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Nutrient Profiling Model Towards Recommendation of A Healthy Diet: A Scoping Review

Ruhaya Salleh[1,2], Roslee Rajikan[1*], Suzana Shahar[1], Mohd Razif Shahril[1], Siti Masitah Elias[3], Noor Ani Ahmad[2]

[1]Centre for Healthy Ageing and Wellness (HCare), Faculty of Health Sciences, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia
[2]Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, 40170 Shah Alam, Selangor, Malaysia
[3]Faculty of Science and Technology, Universiti Sains Islam Malaysia, Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan, Malaysia

ABSTRACT

The objective of this study is to identify the availability of Nutrient Profiling (NP) models worldwide and discuss their application. This scoping review is based on the Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for the Scoping Review (PRISMA-ScR) and the Arksey and O'Malley framework. Articles related to NP among adults published from 2012 to 2022, written in English, were retrieved from the Web of Science, Science Direct, Scopus, and Pubmed databases. Mendeley software was used for database acquisition and MS Excel for the syntesis process. Only 17 articles out of 2,019 article titles identified met the inclusion criteria for the review. This review discovers that the applications of NP in nutrition policies include food labelling, Front-Of-Pack (FOP), and regulations on food marketing, health, and nutrition. Fibre is the nutrient that needs to be included in the NP application compared to saturated fats, fatty acids, sodium, and total sugar. This scoping review demonstrates the scientific basis of the NP model's development in public health policy, leading to advocacy and the recommendation of healthy diets.

Keywords: adults, healthy diet, nutrient profiling, nutrient density, nutrient-rich food index

INTRODUCTION

Excessive intake of unhealthy diets is also one of the main causes of Non-Communicable Diseases (NCDs), such as stroke, coronary heart disease, and some types of cancer other than smoking, alcohol consumption, and physical inactivity (WHO Regional Office for Europe 2016). In 2015, the World Health Organization (WHO) stated that factors such as financial levels, personal preferences and beliefs, cultural traditions, and geographical location, such as climate change, pose challenges to the accessibility and availability of healthy and nutritious foods.

The definition of Nutrient Profiling (NP) is "the science of categorising or ranking foods with their nutritional composition". Therefore, NP is a helpful instrument to motivate consumers to choose healthier foods (WHO 2015). Hence, it could prevent the risk of diseases and promote a healthy diet (WHO 2011). Globally, NP is used as a tool for developing applications related to nutritional policy. According to Labonté *et al.* (2018), the applications of NP models include establishing health or nutrition claims regulations, implementing restrictions on food marketing to children, and assisting consumers in making decisions about which food products to sell in schools through food labelling systems. For instance, in the United Kingdom, the Food Standards Agency (FSA) developed the Nutrient Profiling Model to track food product advertisements targeted towards children (Scarborough *et al.* 2007; Department of Health, Food Standards Agency, British Retail Consortium 2013), while the United States developed the Nutrient Rich Food (NRF) model for their consumers (Fulgoni III *et al.* 2009). The British FSA uses colours to label the product's nutrition level, called the Nutri Score, with green indicating the highest nutritional quality and red

[*]**Corresponding Author:** tel: +60389213856, email: roslee@ukm.edu.my
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indicating products with lower nutritional quality. The same food labelling is also used in France with the Nordic Keyhole scheme and Health Star Rating in Australia and New Zealand.

NP ranks foods based on their nutrient content and uses them for regulating health claims, nutrition labels, and marketing and advertising towards children (WHO 2011). Some NP models developed by scientists, government agencies, and the food industry focus on limiting sugar, fat, and sodium, and some emphasise nutrients that benefit health, such as protein, vitamins, dietary fibre, and iron. NP models are often tailored through the use of science-driven rule development procedures, such as the selection of reference amounts and index nutrients, the creation of a suitable nutrient density calculation algorithm, and the validation of the selected nutritional profile model against a healthy diet. Although there are several available NP models, little is known about their applications in relation to the recommendation of a healthy diet. Thus, this scoping review aims to identify the established models of NP that have developed as a tool to establish public health interventions toward a healthy diet.

METHODS

Sources of information and search strategy

NP articles, full text, were included in this scoping review. Arksey & O'Malley's (2005) framework and the Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for the Scoping Review (PRISMA-ScR) method (Trico *et al.* 2018). PubMed, Scopus, Science Direct, and Web of Science are the four databases used in searching research papers published in English between 2012 and 2022. To find the established NP models as a tool to form public health interventions related to nutritional status, suitable keywords were chosen to search the relevant articles. The keywords used in the database machines comprised nutrient density, nutrient-rich, nutrient profiling, nutrient profiles, affordable diet, low cost, healthy eating, healthy food, and adults. The search strategy included all possible combinations of key search terms, which were "nutrient density" OR “nutrient-rich" OR "nutrient rich food index" OR "nutrient dense" OR "macronutrients" OR "diet quality" OR "dietary index" OR "diet index" OR “nutrient profiling" OR "nutrient profiles" OR "food profiles" OR "nutrient profile" OR "nutritional profiles" AND "affordable diet OR "low cost" OR "modest" AND "healthy eating" OR "health food" OR "healthy diet" OR "adequate diet" OR "adequate food" OR "good nutrition" OR "proper nutrition" AND "adults."

One of the research questions that emerged from reviewing the literature and recognising the need for the study was, “What is the available model related to NP and methods for developing it?” The other research question that arose during this stage was, “What are the assumptions used during the development of NP?” Additionally, the relation of NP models to a healthy diet was explored.

Study selection and data charting

The selection of the research papers was based on the study objectives. Citations that did not address the research questions or that were deemed irrelevant were excluded according to the inclusion and exclusion criteria. The inclusion criteria are the methods used in the development of NP models and the focused approaches to the various NP models. The exclusion criteria are the articles that were not related to NP and published outside of the range of 2012 to 2022. The articles were screened based on their titles and abstracts. Those that did not meet the outlined scope were excluded, and for those that did, full articles were extracted from the databases and revised to ensure they answered the research questions before being selected for final review. Mendeley software was used to manage all research papers, and the data extracted were documented in Microsoft Excel. Two researchers charted the data independently, which includes author(s), years of publication, country or organisation, objectives, methodology, results, and conclusions.

Collating, summarising, and reporting the results

Table 1 lists the characteristics and findings of the NP models from the selected articles. Each article was thoroughly screened for eligibility by scrutinising its title and abstract. The full text was then retrieved for further assessment of the suitability of the studies based on the research questions. The extracted data were then analysed to generate a summary of NP characteristics based on the research scope. Limitations and research gaps were also identified for future research. The process of selection is outlined in Figure 1. A total of 2,019 titles were identified from the electronic databases. Four hundred articles were removed due to duplications and other reasons, such as the fact that the studies were conducted among children, adolescents, and the elderly and were not focused on NP. Mendeley software was used to record, track, sort, and verify the duplicate articles. Out of 1,619 abstracts that were assessed for eligibility, only 17 articles met the inclusion criteria (Table 1). The term "study" in this review refers to the selected articles.

RESULTS AND DISCUSSION

Most studies on NP models were conducted in European countries (n=7), followed by Asia (n=3) and the United States (n=2). There are also studies conducted in other countries, for instance, Australia and New Zealand (n=1); Australia, France, the United Kingdom, and the United States (n=1); and the United States and France (n=1). Sample sizes are range from 147 to 41,255. Only four studies focused on food and beverage products, and the others included one type of sample meal in the research, such as breakfast cereal, Romanian traditional dishes, and packaged products (Voinea *et al.* 2020; Mhurchu *et al.* 2016; Debeljak *et al.* 2015; Vlassopoulos *et al.* 2017; Duran *et al.* 2021). Table 1 describes the summary of the NP model related to a healthy diet.

Type of NP models

This study found that there are various NP models developed, namely the Nutrient Profiling System (NPS), NOVA food classification, Pan American Health Organization (PAHO), Chilean nutritional FOP labelling policy, British Office of Communications (Ofcom), Nutrient Profiling Scoring Criterion (NPSC), UK Ofcom, Food Standards Australia New Zealand (FSANZ), Traffic Light, Nutri Score, and others. In general, the NP models are categorised into two classes: food category-specific (n=5) and across-the-board (n=12).

NP models may endorse restrictive policies pertaining to regulations on child-directed marketing and labelling in the United States to aid the nation's battle against obesity and NCDs (Frank *et al.* 2021). Thorough evaluations of the NP models are crucial for their effective use in food and public health policies, especially in regulating nutritional labelling to assist consumers in choosing healthier foods (Duran *et al.* 2021). In addition, the limited availability of healthy options in staple foods is alarming, empathising the potential of product reformulation to enhance food quality that will have a positive impact on the population diet (Mhurchu *et al.* 2016).The European Union's legislation on NP remains a persistent concern, progressing at a slow pace since 2009.

A fundamental benefit of continuous and universal NP models is the capability to compare nutrients within and outside of certain food categories such as "high in fat", "high in sugar", or "high in salt." Nevertheless, the NP model's design should be taken into consideration while interpreting the results. Since the model only takes into account a limited number of nutrients, it cannot provide a comprehensive analysis of which meals are healthier. Therefore, a more comprehensive approach would be required, especially regarding the selection of food nutrients and ingredients. The methodical approach to NP can generate a wide range of NP models, even for the same goal. Furthermore, it is necessary to

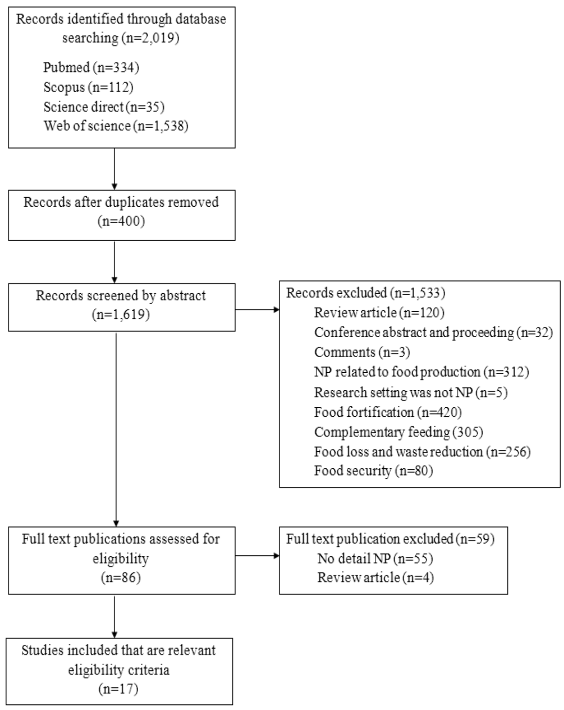

Figure 1. The PRISMA flow article selection diagram

Table 1. Summary studies on Nutrient Profiling Model related to a healthy diet

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
Journal of Nutritional Science (Sluik *et al.* 2015) Netherlands	Cross-sectional & Respondents (n=2,106)	NRF. Acrross-the-board	Fifteen NRF index scores are compared to energy density and the DHD-Index.	No significant variations in the DHD index prediction based on the 15 NRF index scores.	NRF9.3. Dairy products, cereals, and veggies contributed the most to the research population's index scores.
The Journal of Nutrition Nutritional Epidemiology (Julia *et al.* 2015) French	Intervention & Respondents (n=3,741)	NPS. Acrross-the-board	Dietary data from 24-hour records between the FSA NPS DI.	A higher risk of developing MetS was substantially linked to poorer diets identified by the FSA NPS DI.	Using NPSs in public health campaigns could encourage people to choose healthier foods could lower their chance of having MetS.
Nutrients (Frank *et al.* 2021) South Africa	Cross-sectional & Packaged foods (n=6,747)	NOVA.	Foods that were packed with nutritional information had their nutritional composition checked as part of the evaluation process.	It is best to modify an NPM and support regulations with a stringent NPM that restricts the amount of unhealthy food ingredients.	Restrictive laws child-directed marketing and labeling in South Africa may be supported by this NPM.
Public Health Nutrition (Duran *et al.* 2021) Brazil	Cross-sectional & foods and beverages (n=11,434)	PAHO and Chilean nutritional FOP labelling policy. Across-the-board	PAHO model and the NPMs used in the Chilean nutritional FOP labeling policy.	Under the PAHO two thirds of packaged products receive FOP warning labels	Level of agreement and strictness amongst the evaluated NPM. Additional high-sugar meals and beverages were found by the PAHONPM to be among the main sources of sugar and energy intake.
Public Health Nutrition (Mhurchu *et al.* 2016) Australia & New Zealand	Cross sectional & food and beverage product (n=23,596)	Ofcom and NPSC. Across-the-board	The relationships between NPSC scores and the amounts of sugar, sodium, saturated fat, and calorie density were measured.	Packaged food products are scored by NPSC. Foods in Australia scored lower than those in New Zealand.	Nutritional standards were met by 50% of packaged goods sold in Australia and New Zealand to support health claims.
Acta Alimentaria (Debeljak *et al.* 2015) Slovenia	Cross-sectional & breakfast cereal (n=221)	UK Ofcom, FSANZ and Traffic Light. Food category-specific	Three nutrient profiling technologies were used to analyze the nutritional composition of breakfast cereals.	The UK Ofcom and FSANZ methods provide outcomes that are more in line with the usage of claims, but the modified Traffic Light system exhibits the most noticeable improvement.	EU's nutrient profile legislation has been a persistently slow-moving matter, yet nonetheless a cause for concern. Likewise, the use of statements about nutrition, health, and related topics on food labels.
European Journal of Nutrition (Kissock *et al.* 2022) Australia, France, UK & US	Cross-sectional & multiple age group. Australia (n=12,153) France (n=2,624), UK (n=4,946), & US (n=5,266)	Nutri Score. Food category-specific	Data on food composition and dietary intake from Australia, France, the United Kingdom, United States, and we compared the original and updated Nutri Scores.	Correlations between whole-grain content and food nutritional score were increased.	Incorporate a whole-grain component into the Nutri Score algorithm in order to better represent.

Continue from Table 1

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
Foods (Ridoutt 2021) Australia	Cross-sectional & multiple age group (n=9,000)	NRFai. Across-the-board	Excessive and inadequate nutrient consumption among Australian adults was taken into account when developing an alternative Nutrient Rich Food Index.	The new models are applied to a variety of dairy products and substitutes, diets high in protein, and foods that are optional.	The advantage of this type of weighing is that it highlights the nutrients that are less prevalent in the overall food chain.
Information (Voinea *et al.* 2020) Romanian	Cross-sectional & Romania traditional dishes (3 menus)	Nutri Score. Food category-specific	Evaluate the traditional Romanian diet's nutritional based on the Nutri Score algorithm.	The findings showed that the traditional menus do not align with a sustainable and balanced eating pattern.	Establishment of a new paradigm for modern Romanian cuisine. Romanian consumers' awareness of changes is referred to as acceptance.
Nutrients (Pandav *et al.* 2021) India	Cross-sectional & food and beverages (n=41,255)	Nutrient profiling; front-of-package labels. Across-the-board	The WHO SEARO and the CWO Phase 3 are two nutritional profile models that were applied to food products that were sold in India.	According to the results, there would be at least one "high-in" level warning label.	This research shows that when evaluating the usefulness of warning labels, a wider range of food products should be included.
Nutrients (Drewnowski & Fulgoni III 2020) United States	Cross-sectional & multiple age group (n=23,643)	NRFh-3.4.3. Across-the-board	Based on three subscores, the new NRFh was created. NRx is the definition of the subscore, which is based on x nutrients to encourage. The MyPlate food groups provide the basis for the subscore.	Six nutrients and four dietary groups (fiber, potassium, and PUFA+MUFA; whole grains, dairy, fruit, nuts, and seeds; saturated fat, added sugar, and sodium) make up the new NRFh3:4:3 score	The NRFh3:4:3 and NRFh4:3:3 models showed strong correlations with HEI-2015 scores, a diet quality metrice.
British Journal of Nutrition (Masset *et al.* 2015) United Kingdom	Longitudinal study & adults (n=7,251)	SAIN, LIM. Across-the-board	127-item FFQ. The number of foods consumed more than once a week was defined as the FVS. Using the UK Ofcom and French SAIN, LIM nutritional profile models.	The risk of all-cause mortality was shown to be reduced, when comparing the third quartile of the FV(Ofcom) to the first quartile.	The findings support the idea that a wide variety of foods should be promoted.
Nutrients (Mainardi *et al.* 2019) United States	Cross-sectional & multiple age group (n=1,348)	Nestle Nutrition Algorithm. Across-the-board	Based on age- and gender-specific healthy guidelines for energy and nutrient intakes over a 24-hour period, the new Nestlé NNA was developed.	There were strong relationships between the HEI 2010 scores and the NNA method. NNA mean scores for two excellent meal plans (MyPlate and DASH) during a seven-day period.	The NNA was able to effectively portray both the inferior quality of diets that are really followed in the US and the superior MyPlate and DASH menu plans.

Continue from Table 1

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
European Journal Nutrition (Vlassopoulos *et al.* 2017) US and France	Cross-sectional & food and beverages (8 food groups)	NNPS.	NNPS is a category-specific system that determines the amount of nutrients to be ingested and additional nutrients to encourage cannot make up for excessive levels of nutrients to limit.	NNPS was linked to an overall downward trend for all nutrients to limit. There was a reduction in the total sugar and sodium. Less consistency in the lowering of total fat and saturated fatty acids among the groups.	Significant reductions in sodium, total sugar, and total fat were linked to the application of the NNPS.
The Journal of Nutrition Nutritional Epidemilogy (Julia *et al.* 2014) France	Randomised & multiple ages (n=4,225)	FSA British food agency. Across-the-board	Repeated 24-hour food logs were used to gather data. The FSA nutritional profile of each food was used to describe it.	Individuals who scored higher on the fruit and fish consumption also consumed fewer snack foods. Less saturated fat and more vitamins and minerals.	In the French setting, the FSA nutritional profile system shows good validity in characterising individual diets.
PLOS One (Egnell *et al.* 2020) Switzerland	Cross-sectional & adults (n=1,088)	Nutri Score. Across-the-board	To the goods within the sets according to their nutritional quality, consumers were asked to choose of three foods with varying nutritional profiles.	Every FoPL was viewed positively, with very slight variations amongst them. The greatest percentage of improvement in dietary choices was shown by the Nutri Score.	Nutri Score was the most effective FoPL.
Nutrients (Finkelstein *et al.* 2019) Singapore	Intervention & adults (n=154)	Multiple traffic light system. Nutri Score	Online grocery store using a (in-person) design.	Based on this metric, neither label is statistically superior, but both considerably improve modified AHEI.	To increase the overall quality of the diet, NS might be the better choice. If the goal is to decrease total energy-consumption, MTL might work better.

AHEI: Alternative Healthy Eating Index; CWO: Chilean Warning Octagon; DASH:Dietary Approaches to Stop Hypertension; DHD-INDEX: Dutch Healthy Diet Index; FFQ: Food Frequency Questionnaire; FOP: Front-Of-Pack; FoPL: Front-of-Pack Labeling; FSA: Food Standards Agency; FSANZ: Food Standards Agency New Zealand; FVS: Food Variety Score; LIM: Limited Nutrient Score; MetS: Metabolic Syndrome; MTL: Multiple Traffic Lights; MUFA: Monounsaturated Fatty Acid; NNA: Nestle Nutrition Algorithm; NNPS: National Nutrition Policy and Strategy; NP: Nutrient Profiling; NPM: Nutrient Profile Model; NPS: Nutrient Profiling System; NPS DI: Nutrient Profiling System Dietary Index; NPSC: Nutrient Profiling Scoring Criterion; NRF: Nutrient Rich Food; NRFai: Nutrient Rich Food Index; NRFh: Nutrient Rich Food Hybrid Score; NS: Nutrition Science; PAHO: Pan American Health Organization; PAHONPM: PAHO Nutrient Profile Model; PUFA: Polyunsaturated Fatty Acid; SAIN: Score of Nutritional Adequacy of Individual Foods; SEARO: South-East Asia Region Organization

test various models to verify if they provide the desired outcome (Scarborough *et al.* 2007).

Theoretically, the classification of food products leaves no opportunity for subjectivity as there are only two food categories, namely, foods and drinks. However, the natural variation in the nutritional composition of foods between food categories is less likely to be explain. However, there are still important issues that require further investigation, such as establishing food groups, selecting an acceptable NP for each food category or food group, and selecting food categories based on cultural differences while balancing them (Labonté *et al.* 2018; Rayner *et al.* 2013).

Nutri Score includes a whole-grain component in its algorithm, which aligns with dietary guidelines and better represents the role of whole grains in improving dietary quality (Kissock *et al.* 2022). Subjective decisions on nutrient selection are avoided by using an NP model that considers the frequencies of both excessive and insufficient nutrient intake in the target population. Such decisions run the risk of undermining confidence in NP tools within the broader food system (Ridoutt 2021).

This new paradigm of acceptance, adaptation, and transformation for contemporary Romanian cuisine emphasises the need to include a wider variety of food products when assessing the value of warning labels (Voinea *et al.* 2020). Nutrient- and food-group-based NP models have the potential to become integral components of dietary guidance (Drewnowski & Fulgoni III 2020).

Methods in developing NP models

This study found that there are six methods used for NP development, including: 1) Comparing the NRF index scores to the current index (Sluik *et al.* 2015); 2) Developing an NP model using data from a one-day dietary record and a 24-hour dietary recall (Julia *et al.* 2015); 3) Analysing the impact of price or NP changes on food categorisation, purchased food labels, and overall food quality (for example, healthier or less healthy food groups) and weighting the techniques according to their food consumption to represent the country's population (Debeljak *et al.* 2015); 4) Assessing the nutritional value of packaged foods with nutritional labels in the food supply chain of South Africa (SA) (Frank *et al.* 2021); 5) Comparing the PAHO model and the NP model used in the Chilean nutritional FOP labelling policy with a NPM proposed by the Brazilian National Health (Duran *et al.* 2021); 6) Calculating the NPSC scores and estimating the products' proportion to eligibility displays the health claims (Mhurchu *et al.* 2016).

Our review found that the majority of NP models developed concentrate on specific nutrients, which are fat, saturated fats, sugars, and salt. However, some of the models were insufficient in capturing the exact nutritional density needed to identify healthy foods (Drewnowski *et al.* 2019). There is a need to create a hybrid NP method that comprises nutrients as well as all suitable food groups and dietary additives (Drewnowski *et al.* 2019; Maillot *et al.* 2018). The hybrid NP model may provide better alignment between policy applications and quantitative assessments of nutrient density to promote healthier food choices. This combination will improve our current strategy of providing dietary advice, create a stronger nutritional policy, and eventually create better benefits for public health (Drewnowski *et al.* 2019). The hybrid nutrient density score takes into account both desirable food groups and nutrients. For example, NP models can be used to design nutrition labels in food packaging, making it easier for consumers to identify healthier food options. Hybrid models can inform the development of labelling schemes like Nutri Score, which assigns color-coded labels based on their nutritional quality.

The methods used in NP model development were mainly to address the quality of micro- and macronutrients in the assigned goods and to determine whether to classify the model in a general food category or a specific one. In the event that local recommendations were lacking, WHO/FAO standards were used as a reference to determine the basis for nutrient consumption using the 100 g, per 100 kcal, or per serving size calculation.

During the development of NP models, a crucial decision emerged: Whether these models should be compensated. This led to several questions that demanded careful consideration. Firstly, should NP scores be designed to strike a delicate equilibrium between beneficial nutrients and nutrients to limit? This deliberation sought to optimise the food product's overall nutritional value. Secondly, the process of formulating the NP algorithm necessitated an important choice: Should the scoring system be continuous, employing letters or numbers, or would a simpler binary approach with just yes or no suffice?

Each of the numerous reference quantities used to create NP models has various benefits and drawbacks. For instance, the use of per 100 g or per 100 mL is easy to standardise and consistent with food labelling, but a model built using this reference value could penalise a meal that has a high nutrient content per 100 g and is consumed infrequently or sparingly (Drewnowski & Fulgoni III 2008).

The issue of consuming too many energy-dense meals could be effectively addressed by an NP model that is based on energy units, the Nutrient-Rich Food Index, or the Nordic Keyhole system and would facilitate the comparison of foods with different energy densities, like liquids and solids. However, for meals with a very low energy content, this reference scale might not be realistic, and consumers would find it difficult to comprehend (European Food Safety Authority (EFSA) 2008).

While creating an NP model, the nutrients and food elements need to be tested in accordance with designated markers, as well as those that are not included. For example, the FSA/Ofcom model algorithm did not incorporate total fat as it was consistent with energy (Rayner *et al.* 2013). Enhancing existing NP models is crucial, which can be achieved by replacing total sugars with other alternatives (Labonté *et al.* 2018).

The validation of NP models is another challenging process in this industry. The validation and testing of the NP models are necessary to determine the appropriate categorisation of foods and their suitability for use in nutrition claims.

Application of NP models

The application of NP models is to create thresholds to meet specific dietary guidelines, algorithms to assess the overall foods' NP, or criteria based on nutrient reference values (Santos *et al.* 2021). Santos *et al.* (2021) also found that the applications of NP models create healthier food labelling, enforce restrictions on marketing products to children, and support regulation of claims. In addition, the NP model also sets stricter criteria in food classifications than carries permission in nutrition and/or health claims (Debeljak *et al.* 2015).

In conjunction with educational campaigns promoting a healthy diet, FOP nutrition labelling is one of the common policies enforced to prevent chronic diseases related to eating habits. However, the nutrition information on food labels may sometimes be confusing for certain consumers. Nor *et al.* (2023) reported that adolescents use food labels to choose better-quality and healthier foods. Therefore, it is important to strengthen the influence of this knowledge on dietary health and nutrition literacy to support educational efforts and raise consumer awareness (Moore *et al.* 2018). The involvement of food businesses is a must to further encourage the production of healthier products by reformulating food items and nutrition labelling concerning the target population (Hawkes *et al.* 2015). Therefore, policymakers ought to acknowledge NP models as a useful instrument for directing food reformulation and monitor their impact on improving people's diet choices (Labonté *et al.* 2018).

NP model related to a healthy diet

In reviewing a healthy diet, vegetables, cereals, and dairy products contribute significantly to the population's index score. The utilisation of nutrient density models offered further insights into dietary quality compared to energy density (Sluik *et al.* 2015). By implementing Nutrient Profiling Systems (NPS) in public health, it could encourage consumers to make healthier food selections, which will potentially decrease the likelihood of developing Metabolic Syndrome (MetS) (Julia *et al.* 2015). MetS is a health disorder that often occurs together with hypertension, hyperglycemia, excess abdominal fat, and abnormal cholesterol levels and leads to serious health problems such as diabetes, heart disease, and stroke. Therefore, making healthier food choices with the help of NPSs could potentially reduce the risk of developing MetS.

The methodology of the proposed system need to be validated on the impact of nutritional intake by the consumers in helping them achieving healthier diets (Vlassopoulos *et al.* 2017). The NP system developed by the FSA proves strong validity in characterising individual diets in France. Therefore, public health nutrition programmes like FOP nutritional information could serve as a foundation (Julia *et al.* 2014).

A NP model should be developed and applied sustainably using a holistic approach. In the framework for NP model development, it should be taken into account whether there is any reliable data demonstrating the link between nutrition and health. A hybrid NP technique that takes into account all nutrients and desirable food groups and components has the potential to capture more healthy foods compared to the current NP models. Therefore, in-depth research is suggested to discover the suitability of these models and how they will align with the national context (Drewnoski *et al.* 2019).

In 2020, Drewnowski & Fulgoni III indicated that NP models based on food groups and nutrients should be included in dietary guidelines as they help promote varieties of healthy foods (Masset *et al.* 2015). For instance, the NNA was able to capture that the diets consumed in the United States are of poorer quality than the MyPlate and Dietary Approaches to Stop Hypertension (DASH) menu plans (Mainardi *et al.* 2019).

Overall, the types of models and methods used in developing NP models depend on the data from the nutrient composition database, for instance, the brand of food available, the availability of nutrients, and so on. There were no standard nutrients to be selected in the NP models. However, the common ones are energy, sodium, total or added sugar, and saturated fat. Vitamin A, B-6, B-12, D, iron, calcium, and zinc are nutrients commonly included in the NP models.

The studies included in this review use various research methodologies in developing NPs and their application towards advocating a healthy diet. There are also several limitations found in this present study. The studies included multiple development methods with different interpretations. This may lead to confusion for both consumers and policymakers. Thus, the NP models urgently need to be optimised and standarised (WHO 2011). Many food groups would need to be created in order to include all foods and food items due to the absence of regional (European) agreement on the definition of food categories. As a result, the NP model's main flaw is its inability to accurately adjust, handle, and classify a large range of food groups (Drewnowski & Fulgoni III 2008).

A wider NP system would aim to provide a more comprehensive view of a food's nutritional value. This could be useful as different nutrients play various roles in health, and a diet that's diverse in beneficial nutrients is generally associated with better overall well-being. It's important to note that there isn't a single "widest" universally accepted as the best. Different systems might be tailored to specific dietary goals or health concerns. Some well-known include the Health Star Rating, the Nutri Score, the Nutrient Rich Food Index, and the NOVA classification system. Each of these considers various nutrients and factors to provide a simplified label or score that consumers can use to compare and choose healthier food options. The NP system depends on its accuracy in reflecting a food's nutritional quality and its ability to guide consumers toward healthier choices. Different countries and organisations might adopt different systems based on their dietary guidelines and population health priorities.

CONCLUSION

Most NP models were initiated with the intention of preventing obesity in high-income nations by penalising items that are rich in calories. Several of these NP models were unable to monitor the nutrient content of foods that have been fortified and, therefore, were unable to support the efforts to increase the nutrient content of the food supply in low- and middle-income countries. The persistent vitamin and mineral deficits need to be addressed in new NP models designed only for low- and middle-income countries. Assuming data on nutritional composition is available in low- and middle-income countries, these models can be developed according to pre-existing principles and guidelines.

NP models have the potential to support restrictive laws like those governing FOP labelling and child-directed marketing; hence, they might be included in dietary recommendations based on nutrients and food groupings. These regulations will support the effort to combat obesity and NCDs. The development of NP and the assessment of nutrient density models are based on a number of methods. These choices of methods may vary depending on the model's goal, but they must always be developed with transparent and unbiased methods that meet scientific standards. In conclusion, the use of NP models in public health campaigns may encourage people to choose better foods, lowering their chance of developing non-communicable diseases

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DECLARATION OF INTERESTS

The authors state no conflict of interest in the implementation of this research from start to finish.

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