Original Article

Nutrient profiling methods applied to mixed dishes and meals

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The stated purpose of nutrient profiling (NP) models is to help implement dietary guidelines by addressing prevailing health issues. In high-income countries, obesity and non-communicable diseases are the main health issues of concern. As a result, NP models typically penalize packaged processed foods that contain calories, total or added sugar, sodium, and saturated fat. This negative nutrition approach may not be optimal for Southeast Asia, where nutrient shortfalls and nutrient deficiencies are still prevalent. A more positive approach featuring nutrients to encourage might be more appropriate. NP models should incorporate protein, fibre, calcium, iron, zinc, vitamin A, B vitamins, vitamin B12, and vitamin E. The specific choice of index nutrients may depend on population health needs. Further, given the diversity of Asian food cultures, it may be time to go beyond packaged foods and apply the NP methodology to mixed dishes and to complete meals. This article illustrates the application of NP models to composite meals.

Key Words: nutrient profiling, nutrient density, WHO Southeast Asia Region, protein, vitamins and minerals

INTRODUCTION

The term nutrient profiling (NP) refers to quantitative methods used to assess the relative healthfulness of foods.[1-4] Initially developed to assess the healthfulness of packaged processed foods,[5,6] NP methods can also be applied to mixed dishes and to complete meals. NP methods have served a variety of educational and regulatory purposes, including front-of-pack labelling, school food standards, and the regulation of marketing and advertising to children.[1-4] Industry-driven NP methods have served to promote innovation and to benchmark product and recipe reformulation by food manufacturers.[4]

The World Health Organization (WHO) views NP models as a way to help implement dietary guidelines.[7] In this view, NP models ought to address an identified health problem by steering consumers toward healthier food choices.[7] The main health problem in high-income countries is overnutrition, manifesting itself as high rates of obesity and overweight.[8,9] For that reason, regional NP models have typically centred on reducing food calories and on limiting fat, sugar, and salt.[10] For example, the UK FSA-Ofcom system, the French Nutri-Score and the Australia New Zealand Health Star Rating penalize calories and give negative scores to foods containing any amount of saturated fat, total or added sugar, and sodium.[1]

Several countries in Asia have followed analogous reasoning to evaluate packaged processed foods. A recent review[11] described front-of-pack Healthier Choice logos developed by Ministries of Health or local authorities in Indonesia, Thailand, Malaysia, and Sri Lanka. The general intent was to discourage consumption of processed packaged foods high in calories, fat, sugar and salt.[11] Nutrient density was effectively defined by the absence of problematic nutrients rather than by the presence of beneficial nutrients or desirable ingredients.

Some NP models in low and middle income countries have adopted a more positive approach by including protein, fibre, and a wide variety of vitamins and minerals.[11] For example, in 2022, the Food Safety and Standards Authority of India (FSSAI) proposed a draft Health Star Rating to rate packaged, processed foods on a 0.5 to 5 star scale.[12] That algorithm reportedly featured protein and fibre along with desirable ingredients: fruits, vegetables, nuts and legumes. Those positive components were balanced against calories, saturated fat, total sugar, and sodium.[12]

NP algorithms that balance the negative and the positive elements to arrive at the final score are viewed as compensatory.[6] Some NP models award additional points for desirable ingredients such as whole grains, fruits, vegetables, nuts, pulses, and dairy.[13] Those hybrid NP models were developed to better align nutrient density metrics with dietary guidelines, which have become increasingly food based.[14]

Some important distinctions need to be made. Models that prioritise food avoidance can be viewed as emblematic of negative nutrition. In those models, sometimes expressed as coloured traffic lights or octagonal black

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warning signs, healthier choices are defined by the absence of calories, saturated fat, sugar, and salt.[15,16] By emphasising food avoidance, negative NP models aim to steer consumers away from less healthy foods.[2]

This negative nutrition approach may not be optimal for Southeast Asia (SE Asia), where dietary nutrient shortfalls and deficiencies are still prevalent.[17] A positive nutrition approach, with more emphasis on protein, fibre, and micronutrients to encourage, might be more appropriate for the region. Among priority micronutrients, typical diets of low- and middle-income countries are often inadequate in calcium, iron, zinc, vitamin A, B vitamins, vitamin B12, and vitamin E.[18,19] Their relative importance can depend on the region and on specific population health needs.

There is also some value in applying the positive approach to mixed dishes and to complete meals and not just to packaged processed foods. Traditional food cultures in SE Asia feature complex mixed dishes and meals that combine different food groups and feature multiple ingredients, condiments, and spices. Applying NP models to meals and to mixed dishes in SE Asia poses several conceptual and technical challenges, discussed below.

THE PURPOSE AND DESIGN OF NP MODELS

NP models are quantitative tools used to evaluate the nutritional quality of foods and beverages. Different types of models are currently in place.[2,20,21] Nutrient-by-nutrient models tend to use fixed threshold values for specific nutrients to limit (e.g., maximum amount of sugar per 100 g). One example is the WHO NP model for SE Asia, which specifies maximum amounts of total fat, saturated fat, total or added sugar, and sodium to be allowed in processed foods.[22] Based on WHO guidelines, marketing is prohibited for foods that fail to meet the proposed criteria. The negative nutrient-by-nutrient model devised by the WHO Regional Office for Europe is also primarily intended to justify marketing restrictions rather than to guide consumer behavior.[23]

Composite NP models calculate the overall nutritional value for a given food item.[1,2] These models assign values or points to selected nutrients (or ingredients) and calculate an overall food healthfulness score, typically per 100g. Prime examples are the Health Star Rating[20] and Nutri-Score,[21] expressed as star ratings or letter grades, respectively. While weighted heavily by nutrients to limit, both Nutri-Score and Health Star Rating do award some points for desirable food groups.[20,21]

There are further critical distinctions to be made. Across-the-board NP models apply the same nutrient standards or criteria to all food groups in the food supply.[1,5,6] Such models are useful for comparing the nutritional value of foods across food categories or food groups. Generally, vegetables, fruit, and pulses get higher scores than do fats and sweets.[1,5,6] By contrast, category-specific NP models apply different nutrient standards to different food groups, based on nutrients characteristic of a given food group. For example, NP models designed to capture nutrient density of vegetables and fruit have used flavonoids and antioxidants in addition to vitamin A and vitamin C.[24] NP models designed to capture nutrient density of grain products have used whole grains in addition to added sugar and dietary fiber.[25,26] Category-specific models are useful in identifying products that are best in class, and for benchmarking improvements in food categories (or product lines) being reformulated by the food industry.

The WHO NP model for SE Asia is category specific, applying slightly different criteria for nutrients to limit to 18 different product categories.[22] It is based only on nutrients to limit and does not include any nutrients to encourage, such as fibre, protein, vitamins, or minerals.

A model more suitable for mixed dishes and meals would be based on nutrients to limit, nutrients to encourage, or on some combination of both.[5,6] Some hybrid NP models include both nutrients and desirable food ingredients,[12] such as whole grains, dairy, vegetables, fruit, legumes, and nuts. The hybrid scores are well suited to the reformulation of mixed dishes and complete meals, where reformulation can consist in swapping one recipe ingredient for another. The goal is to make such NP models sensitive to recipe improvements.

In general, nutrient density is calculated per reference amount, which can be 100 g, 100 kcal, or a serving.[27,28] NP models originating in the European Union have taken 100 g as the standard.[11] However, solid foods and beverages have different volumes, different energy densities, and different portion sizes. Nutri-Score simply penalizes energy-dense foods without capturing their nutrient content.[21] The Nutrient Rich Food (NRF) index, developed in the United States, has used 100 kcal as reference amount.[29,30] Here, the disadvantage is that foods with low energy density (e.g., spinach) have high nutrient-to-energy ratios and so receive very favourable scores. When it comes to mixed dishes and complete meals a system to capture nutrient density per serving may be the best option.The U.S. Food and Drug Administration (FDA) uses servings, otherwise known as reference amounts customarily consumed, or RACC.[31] Any future NP system developed or promoted by the FDA will most likely use servings as opposed to grams or calories.

The scoring algorithm is generally very simple. One important question is whether the algorithm is compensatory or not. In a non-compensatory scoring algorithm, excess amounts of nutrients to limit disqualify the food altogether, and beneficial nutrients are not taken into account. In a compensatory algorithm, beneficial nutrients are balanced against fat, sugar, and salt so that the total score reflects the presence of both.[29]

Typically, the final score in a compensatory NP model is the combined value for positive nutrients to encourage minus the combined value of negative nutrients to limit. The final value can be a continuous scale or can be translated into points or letter grades. NP models have been validated with respect to expert opinion and by comparing nutrient density of all foods consumed with independent measures of a healthy diet.[30] In general, the consumption of healthy foods translates into healthier diets overall.

There are limitations. First the concepts of nutrient adequacy, moderation, and balance apply to total diets and not to individual packaged foods. Mixed dishes and complete meals occupy the middle space. Second, the issue of nutrient bioavailability, often determined by diet composition is not fully settled. There are ongoing efforts to adjust for

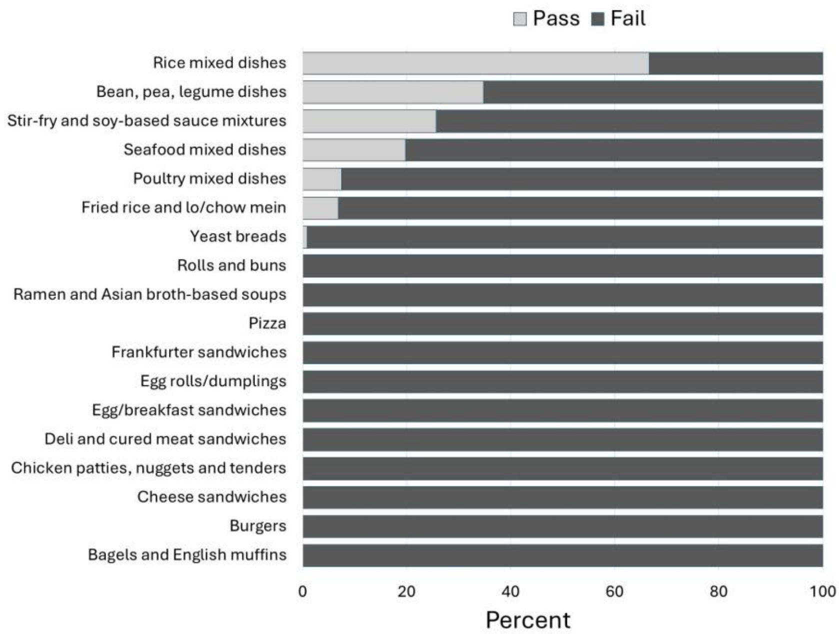

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Figure 1. Percentages of mixed foods that passed or failed the WHO nutrient profiling model for Southeast Asia by food category. Selected categories from the What We Eat in America study

protein quality [32] and to recognize differences in bioavailability of calcium, iron and zinc depending on food source.

THE WHO NP MODEL FOR SE ASIA

The WHO NP model for the SE Asia Region classifies foods based on energy, total and added sugar, total and saturated fat, and sodium.[22] The model is intended to identify unhealthy foods and restrict their marketing to children.[22] The stated goal is to promote healthier choices and to encourage product reformulation by the SE Asia food industry.[22]

The WHO SE Asia model was based on the principles of the Pan American Health Organization's NP model and the WHO NP model for the Western Pacific Region. First, the WHO SE Asia model is category specific, since slightly different criteria are applied to its 18 categories of packaged processed foods.[22] Each category has established thresholds for energy and nutrients of concern: total or saturated fat, total or added sugar, and sodium.[22] For example, thresholds for bread and rolls (category 3) are set at <8.0 g/100 g for total fat, 6.0 g for total sugars, and 250 mg/100 g for sodium.[16] The thresholds for prepared foods or dishes (category 10) are 8.0 g for total fat, 3.5 g for saturated fat, 9.0 g for total sugars, and 350 mg/100 g for sodium.[22] Among listed examples of processed mixed foods and meals in category 10 are burgers, fried chicken, pizza, sandwiches, and soups, as well as other mixed dishes prepared from meats, grains, cheese, vegetables, and sauces.

The setting of NP thresholds followed scientific evidence on diet–disease links in relation to national/international dietary guidelines, with expert consultations and testing using food composition data. WHO member states were encouraged to use the NP model to implement policies related to food marketing to children and to promote healthier diets. Based on the WHO guidelines, marketing is prohibited if the nutrients to limit exceed specified threshold values per 100 g.

THE WHO MODEL FOR SE ASIA APPLIED TO MIXED DISHES

Figure 1 shows the application of the WHO NP model for SE Asia to 18 food categories selected from within the mixed dishes food group in the U.S. Department of Agriculture's Food and Nutrient Database for Dietary Studies (FNDDS 2021-23).[33] The FNDDS database is used to calculate dietary energy and nutrient intakes in the What We Eat in America study, the dietary component of the U.S. National Food and Nutrition Examination Survey. The foods listed are those reported as consumed by survey participants during two 24-hour dietary data collection periods. The categories were specifically selected to include different types of mixed dishes (Figure 1).

Very few mixed dishes and meals in the FNDDS database passed the WHO NP criteria. The only ones that did were some stir-fried mixed dishes, rice dishes, and seafood. All other items failed, including nearly all of the breads, pizza, and burgers. Dichotomous (pass/fail) scores provide no hint of why a given product failed and offer no opportunity for improvement. Interestingly, among the foods that failed were important sources of animal protein, such as meat, chicken, egg, and cheese dishes (see Figure 1).

THE NUTRIENT RICH FOOD INDEX

The Nutrient Rich Food Index (NRF), presented here as an alternative to the WHO model, is an across-the-board NP model that calculates the healthfulness of foods based on their nutrient composition.[29,30] The NRF index has two subscores: the positive NRn subscore, based on a variable number n of nutrients to encourage (equation 1), and the negative LIM subscore, which is usually based on the same 3 nutrients to limit, saturated fat, added sugar, and sodium (equation 2). Nutrients to encourage typically include protein, fibre, iron, calcium, and potassium, along with several vitamins. NP models in the NRFn.3 family of scores take their name from the n number of nutrients to encourage, which has varied from 6 to 9 or more, and the three nutrients to limit.

The final NRFn.3 scores (equation 3) are calculated as the sum of percent daily values (DV) for n nutrients to encourage (Nut_enc) minus the sum of percent daily values (maximum recommended value, MRV) for the three nutrients to limit (Nut_lim). Percent daily values are normally calculated per 100 kcal of food and are capped at 100%. Some versions of the NRF have calculated percent daily values per 100 g or per serving. The final NRFn.3 score, based on percent daily values, is therefore continuous rather than point based.

The NRFn.3 nutrient standards for are taken from the Codex Alimentarius (Table 1).[34] The mathematical expressions are as follows:

(1) $NRn = \sum_{i=1}^{n} (Nut\_enc_i)/(DV_i) \times (100/ED_i)$

(2) $LIM = \sum_{i=1}^{3} (Nut\_lim_i) / (MRV_i) \times (100/ED_i)$

(3) NRFn.3 = NRn-LIM

Several versions of the NRF index are available; some were developed specifically for different food groups and are therefore category specific. The NRF9.3 (standard version) measures nine nutrients to encourage: protein, fibre, calcium, iron, potassium, magnesium, vitamin A, vitamin C, and vitamin D.[29,30]

The NRF6.3 priority micronutrients algorithm, developed for lower-income countries, is based on six nutrients to encourage: iron, zinc, calcium, vitamin A, vitamin B12, and folate.[10] Those nutrients are frequently lacking in typical diets of low- and middle-income countries. The NRF15.3 NP model with extended priority micronutrients uses 15 micronutrients to encourage: vitamins A, D, E, C, B1, B2, B3, B6, and B12; folate; copper; calcium; iron; magnesium; and zinc.[10]

THE NUTRIENT RICH FOOD INDEX APPLIED TO MIXED DISHES

Figure 2 shows the application of the NRF9.3 index to the same 18 categories from within the mixed food groups in the same FNDDS 2021-23 database.[33] Whereas the WHO NP model used a pass/fail approach, the NRF model measures nutrient density along a continuous scale. The same food categories that were evaluated in Figure 1 were re-evaluated using the NRF9.3 model. Figure 2 plots mean NRF9.3 values for each food category against mean energy density scores. There was an inverse relation between energy density (expressed as calories per 100 g) and nutrient density, expressed as nutrients per 100 kcal. The food categories that were scored as more nutrient rich, for example, seafood and stir-fried mixed dishes, were also lower in energy density (kcal/100 g). Lowest NRF9.3 nutrient density scores were obtained for fatty frankfurter sandwiches and for salty soups.

Compared to the WHO pass/fail model, the NRF approach scored nutrient density along a continuum. Figure 2 shows that there was no simple dividing line that separates good foods from bad foods. Even foods within a given food category can have different nutrient density scores, depending on their nutrient composition. Such granular assessments of nutrient density can provide benchmarks for product reformulation, a more productive approach than a simple pass/fail score.

APPLYING NP MODELS TO COMPOSITE DISHES IN SE ASIA

Composite meals in SE Asia are made of multiple dishes eaten together.[35] Rice is almost always the central element, though other staples (noodles, bread) are used as well.[35-37] Protein sources often include fish, seafood, poultry, tofu, and legumes rather than red meat.[35-39] Meals are served with a variety of side dishes, sauces, and condiments, in-

Table 1. Reference daily values for micronutrients of interest in the Nutrient Rich Food Index (NRF)

Nutrient to encourage	Reference daily value†	Nutrient to limit	Maximum recommended value
Protein (g)	50	Saturated fat (g)	20
Fiber (g)	25	Added sugars (g)	50
Vitamin A (RAE)‡	800	Sodium (mg)	2000
Vitamin C (mg)	100		
Vitamin D (µg)	15		
Calcium (mg)	1000		
Iron (mg)	14		
Potassium (mg)	3500		
Magnesium (mg)	310		
Zinc (mg)	11		
Folate (mcg)	400		
Copper (mcg)	900		
Vitamin B1 (mg)	1.2		
Vitamin B2 (mg)	1.2		
Vitamin B3 (mg NE)‡	15		
Vitamin B6 (mg)	1.3		
Vitamin B12 (µg)	2.4		

†Daily values were taken from the Codex Alimentarius,
‡NE, niacin equivalents; RAE, retinol activity equivalents.

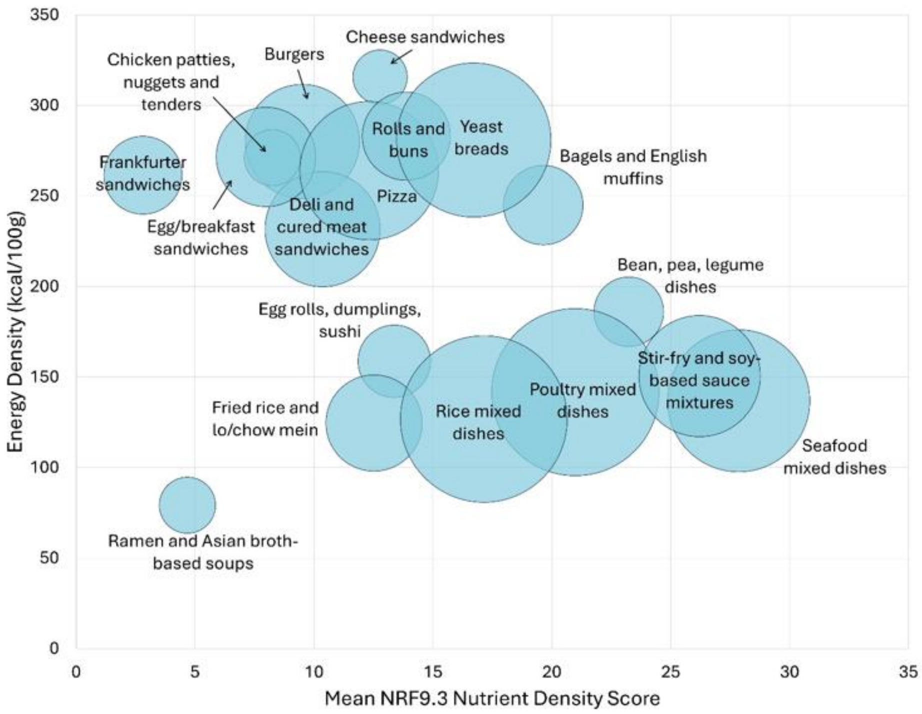

Figure 2. Mean energy density (kcal/100 g) and nutrient density (Nutrient Rich Food NRF9.3 scores) by category. Selected categories from the What we Eat in America stusy. Circle size reflects the number of food items within a category.

cluding fresh herbs, raw vegetables, and pickles. Dishes tend to be high in salt, which comes from fish sauce, soy sauce, and salted fish. Vitamin C and antioxidants are provided by citrus and other fruit, and fresh or dried chilies.[35-39]

This meal structure has implications for designing meal-based NP models. First, accurate nutrient composition data are required for complex dishes, each with multiple ingredients and regional variations. A recipe file will be indispensable. Also, data on bioactive ingredients (e.g., flavonoids, polyphenols) for condiments, herbs, and spices are unlikely to be available.

Second, the selection of nutrients to encourage and nutrients to limit needs to reflect local conditions, dietary requirements, and health needs. For example, protein quality is not an issue in high-income countries, where the main source of protein is meat.[38] Protein quality may be an issue when a diet is largely rice based, with few animal foods and little dietary variety. In those cases, NP models should be corrected for protein quality using existing digestibility metrics. Similarly, iron and calcium from plant sources may be less bioavailable than heme iron from meat or calcium from dairy.[39] NP models developed in high-income countries have not made these corrections, given an ample supply of animal protein.

Third, nutrient standards need to be adapted to local conditions. Existing NP models have used nutrition standards developed by national or international agencies. Models in the United States are based on FDA standards; those developed in France are likely based on the French Dietary Guidelines.[40] When no local or regional guidelines are available, NP models default to FAO standards or the Codex Alimentarius. One might consider using serving sizes as reference amounts instead of 100 g. This will allow a more direct comparison of different types of dishes or meals. One potential approach is to use hybrid NP models that include nutrients, ingredients, and desirable food groups as well as condiments and spices that are not typically featured in existing NP models.

Finally, any NP model applied to meals and mixed dishes in SE Asia needs to be tested in several regional databases. As an example of this approach, consider ramen bowls. The ingredients are cooked ramen noodles, broth (with soy sauce), boiled egg, pork, scallions, spinach, seaweed; amounts may vary. So, the nutrients are protein (from meat, egg, or tofu); refined carbohydrates (white noodles), vegetables (amounts may vary), saturated fat (from meat and oils from fried noodles), and salt (from miso broth and soy sauce). The score will depend on the type of broth. Overall nutrient content will depend on the type of broth, toppings, and preparation.

NP models ought to be validated with respect to dietary guidance and tested against independent measures of a healthy diet. Dietary intakes from national nutrition surveys are needed to accomplish this. Whereas nutrient composition data have now become available for several countries (India, Bangladesh, VietNam), data on dietary intakes are still scarce. The Nutrient Rich Food Index was validated against diet quality measures from the National Health and Nutrition Examination Survey in the US.[5]

CONCLUSIONS

NP methods, initially developed for packaged processed foods, can be applied to mixed dishes and to complte meals. Continuous NP models of nutrient density, that include both nutrients to encourage and nutrients to limit, offer more opportunities for recipe reformulation than do pass/fail models. NP models that feature dietary ingredients can also provide useful benchmarks for recipe reformulation and improvement.

DISCLOSURE ON THE USE OF AI AND AI-ASSISTED TECHNOLOGIES

No AI-assisted technologies were involved in data collection or analysis, or in creation of images or graphical elements. The authors reviewed and edited the content and takes full responsibility for the content of the publication.

CONFLICT OF INTEREST AND FUNDING DISCLOSURES

AD is the original developer of the Naturally Nutrient Rich (NNR) and the Nutrient-Rich Food (NRF) nutrient profiling models and is a member of scientific advisory panels for Nestlé, Lesaffre, and BEL. AD has worked with Ajinomoto, Carbohydrate Quality Panel supported by Potatoes USA, dsm-firmenich, FoodMinds, FrieslandCampina Institute, Kraft Heinz, Meiji, MS-Nutrition, National Pork Board, Nutrition Impact LLC, Nutrition Institute, PepsiCo, Samsung, and Soremartec on quantitative ways to assess nutrient density of foods.

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