An overlap between "ultraprocessed" foods and the preexisting nutrient rich foods index?

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

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The category of "ultraprocessed" foods in the NOVA food classification scheme is ostensibly based on industrial processing. We compared NOVA category assignments with the preexisting family of Nutrient Rich Food (NRF) indices, first developed in 2004. The NRF indices are composed of 2 subscores: the positive NR based on protein, fiber, and vitamins and minerals, and the negative LIM subscore based on saturated fat, added sugars, 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 nutrients to limit. Nutrient density led to higher increased NRF scores but had less impact on NOVA categories. As a result, the NOVA scheme misclassified some nutrient-rich foods. We conclude that the NOVA classification scheme adds little to the preexisting nutrient profiling models. The purported links between NOVA categories and health outcomes could have been obtained using preexisting $NRF_{n.3}$ nutrient density metrics. Nutr Today. 2020;55(2):75–81

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Adam Drewnowski is the original developer of the Naturally Nutrient Rich and the Nutrient Rich Food (NRF) indices. That work was supported at the time by the Nutrient Rich Coalition. Coalition members were The Beef Checkoff Program through the National Cattlemen's Beef Association, California Avocado Commission, California Kiwifruit, California Strawberry Commission, Egg Nutrition Center, Florida Department of Citrus, Grain Foods Foundation, National Dairy Council, National Pork Board, United States Potato Board, Wheat Foods Council, and Wild Blueberry Association of North America. He has received contracts and honoraria from entities both public and private with an interest in nutrient profiling of foods. Nicole Darmon is the original developer of the SAIN, LIM nutrient density profiling system, developed on behalf of the French Food Standards Agency and supported by the government of France in 2008. In 2017, Nicole Darmon adapted the SAIN, LIM to obtain the SENS algorithm within a project funded by a consortium of several food companies (Atla, Auchan Retail, Boissons rafraîchissantes de France, Carrefour, Casino, Findus, Fleury Michon, Marie Sablé, Monoprix, Système U, Unijus). Shilpi Gupta has no conflicts to report.

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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 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 nutrient density concept and the NRF indices $NRF_{9.3}$ index were developed in 2004[1,2] at approximately the same time as the British Food Standards Agency-Office of Communications model[5] and the Unilever Choices model.[6] Initially based on protein, fiber, vitamins, and minerals, the Nutrient Rich Foods model soon incorporated nutrients to limit: saturated fat, added sugar, and sodium.[7] The SAIN,LIM[8] and Nutrient Rich Foods ($NRF_{n.3}$)[3] models shared the same negative LIM subscore, composed of saturated fat, added sugar, and sodium. Multiple NP methods, including the $NRF_{9.3}$ model,[9–14] have been 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 "ultraprocessed," and culinary ingredients. The purpose of "ultraprocessing" alleged by the NOVA creators was to produce purportedly hyperpalatable foods with longer shelf life and "quasi-addictive" properties.[17] A practical way suggested to identify "ultraprocessed" 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, pasteurization, chilling, freezing, placing in containers, vacuum packaging, and nonalcoholic 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 "ultraprocessed" 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 "ultraprocessed" 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 preexisting NP models that had long included the foods' content of saturated fat, added sugar, and salt.

METHODS

The Fred Hutchinson Food Frequency Questionnaire Component Food Items

The Fred Hutchinson semiquantitative food frequency questionnaire (FFQ) is built around 384 component foods, of which 378 have energy density greater than 10 kcal/100 g. To avoid dividing by zero, unsweetened tea, coffee, and diet beverages with low energy density less than 10 kcal/100 g 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 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, namely, "unprocessed," "processed," "ultraprocessed," and culinary ingredients, using published classification schemes.[16] On the basis of NOVA publication from 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 kernels, wheat berries, or grains; legumes such as beans of all types, lentils, and chickpeas; and 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.

"Ultraprocessed" foods were defined as industrial creations, which contained ingredients, chemicals, and nonnutritive substances not found in home cooking,[16] in addition to fat, sugar, and salt. On the basis of NOVA descriptions from a 2016 publication,[17] "ultraprocessed" foods included industrial breads (refined and whole grain), ready-to-eat breakfast cereals, cakes, sweet snacks, pizza, French fries, 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 with 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. Following published guidelines, mass-produced whole grain breads, commercial sweetened yogurts, commercial fruit juices, and ready-to-eat cereals all were assigned to the ultraprocessed category.

Nutrient Profiling 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 3 (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 that were the basis of percent daily value calculations.[34] The preexisting 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]

TABLE 1 Daily Values and Maximum Recommended Values Used in Calculation of Nutrient Profiles, Based on 2000 kcal/d

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

Statistical Analysis

Means (SDs) 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. κ Statistic was computed across 2 groups of NRF scores (created by median split) and 2 NOVA categories (category 1, unprocessed and processed; category 2, ultraprocessed and culinary ingredient). Spearman correlation were also computed between quartiles of $NRF_{n.3}$ and NOVA categories. Descriptive statistics were 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 100 kcal. All statistical analyses were conducted using SPSS 22 statistical software and Microsoft Excel (2016).[36] Level of significance was $P < .01$.

RESULTS

Table 3 shows the relation between the 4 NOVA categories and the LIM score (per 100 kcal). "Ultraprocessed" foods and culinary ingredients, that is, foods high in fat, sugar, and salt, received the highest and least favorable LIM scores. The κ value was 0.50, and Spearman correlation was 0.55. Also shown in Table 3 are κ 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 (multiple panels) shows tertiles of selected $NRF_{n.3}$ scores plotted against NOVA categories. "Ultraprocessed" foods and "culinary ingredients" were combined. Again, NOVA category assignments were adequately captured by tertiles of NRF scores.

DISCUSSION

The NOVA classification seems to be based largely on fats, sugar, and salt. This is contrary to published claims but not altogether surprising, given that the "ultraprocessed" 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 NP systems. The adverse health effects of diets excessively high in fat, sugar, and salt are well known. Yet, in a 2009 article, Monteiro[16] claimed that the issue was not food, nor nutrients, as much

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	Darmon et al (2009)[8]
NR 6	Protein, fiber	Vit A and C	Ca, Fe	Drewnowski et al (2009)[33]
NR 7	Protein, fiber	Vit A, C, and E	Ca, Fe	Drewnowski et al (2009)[33]
NR 8	Protein, fiber	Vit A, C, and E	Ca, Fe, Mg	Drewnowski et al (2009)[33]
NR 9	Protein, fiber	Vit A, C, and E	Ca, Fe, Mg, K	Drewnowski et al (2009)[33]
LIM subscore	Saturated fat, added sugar, sodium			Maillot et al (2007)[7]

Abbreviation: Vit, vitamin.

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 $NRF_{9.3}$ scores.

By contrast, refined grains, fats, sweets, and desserts had higher and more unfavorable LIM values and lower $NRF_{9.3}$ scores. Here, the arbitrariness of the NOVA categorization made for some mismatches. "Ultraprocessed" foods were mostly fats and sweets, but the category also included

TABLE 3 NOVA Category Assignments and $NRF_{n.3}$ Scores for 378 Component Foods of the Fred Hutch Food Frequency Questionnaire

NRF Scores	Total Sample	NOVA Categories				κ Statistics[a]	Spearman Correlation Coefficients[a]
		Unprocessed	Processed	Ultraprocessed	Culinary Ingredients		
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
$NRF_{n.3}$ scores,[b] mean (SD)							
$NRF_{2.3}$	–1.7 (24.6)	18.9 (17.3)	–4.2 (22.1)	–13.6 (19.6)	–26.4 (19.8)	–0.550	–0.611
$NRF_{4.3}$	15.5 (45.5)	49.3 (51.9)	5.3 (16.5)	–2.9 (30.1)	–25.5 (19.9)	–0.540	–0.581
$NRF_{5.3}$	22.6 (51.5)	58.4 (56.8)	9.9 (20.0)	3.6 (38.5)	–25.3 (19.8)	–0.519	–0.551
$NRF_{6.3}$	37.9 (70.4)	84.5 (84.2)	21.9 (32.3)	12.9 (47.7)	–22.7 (19.8)	–0.476	–0.495
$NRF_{7.3}$	43.3 (77.4)	91.2 (91.9)	25.0 (33.7)	18.0 (56.4)	–18.1 (24.0)	–0.466	–0.500
$NRF_{8.3}$	48.4 (81.9)	98.9 (98.5)	29.5 (35.5)	21.7 (58.8)	–17.8 (24.1)	–0.466	–0.493
$NRF_{9.3}$	53.0 (86.6)	107.1 (105.0)	32.7 (37.6)	24.5 (60.6)	–17.5 (24.2)	–0.468	–0.495

[a]All correlations are significant at the .001 level.
[b]Mean values were statistically different (at a .001 significance level) across NOVA categories.

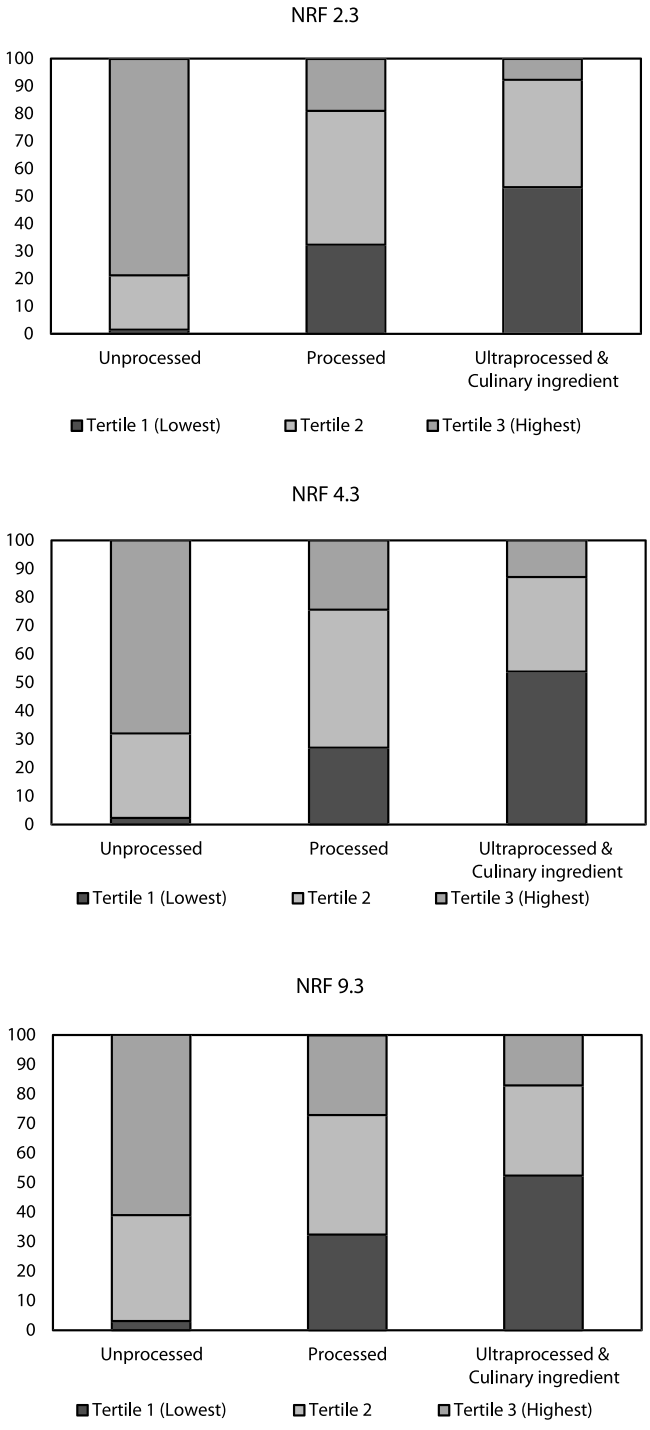

FIGURE. Proportion of NOVA categories across tertiles of selected $NRF_{n.3}$ scores.

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 ultraprocessed, whereas the same bread was considered unprocessed when homemade.[20] Furthermore, the NOVA definitions have shifted with time.[20] In some cases, it was noted that 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 "ultraprocessed" 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 preexisting NP systems. The so-called "ultraprocessed" foods had been identified in previous NP research as being of low cost, energy dense, and nutrient poor.[16,21,39–42] The NOVA literature makes no mention of the extensive previous work on NP 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 2 published studies have noted that the NOVA "ultraprocessed" foods were energy dense and had lower costs per calorie of energy. One clinical study reporting that "ultraprocessed" foods induced overeating and weight gain[43] also noted that the weekly cost for ingredients to prepare 2000 kcal/d of ultraprocessed 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.[43] Excess energy intake was attributed to the high energy density of "ultraprocessed" foods.[44,45] Recent studies have pointed to links between NOVA categories and metabolic syndrome,[46,47] cancer,[48] and all-cause mortality.[24,49,50] Arguably, the same results could have been obtained if 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. On the basis of 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 ultraprocessed foods altogether. The French national plan for nutrition and health 2018–2022 aims to reduce the consumption of "ultraprocessed foods" by 20%. The NOVA emphasis on foods that are fresh, natural, and homemade ought to be examined in the light of the United Nations Sustainable Development Goal 5 on achieving gender equity.[51] Empowering women and girls to assume their place in the political and economic worlds is said to benefit humanity at large.[51] An unintended consequence of following the NOVA ukases might be to ensure that women leave the labor market and stay at home 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.

This 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 data set. 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 ultraprocessed foods with adverse health outcomes, including obesity,[46] hypertension,[47] cancer,[48] and all-cause mortality.[49] On the other hand, studies conducted in the United States, 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.[25,41,52–54] There are other studies that fail to show any link between body mass index and consumption of "ultraprocessed" foods.[48,55]

CONCLUSION

The similarity between the NOVA scheme and the preexisting NP models has been noted before.[40,56] Despite assurances to the contrary, and in the absence of any consistent or reproducible algorithm,[10] the NOVA scheme seems 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 preexisting 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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DISCARDED WEIGHT LOSS DRUGS WORKSHOP

On April 29, 2020 an all day public workshop which can be viewed over the web will be held on Implications of Discarded Weight Loss Drugs. It is free to all interested parties but registration is required at the National Academies website.

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