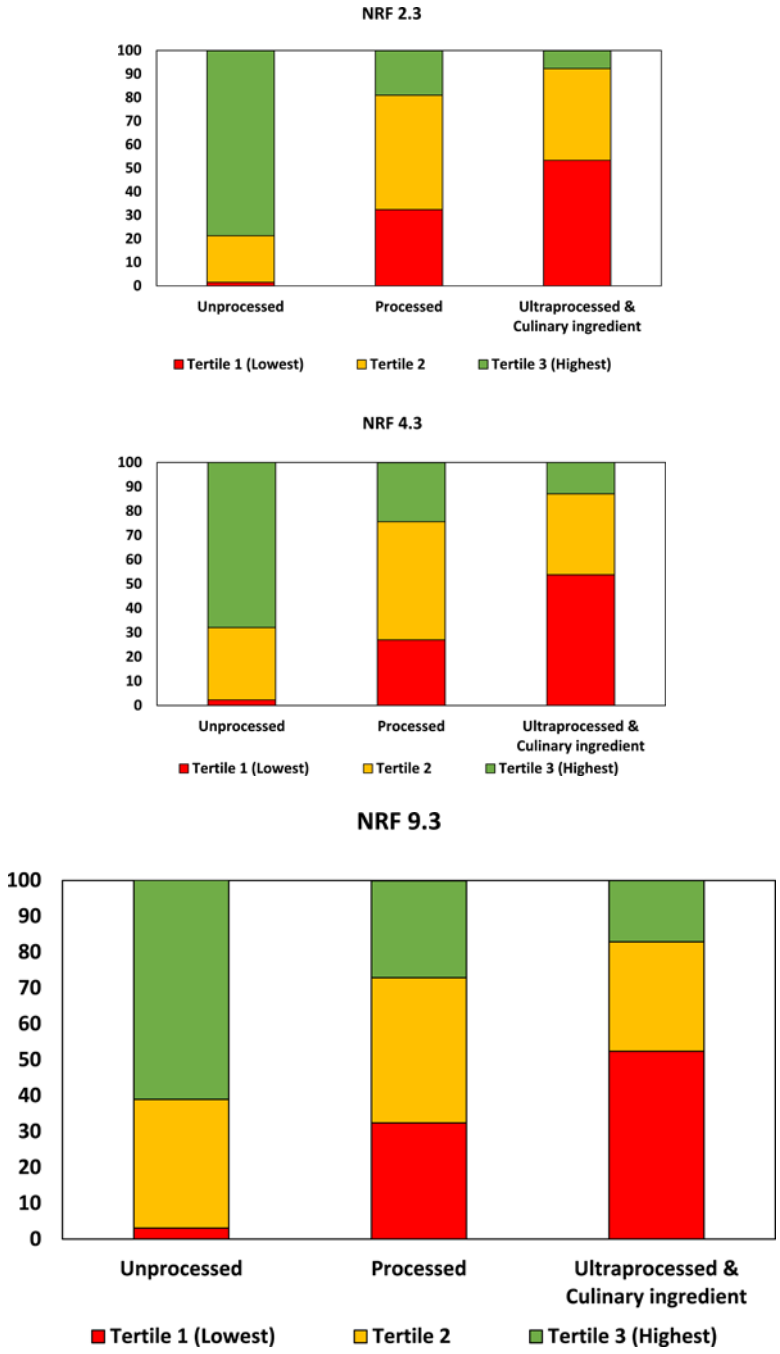

Figure 1:
Proportion of NOVA categories across tertiles of selected NRFn.3 scores

Table 1:

Daily values and maximum recommended values used in calculation of nutrient profiles, based on 2000 kcal per day

Nutrients	**Desirable nutrients Daily values**
Protein	50 g
Fiber	28 g
Vitamin A	3000 IU
Vitamin C	90mg
Vitamin E	15 mg
Calcium	1300mg
Iron	18mg
Potassium	4700mg
Magnesium	420mg
Nutrients to limit Maximum recommended values	
Saturated fat	20 g
Sugars, added	50 g
Sodium	2300mg

Abbreviations: MUFA, monounsaturated fatty acid.

Table 2:

Nutrient basis of selected nutrient profile models

NR index	Macronutrients	Vitamins	Minerals	Reference
NR 2	Protein, fiber			
NR 4	Protein, fiber	Vit C	Ca	
NR 5	Protein, fiber	Vit C	Ca, Fe	AFSSA 2008
NR 6	Protein, fiber	Vit A, C	Ca, Fe	Drewnowski et al 2008
NR 7	Protein, fiber	Vit A, C, E	Ca, Fe	Drewnowski et al2008
NR 8	Protein, fiber	Vit A, C, E	Ca, Fe, Mg	Drewnowski et al2008
NR 9	Protein, fiber	Vit A, C, E	Ca, Fe, Mg, K	Drewnowski et al 2008
LIM subscore	Saturated fat, added sugar, sodium			Darmon et al. 2008

Table 3.

NOVA category assignments and NRFn.3 scores for 378 component foods of the Fred Hutch food frequency questionnaire

	NOVA categories						
NRF scores	**Total Sample**	**Unprocessed**	**Processed**	**Ultra processed**	**Culinary Ingredients**	**Kappa Statistics***	**Spearman correlation coefficients***
N (%)	378	131 (35%)	37 (10%)	202 (53%)	8 (2%)	-	-
LIM per 100 kcal							
Mean (SD)	18.6 (17.9)	7.4 (7.0)	22.7 (25.9)	24.8 (17.6)	27.1 (19.9)	0.497	0.551
NRFn.3 scores ** *Mean (SD)*							
NRF2.3	−1.7 (24.6)	18.9 (17.3)	−4.2 (22.1)	−13.6 (19.6)	−26.4(19.8)	−0.550	−0.611
NRF4.3	15.5 (45.5)	49.3 (51.9)	5.3 (16.5)	−2.9 (30.1)	−25.5 (19.9)	−0.540	−0.581
NRF5.3	22.6 (51.5)	58.4 (56.8)	9.9 (20.0)	3.6 (38.5)	−25.3 (19.8)	−0.519	−0.551
NRF6.3	37.9 (70.4)	84.5 (84.2)	21.9 (32.3)	12.9 (47.7)	−22.7 (19.8)	−0.476	−0.495
NRF7.3	43.3 (77.4)	91.2 (91.9)	25.0 (33.7)	18.0 (56.4)	−18.1 (24.0)	−0.466	−0.500
NRF8.3	48.4 (81.9)	98.9 (98.5)	29.5 (35.5)	21.7 (58.8)	−17.8 (24.1)	−0.466	−0.493
NRF9.3	53.0 (86.6)	107.1 (105.0)	32.7 (37.6)	24.5 (60.6)	−17.5 (24.2)	−0.468	−0.495

* all Correlations are significant at the 0.001 level.

** Mean values were statistically different (at 0.001 significance level) across NOVA categories.