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HD4HL
Healthier Diets 4 Healthy Lives

Identifying potentially relevant nutrient profiling models (NPMs) for consideration by the HD4HL Nutrient Profiling sub-committee

CAPHA
Coalition of Actors for Public Health Advocacy

List of Abbreviations

BFPDB	Branded Food Products Database
DHSS/USDA	United States Department of Health and Human Services/Department of Agriculture
FCS	Food Compass Score
FOPL systems	Front of Pack Labeling system
FSA-OFCOM model	Food Standards Agency-OFCOM nutrient profiling model
FSANZ-NPSC	Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion
FVNL	Fruits, Vegetables, Nuts, Legumes
HD4HL Project'	Healthier Diets for Healthy Lives Project
HEI	Healthy Eating Food Index
HSR	Health Star Rating System
LMICs	Low and Middle Income Countries
M3T	Multi-Stakeholder Technical Task Team
NCDs	Non-Communicable Diseases
NHSC	National Healthy School Canteens Project
NPMs	Nutrient Profiling Models
NRFI	Nutrient-Rich Food Index
ONQI	Overall Nutritional Quality Index
SENS	Simplified Nutritional Labelling System
WHO	World Health Organization

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Declarations & Acknowledgments

This Report was commissioned by the HD4HL Project. The HD4HL Project seeks to motivate a comprehensive policy response to the double-burden of malnutrition in Ghana - by building evidence and mobilizing multi-stakeholder action toward a policy bundle for healthier and more equitable consumer food environments and systems. A coalition of government agencies (led by the Ministry of Health, Food and Drugs Authority, National Development Planning Commission), members of Academia (led by the University of Ghana School of Public Health) and Civil Society (led by the Coalition of Actors for Public Health Advocacy) are collaborating through four work packages that will establish the evidence, tools, policy pathways and evaluation to enable the political commitments and food systems change to be realized.

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1.0 Background

Ensuring food and nutrition security, which means" all people at all times have physical, economic, and social access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1983; FAO, IFAD, WFP, UNICEF, WHO, 2020) has been a challenge to many nations. In response to the rising burden of diet-related health challenges, public health agencies with the mandate to protect and promote health recommend limiting dietary calories and replacing foods containing excess amounts of saturated fats, free and added sugars, and salt with more healthful options (UK Government Office for Science, 2007; US DHSS/USDA, 2015). In this regard, nutrient profiling – "the science of categorizing foods according to their nutritional composition and ranking healthful nutrient-rich foods above foods of lower nutritional value" has become an important public policy tool (Drewnowski, 2005, 2017; Labonte et al 2018).

Over the last three decades, governments (eg public health and regulatory authorities), private sector actors (e.g. food industry), and other stakeholders have developed hundreds of nutrient profiling models (NPMs) that are used to inform a variety of policy, regulatory, and educational interventions including product reformulation, labeling and claims regulations, restrictions on marketing to children, restrictions on point of sale promotions and food procurement (European Heart Network, 2015; Scarborough et al 2016; Labonte et al 2018). The WHO advises that NPMs should aim to address identified public health problems (WHO, 2010). NPMs and their associated applications should be able to help consumers identify nutritious foods, make decisions on food purchasing and improve diet quality by encouraging a healthy diet (WHO, 2019, Monteiro 2019).

Resourcing, and facilitating public health and regulatory agencies to scientifically define healthier food options is one of the topmost priorities of Ghana's Ministry of Health. To this end, a coalition of government agencies (Ministry of Health, Food and Drugs Authority, National Development Planning Commission), Academia (University of Ghana) and Civil Society (Coalition of Actors for Public Health Advocacy) are collaborating and leveraging their resources to support Ghana's effort to develop an NPM, which will in turn facilitate the development and implementation of a number of food-based policies. This is part of the 'Healthier Diets for

Healthy Lives (HD4HL) Project', which among others, aims to inform and empower; guide and influence; incentivize or discourage consumer action within their food environments. These are achieved through bold and truthful information for all consumers; healthier food availability in public institutions and markets, and adjustment of the relative price of foods to equitably promote health and economic value.

Although numerous NPMs exist, one should exercise caution when adopting an NPM developed to address dietary or health problems in populations other than the setting it was developed for. In Ghana, although the prevalence of overweight, obesity and diet-related NCDs is on the rise (Ofori-Asenso et al 2016; de Graft Aikins et al 2012), hunger (protein-calorie deficiencies), micronutrient deficiencies, acute and chronic undernutrition (particularly in children and women in reproductive age) remain prevalent and represent a continuing danger to population health (GSS et al 2015). Preventing the persistent undernutrition which now coexists with the rising prevalence of overweight, obesity and other diet-related NCDs, is a priority for Ghana. Ghana's food-based policies and interventions should respond to this need. Therefore, an NPM intended for use in Ghana and other LMICs ought to address inadequate intakes of vitamins (such as vitamin A, B vitamins, folate), minerals (calcium, iron, iodine, and zinc) and the frequent lack of high-quality protein (Drewnowski et al 2021; Abdul-haq, 2022). Given this background, NPMs that focus on nutrients to encourage (high-quality protein, vitamins, minerals, and trace elements) as well as nutrients or food to limit (saturated fatty acids, trans fatty acids, sodium, sugar) may be better suited to the Ghanaian context.

Detailed elsewhere (see HD4HL Project Framework and Guiding Principles), the aims, scope and principles of the Ghana NPM recognize this need. For example, *Guiding Principle 1 states: "The development and implementation of the NPM should be responsive to contextual realities and needs…."; Guiding Principle 6 states: "The NPM should respond to the multiple forms of malnutrition (including diet-related NCDs, micronutrient deficiencies etc.)"*. To this end, such nutrients and food components that need to be encouraged will included protein, vitamins A, C, E and iron, calcium, potassium, magnesium, zinc, folate, fibre/FVNL); nutrients/food-based ingredients/additives to limit will include sugar, saturated fatty acids, sodium, artificial sweeteners.

1.1 Objectives of this report.

This report summarizes the approaches deployed to identify potentially relevant NPMs for consideration by Nutrient Profiling Development sub-committee of the HD4HL Project Multi-Stakeholder Technical Task Team (M3T). The M3T deliberated on the merits and demerits of developing anew or adapting or adopting an existing NPM – given that several NPMs exist. The stakeholders agree that it will be expedient and appropriate to adapt an existing NPM (to suit Ghana's needs), which takes less time and costs less than developing a new system from scratch. A team was established to identify and review existing nutrient profiling models noting their motivations, strengths and limitations, as well as relevance and potential for applicability to the Ghanaian context. The report suggests, with justifications, the top three NPMs that should be consideration for adaptation by the M3T.

2.0 Methods

The review process benefited from three existing systematic reviews (Labonte et al 2018; Santos et al 2021; Abdul-haq, 2022). All nutrient profiling models included in the reports of the indicated reviews were eligible to be screened. Additional searches identified two recent models not included in the reviews. Two team members assessed the eligibility of all the NPMs identified according to the HD4HL Project's inclusion and exclusion criteria (outlined below). Initial screening focused on identifying double-duty NPMs - models that meet the second inclusion criterion (details given below). Those models were retained for further screening.

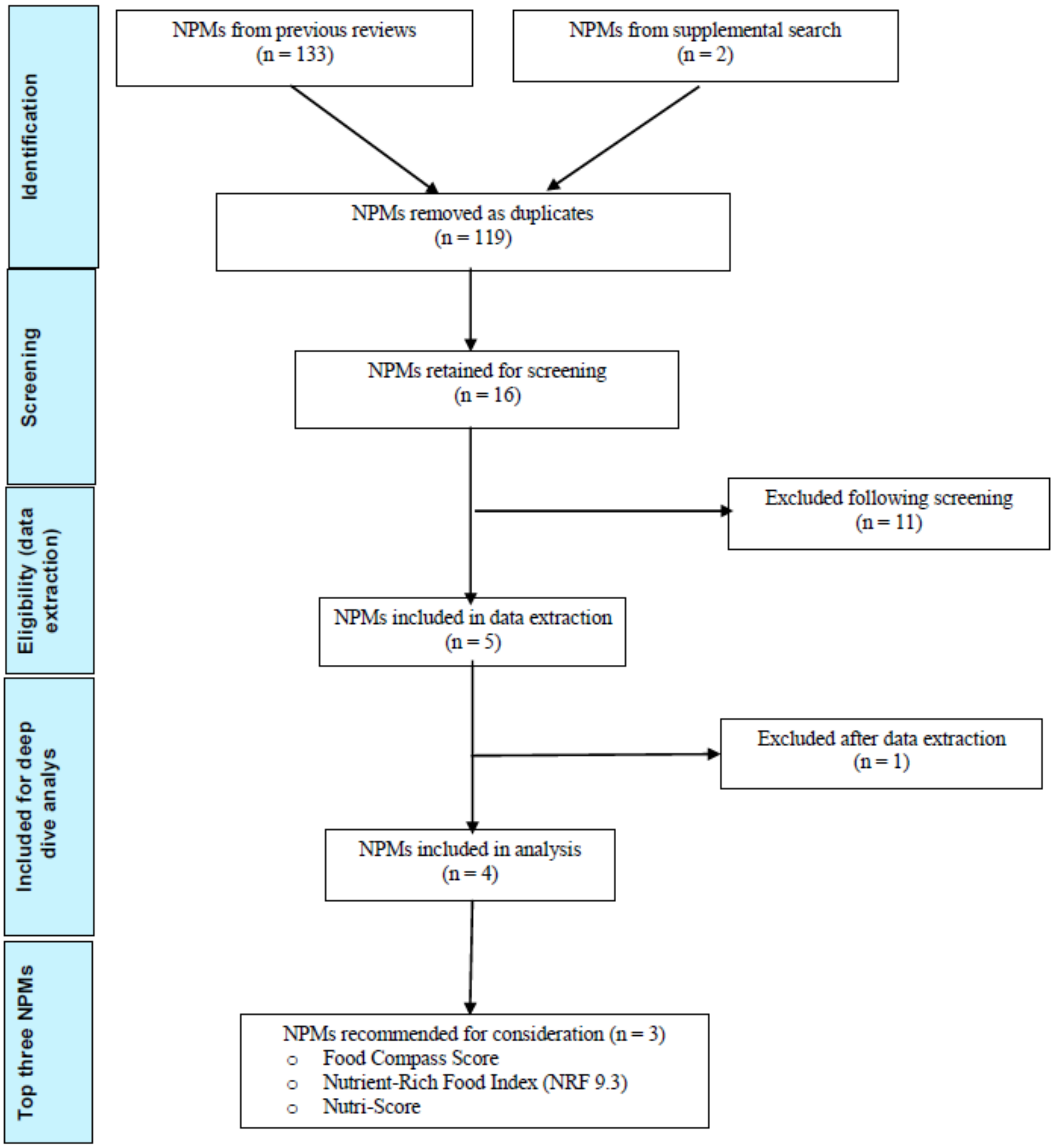
2.1 Eligibility assessment of NPMs according to the HD4HL Project criteria

1. All NPMs included in the previous systematic reviews and those identified through the supplementary searches were eligible for screening.
2. Only models that include both nutrients to limit and nutrients to encourage are to be considered for further screening
3. In selecting the three candidate models, only one of a family of models, or models from the same genealogy should be included
4. In selecting the three candidate models, consideration should be given to whether or not details of the algorithm for the NPM are publicly available (or can be accessed by the HD4HL Project Team)

5. In selecting the three candidate models, consideration is given to the output – whether a numerical score or pre-determined thresholds. Only models that generate scores (i.e., continuous variables, either with or without accompanying classifications based on pre-determined thresholds) should be considered. This is deemed important as it lends itself to application malleability. Having a predetermined threshold from the onset makes it challenging to apply the NPM for purposes not directly related to the original cut-off points. Of note, scores can easily be converted to thresholds, but not the other way round.

Additional considerations in selecting the top three potentially relevant NPMs, derive from the WHO Checklist for identifying and adapting existing NPMs (WHO, 2019) - including ability of the NPM to facilitate healthy food choices quickly and easily in the Ghanaian setting; whether or not the underpinning nutrient profiling criteria reflect dietary guidelines and eating habits of the Ghanaian population, and if available, evidence on the effectiveness of the NPMs.

Figure 1. PRISMA diagram outlining nutrient profiling model selection process



A total of 133 NPMs from three systematic reviews identified as comprehensive and relevant NPM reviews conducted in the past five years were shortlisted for screening- 78 from Labonte et al (2018), 20 from Santos et al (2021) and 35 from Abdul-haq (2022). Two other models were identified from the supplementary searches. From a total of 135 (133 + 2), **8** out of the 78 models analyzed by Labonte et al (2018); 11 of the 20 analyzed by Santos et al (2021); 14 of the 35 analyzed by Abdul-haq (2022) and the 2 from the supplemental searches, met our double-duty criterion (inclusion criterion #2). Sixteen of these were retained after removing duplicates (see table 1).

Table 1 Potentially relevant double-duty NPMs

Name of NPM	Applied/recognized in (jurisdiction)	
Food Standards Agency-OFCOM nutrient profiling model (FSA-OFCOM model)	United Kingdom	
Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (FSANZ-NPSC)	Australia and New Zealand	
Nutri-Score	France+	
Ireland model	Ireland	
Health Star Rating (HSR) System	Australia	
FSANZ-South Africa	South Africa	
Nutrient Value Score	United Nations World Food Program	
SAIN-LIM model	France	
Nutrient-Rich Food Index (NRF 9.3) & family	Not adopted by any jurisdiction	
Overall Nutritional Quality Index (ONQI)	USA; discontinued	
Simplified Nutritional Labelling System (SENS)	Not adopted by any jurisdiction	
Choices Programme (Healthy Choice logo)	The Netherlands+; discontinued	
The Nordic keyhole scheme (Keyhole logo)	Sweden+	
National Healthy School Canteens (NHSC) Project	Australia	
Food Compass - not adopted by any jurisdiction	Not adopted by any jurisdiction	
CHOICES 5-Level criteria system	Not yet adopted by any jurisdiction	

Of the 16 models, 11 were excluded for varying reasons (see table 2). Five of these models had been excluded from a similar analysis done by Leblanc et al (2021). The justification for exclusions as articulated by Leblanc et al apply to the current exercise (see our exclusion criterion 3). The FSANZ-South Africa, Health Star Rating (HSR) System, FSANZ-NPSC, FSA-OFCOM model, the Ireland model, and Nutri-Score are all based on a similar algorithm. As with Leblanc et al, we kept the most up-to-date or improved versions of this family of NPMs. Thus, the Health Star Rating (HSR) System (Australia) and The Nutri-Score (France) were retained. Of note, the same yardstick was applied to the family of Nutrient-Rich Food Index models (only NRF9.3 was retained).

Five others were excluded as those failed to meet our inclusion criterion 5. The SAIN-LIM and SENS models, the CHOICES Healthy Choice Programme, the NHSC, and the Nordic keyhole were discarded for not providing a numerical score. Only models that generate scores with or without accompanying pre-determined thresholds were eligible to be included. Most of these models also include just fiber, or fiber and wholegrain as nutrients or food components to encourage.

One other model was excluded for reasons related to data/algorithm opacity or potential conflict of interest. The Overall Nutritional Quality Index (ONQI) was excluded due to concerns previously raised about the model - the model's algorithm, including the relative weights of the nutrients, was never disclosed to the public (Xion, 2017).

Table 2 NPMs excluded from full data charting

Name of NPM	Reasons for exclusion	Other comments
FSANZ-South Africa	Shared genealogy/algorithm	-
Health Star Rating (HSR) System	Shared genealogy/algorithm	most up-to-date or improved
FSANZ-NPSC	Shared genealogy/algorithm	-
FSA-OFCOM model	Shared genealogy/algorithm	-
Ireland model	Shared genealogy/algorithm	-
Nutri-Score	Shared genealogy/algorithm	most up-to-date or improved
Choices Programme (Healthy Choice logo)- threshold, discontinued,	Threshold	Discontinued
The Nordic keyhole scheme (Keyhole logo) - (fiber and wholegrains are nutrients to encourage) threshold	Threshold	Fiber & wholegrain only nutrients to encourage
National Healthy School Canteens (NHSC) project – only fiber is the nutrient to encourage (threshold)	Threshold	Fiber as only nutrient to encourage

Table 2 NPMs excluded from full data charting

SAIN-LIM Model	Threshold	
Simplified Nutritional Labelling System (SENS)	Threshold	Variant of SAINS-LIM model
Overall Nutritional Quality Index (ONQI)	Discontinued due to data opacity or potential conflict of interest	Double-duty NPM with continued scoring, but excluded for reasons indicated

The NPMs that met our eligibility criteria for full data extraction were five - the Health Star Rating (HSR) System (Australia), Nutri-Score (France), the Nutrient-Rich Food Index (NRF9.3), the Food Compass Score, and the Choices 5-Level Criteria. The Choices 5-Level Criteria was eventually excluded after data extraction (the NPM's uses pre-determined thresholds aimed at identifying best-in-class food products; fiber is the only nutrient to encourage included in the model).

3.0 Preliminary findings and recommendations

A total of five NPMs that met the double duty criteria listed above were catalogued in a data extraction sheet and comparatively analyzed. The five NPMs were Food Compass, Choices International, Nutrient Rich Food Index 9.3, Nutri-Score, and Health Star Rating. After careful consideration and discussion across team members, 28 attributes and variables were selected for the analysis (not included in this report). The goal of this exercise was to include as much information as possible about the NPMs, including links to their publication and publicly available algorithm to help the team members best understand the broader differences and similarities among the models. The full assessment of the NPMs using the comparative analysis data extraction and 28 variables permitted the eventual exclusion of three models and identification of the top three NPMs to be recommended for further analysis and potential adoption in the Ghana context.

Main Characteristics of NPMs (n=5) included in data extraction

Applications:

The goal of the HD4HL project is to develop a food-based policy bundle in Ghana. The policies under consideration include fiscal policies, public food procurement policies, food marketing regulations, and front-of-pack labeling policies. Toward implementing these policies, the project will mobilize multi-stakeholder action for healthier and more equitable consumer food environments. The NPM of choice will play a significant role in the development and implementation of these policies. Therefore, the indicated or possible applications of the NPMs (under review) was a vital component to consider.

Such applications include guidance for FOPL systems, product reformulation, food quality standards for schools, and general research purposes. For instance, Nutri-Score, currently being applied in France is largely a FOPL system however the algorithm is used for food certification and reformulation.

In the following paragraphs, we present other attributes included in our evaluation: adoption or uptake by countries/jurisdictions; lists of nutrients to encourage / limit; reference amount; data requirements; and validation (also see table 3).

Table 3: Summary information on the short-listed nutrient profiling models

Potential programmatic application	Food Compass Score	Nutrient-Rich Food Index (NRF 9.3)	Nutri-Score	Health Star Rating (HSR)
Certification scheme for labelling	x	x	x	x
Consumer education	x	x	x	x
FOPL	x	x	x	x
Support Healthier food choice	x	x	x	x
Marketing restriction	x	x	x	x
Reformulation	x	x	x	x
School feeding/procurement	x	x	x	x
Tax policy (SSB)	x	x	x	x
Date sources	Based on the NHANES 2015–16 US population data and other multiple USDA nutrient databases	Based on Food and Nutrient Database for Dietary Studies (FNDDS) 2013–2014 data	Based on British Food Standards Agency nutrient profiling system (modified version) (FSAm-NPS)	Adapted from Nutrient Profiling Scoring Criteria (NPSC) which is also derived from the validated United Kingdom Ofcom model
Food category	Nutrient ratios (saturated to unsaturated fat, fiber to carbohydrate ratio, potassium to sodium ratio) Vitamins and Minerals, Food-based ingredients, Additives, Processing, lipids, Fibre and protein, phytochemicals	Fruits, vegetables, grains, dairy, protein foods, fats, refined grains, sodium, empty calories	Fruits, vegetables, grains, dairy, protein foods, fats, refined grains, sugary and salty snacks, cheese, beverages, added fats	non-dairy beverages (Category 1); oils and spreads (Category 3); other non-dairy foods (Category 2); dairy beverages (Category 1D); cheeses (Category 3D); and other dairy foods (Category 2D)
Mode of validation	Predictive validity, content validity and face validity confirmed with 8,032 foods and beverages reported in NHANES/FNDDS 2015–16 data; Convergent and discriminant validity confirmed with the NOVA classification, the Health Star Rating and the Nutri-Score. Also, new research to be published about the use of FCS to score 50,000 food items.	Validated with data from NHANES 1999–2002. Corelated with HEI-2005 of the US population. Was also applied to Ghanian food and is currently being used for academic research purposes around the world.	Predictive validity, convergent validity with other NP models; and agreement with reference standards. Also adopted by several European countries (Belgium, France, Germany, Luxembourg, the Netherlands, Spain, and Switzerland)	Implemented in Australia/New Zealand since 2014, content and construct validity showed its similarities with other nutrient profiling algorithms.

Nutrient/components to encourage	Vitamin A, Vitamin C, iron, calcium, protein, dietary fiber	Protein, fiber, vitamins A, C, E and calcium, iron, potassium, magnesium	Protein, fibers, FVNL	Protein, fibers, FVNL
Nutrient to limit	Fat (total, saturated, trans), cholesterol, sodium, ultra-processed foods	Saturated fats, (total or added) sugars, sodium	Energy, saturated fat, sugars, sodium	Energy, sat fat, sugars, sodium
Reference amount	100 kcal	kcal/100g (energy density) or 100 g, 100 kcal (418 kJ)	100 g (or per 100 mL for beverages)	100 g /100ML
Exempted/ not eligible products	NA	NA	Unprocessed products (e.g: fresh fruits or vegetables, etc.), water -added carbon dioxide and/or flavoured, Herbs, spices, salt, table top sweeteners, coffee and their products, herbal and fruit infusions, vinegar, food additives, processing aids, yeasts. chewing gums, food in packaging or containers less than 25 cm2, food supplements	Products inherently low nutritional contribution (e.g., herbs, spices, vinegar, salt, pepper, tea), small packages (less than 100mm²), 'fresh value-added products', such as packaged fruit, vegetables, meat, alcoholic beverages (>1.15% alcohol by volume), products ineligible to display nutrition content, special purpose foods (e.g. (infant formula products, foods for infants, formulated supplementary foods for young children)
Type of outcome	Scoring: (1 to 100) 1 (least healthy) - 100 (most healthy)	Scoring: Final score theoretically ranges between 0 and 600 (for NRF 6.3). A higher score representing a better overall nutritional quality	Scoring: Final Score = Energy + Sat fat + Sugars + Na - Protein - Fibre - FVNL ranges from -15 (least healthy) to 40 (most healthy)	Scoring: Final Score = Energy + Sat fat + Sugars + Na - Protein - Fibre - FVNL* ranges from -40 (least healthy) to 96 (most healthy)

FVNL: Fruit, Vegetables, Nuts and Legumes || RACC= Reference Amounts Customarily Consumed || HEI= Healthy Eating Index || NA= not reported

Adoption/application/uptake by countries/jurisdictions

Only two of the five NPMs are currently applied in countries/jurisdictions. The Nutri-Score (in France, Belgium, Spain, German, Switzerland, the Netherlands and Luxembourg) and the Health Star Rating System (in Australia, New Zealand). However, both of these are applied on a voluntary basis.

List of nutrients to encourage / discourage:

Only models that included both nutrients to limit and nutrients to encourage were considered. For the comparative analysis, each NPM has a list of nutrients to encourage and nutrients to limit (see table 3). Dietary fiber and protein, along with vitamins, minerals and FVNL (fruits, vegetables, nuts, legumes) were common across the board as nutrients to encourage. Saturated fat, sugar, sodium, and energy were common nutrients to limit. The Food Compass separates unsaturated, trans and total fats as nutrients to discourage. Food Compass also uniquely includes nutrient ratios in the total score, such as the ratio of unsaturated and saturated fat, carbohydrate to fibre ratio, and potassium to sodium ratio.

Calculation method:

Each NPM included in the data extraction had a different approach to calculating the final score of various foods. The Food Compass includes 54 attributes in which across 9 domains they are assessed per 100 kcal of food product. The scoring ranges from 0 to 10 for harmful attributes and -10 to 10 for attribute ratios that could range from harmful to beneficial. The final score is on a scale of 0 to 100, 1 ranking least healthful and 100 raking most healthful.

The Nutrient Rich Food Index (NRF) is based on 2 subscores in which one subscore is based on nutrients to encourage and one is based on three nutrients to limit (usually saturated fat, total or added sugar, and sodium). There are however, various iterations of the number of nutrients to encourage range from 6 to 15. The illustration below from Abdul-haq's NRF11.3:

The final NRF index algorithm was calculated as the arithmetic difference between the positive (NR_{11}) and the negative (LIM) components.

- NRF11.3 =NR_{11}- LIM_3

- NRF11.3 = [(%dv protein + %dv fiber + %dv calcium+ %dv iron +%dv potassium + %dv magnesium + %dv zinc+ %dv folate + %dv vitamins A + %dv vitamin C+ %dv vitamin E) -(%dv total sugar+%dv total fat+%dv sodium)]/100grams*.

*The step that converts per 100g to per 100kcal is not shown here.

Like, the NFR, the Nutri-Score uses continuous calculation and assigns either "bad (N)" points based on the content of energy, saturated fat, total sugar, and sodium or "good(C)" points based on protein, fiber and the foods percent by weight of vegetables, fruit, nuts and legumes. Nutri-Score has separate calculations for a food's protein content assigning "protein points", however only if the food contains 80% fruit, vegetables, nuts, or legumes. Otherwise, "protein points" are not considered.

- Nutri-Score = (Energy + Sat fat + Sugars + Na) – (Protein +Fiber + FVNL*)

  *FVNL = % of fruits, vegetables, nuts and legumes. Scores range from -15 to 40

Health Star Rating score is based on the amount of energy, saturated fat, total sugars, sodium, protein, fiber and percentage of fruits, vegetables, nuts and legumes in a given food product. Points gained for components to encourage are subtracted from points gained for components to limit.

- HSR Score = (Energy + Sat fat + Sugars + Na) – (Protein +Fiber + FVNL*)

  *FVNL = % of fruits, vegetables, nuts and legumes. Scores range from -40 to 96

Reference amount:

The nutrient density of foods is calculated per reference amount, which can be 100 grams, 100 kcals, or serving size. The base or combination of bases (i.e., 100 g, serving size and 100 kcal or 418.4 KJ) to choose has both scientific and pragmatic/regulatory motivations. Most often, the choice is driven by local regulatory demands. No government approved serving sizes calculation bases exist in Ghana (or most other countries) currently. Because of the lack of standardized serving sizes NPMs that make use of a serving size approach are more inclined to be manipulated by the food industry, and are thus not recommended as a reference measurement for NPMs used in government regulations. The NRF11.3 recently pilot-tested in Ghana was calculated per 100 kcals). It has been previously reported that models based on 100 g standard have difficulty handling different serving sizes by food group. Calculations based on 100 grams ignore the often-substantial differences in portion size and may penalise foods that are consumed in small amounts. However, the per 100g approach aligns with Codex Alimentarius guidelines on labelling requiremnets and using this approach could potentially make monitoring and evaluation efforts of polices more effective if products are expected to have nutritional information in the per 100g format on packaging. On the other hand, calculations based on 100 kcals have the effect of assigning highest scores to foods with the highest water content and lowest energy density (Drewnowski and Fulgoni, 2008; Drewnowski et al,2009). For example, fats, sugar, and sodium calculated per 100 grams of food or beverages and consumed in small amounts tend to be penalised (i.e., nuts, dried fruits), while giving favourable scores to sugary beverages of low energy density unless volume corrections are made. Of note, in some models a combination of these basis are use (Maillot, Sondey, Braesco, & Darmon, 2018). From the short-listed, the two NPMs that follow this reference amount (100 kcals) are the Food Compass and NRF. Choices International calculates the final score using per 100 grams, as well as Nutri- Score and Health Star Rating System

Data requirements:

A top consideration for the HD4HL project surrounds the limitation of data available for the calculation of final NPM scores. The amount and types of data used in each NPM required extensive thought and consideration as to whether the HD4HL project would be able to recreate the score of an NPM algorithm with foods relevant to the Ghana context. The Food Compass used 8,032 foods and beverages relevant to the US context based on NHANES data and other USDA nutrient databases to obtain the final score (0-100). Additionally, the FCS makes use of nutrient ratios and 54 attributes in the calculation method (Mozaffaria et. al, 2021l). Choices International Nutrient Profiling System used data from the George Institute database of over 64,600 food products from 8 countries (Tognon et al, 2021). The NRF used data from Food and Nutrient database for dietary studies, Nutri-score included data based on the NPS of the British Food Standards Agency score. Despite the availability of a variety of international databases, the question remains whether obtaining reliable data for foods within the Ghana context suitable for the algorithms of these NPMs needs to be answered. For instances, do local food composition databases contain sufficient information to facilitate computation of nutrient ratios, or to make feasible the adaptation of NPMs algorithms that make use of % FVNL?

Validation:

Different forms of validity were used across NPMs that were highlighted in the comparative analysis. According to Fulgoni et al (2009), all NPMs must be validated against an accepted independent measure of diet quality and need to follow science-driven rules. The nutrients in the algorithms should also be evaluated across multiple criteria. The Nutrient Rich Food Index has been validated multiple times using regression analysis with the Healthy Eating Food Index (HEI) as the dependent variable and the weighted energy average food quality score provided by each NRFn.3 algorithms as the independent variable. Significant results showed that diet scores based off NRF indices were related to HEI. The Food Compass emphasized face, content and discriminant validity. Face validity was assessed using the FCS for 8,032 foods and beverages report in NHANES/FNDDS 2015-2016. Choices international confirmed convergent validity based on the good based dietary guideline of UK, Europe, Africa and Asia that were tested with the model. Nutri-Score was associated with a higher nutritional quality of purchases in experimental and large-scale trials, confirming criterion validity, among others. Along with Health Star Rating System, Nutri-Score is also currently implemented in its country of origin, confirming feasibility.

<u>Attributes of the top three models recommended for consideration</u>

This section covers the evidence behind each model, the strengths and weaknesses of each, the relevance and applicability of each model in the Ghanaian context, the existing approaches / methodologies, and innovations in nutrient profiling model development.

Nutri-Score (France)

Nutri-Score is also a FOPL system that assigns letters and colors in front of food packaging ranging from A(most healthy) to E(least healthy). The algorithm's nutrients to limit include energy, total sugars, saturated fats, and sodium. The nutrients to encourage include fiber, protein, percentage of fruits, vegetables, nuts and legumes. Similar to the limitations noted in HSR, Nutri-Score is largely applied as a food certification scheme for food labeling (front of package, store shelves or in advertising related to food products). However, it is also applied and used for product reformulation. Also similar to the strengths of the HSR, Nutri-Score is currently in use in France and other European countries indicating its algorithm's feasibility.

Nutrient-Rich Food Index version 6.3 (NRF 6.3) (University of Washington, USA)

The NRFI is a family of nutrient profiling models that includes 3 nutrients to limit and 6(9) to encourage. The models derive from the Naturally Nutrient Rich Score and were first developed in 2009, yet have continually been updated to relevant nutritional advancements. The score can be applied to individual foods and to total diets. The NRFI incorporates both positive and negative elements and the algorithm can be applied to all different food groups, and beverages using the same algorithm (Drewnowski 2021). It also calculates nutrient density scores per 100kcal which is consistent with the most up to date nutritional knowledge. Highlighted strengths of the NRFI are that it is well documented and tested across the board. Its limitations are that it is largely intended for use within the US. Additionally, the Nutrient-Rich Food Index was developed by an academic organization, the University of Washington, Seattle, mainly for research purposes.

Food Compass

The Food Compass scores food items using 54 attributes, across nine domains. Uniquely, it incorporates a broader range of food characteristics, attributes and domains than previous systems. This attribute was seen as both a strength and limitation in the relevance to the HD4HL project as although it is one of the most up to date systems that includes the most nutritional information compared to other models, the amount of nutritional information required to create the algorithm is largely unobtainable in the data-limited reality of Ghana. Such information it includes relates to nutrient ratios, additives, processing, specific lipids, fiber and protein and phytochemicals. It has broad-reaching applications, following the goals of the HD4HL project. Some limitations considered in the context of the HD4HL project aside from the amount of data used to create the algorithm, are that the FCS was created in the US, largely for use within US industry and government policy, and has not been tested in other countries or implemented in the US.

4.0 Discussion

This report aimed to describe the approaches used in identifying and prioritizing potentially relevant NPMs for consideration by the Ghana HD4HL Project. Among other goals, the HD4HL

Project aims to develop a fit-for-local-purpose NPM that can be used to facilitate the implementation of multiple food-based policies. Referred to as a "double-duty food policy bundle", such policies will respond to the current double-burden of malnutrition in Ghana. The policies include food-related fiscal policies (taxes and subsidies), public food procurement policies, restricting the marketing of unhealthy foods to children, and front-of-pack labeling policies. Other opportunities for use of the NPM will be in the food supply chain and other sectors of the food system (involving food manufacturers and processors, food wholesalers and retailers, caterers, schools, government food and nutrition policy professionals, social support and welfare officers, researchers, and civil society). To this end, and in line with the overarching principles for the development and implementation of the NPM (see Appendix 1), the process prioritized NPMs that are deemed to be double-duty in nature – models that include both nutrients/food components to limit and nutrients/food components to encourage.

Invoking the double-duty principle resulted in the short-listing of 16 models – from the pool of NPMs previously documented (Labonte et al, 2018; Santos et al 2021; Abdul-haq, 2022). From these, 11 models were excluded for varying reasons (see table 2). Five of these 11 models had been excluded from a similar analysis done by Leblanc et al (2021). The exclusion justifications articulated by Leblanc et al (2021) apply to the current exercise (see our exclusion criterion 3). A similar yardstick was applied to the family of Nutrient-Rich Food Index models. Five others were excluded as those failed to meet our inclusion criterion 5. Only models that generate scores with or without accompanying pre-determined thresholds were eligible to be included (Table 1). Most of these double-duty models (with pre-determined thresholds) also included just fiber, or fiber and wholegrain as nutrients/food components to encourage. The Overall Nutritional Quality Index (ONQI), however, was excluded due to concerns previously raised about the model. Developed in 2008, and once used in the USA, the model's algorithm considers thirty nutrient factors, including the relative portions of vitamins, sugar, saturated fat, and trans fats and the quality of the protein and fat (ONQI, 2017) and produces a score from 1 to 100. Higher scores represent greater overall nutritional value. Watson (2017) reported that over 1600 grocery stores in the United States placed the model's scores on product shelf tags next to the price. Although this model has promising attributes, available reports indicate that, the actual algorithm, including the relative weights of the nutrients, was never disclosed to the public

(Xion, 2017) leading to accusations of conflicts of interest and subsequent discontinuation of the model from commerce in 2017.

Five NPMs met our eligibility criteria for full data extraction. The Health Star Rating (HSR) System (Australia), Nutri-Score (France), the Nutrient-Rich Food Index (NRF9.3), the Food Compass Score, and the Choices 5-Level Criteria. The CHOICES 5-Level Criteria was eventually excluded after data extraction when it was confirmed that the model was based on pre-determined thresholds aimed at identifying best-in-class food products. Second, it appears fiber was the only nutrient to encourage that is included in the model. From these, we prioritized three: The Food Compass Score; the Nutrient-Rich Food Index (NRF 9.3); and Nutri-Score/ or Health Star Rating (HSR). All of the three models have comparable attributes with respect to the type of system; base; principal application; target population; nature of outputs and validation status (see table 3). The models, however, differ with respect to their data requirements. Data requirement is a decision point in NPM development or adaptation. Ghana currently lacks the requisite food composition data. Ghana's Food Composition Tables developed in 1975 (Eyeson, & Ankrah, 1975) have since received only tokenistic updates. The project plans to consult the West African Food Composition Tables (Charrondière, Vincent, & Grande, 2020). Additionally, an exercise to compile the composition of processed/branded food products is underway. To complement the local data, international databases such as the USDA Branded Food Products Database (BFPDB), which contains over 200,000 branded foods may be consulted. Caution, however, needs to be exercised as the composition of branded processed foods sold outside Ghana may not be the same as that of equivalent food products sold in Ghana. The Food Compass used 8,032 foods and beverages relevant to the US context based on NHANES data and other USDA nutrient databases. The NRF used similar data from Food and Nutrient databased for dietary studies. The Nutri-score included local (France) as well as data from other countries such as that used by the British Food Standards Agency.

Albeit with real challenges, a recent doctoral study demonstrates the potential of the NRF9.3 to be adapted to the Ghanaian context using the currently limited food composition data (Abdul-haq, 2022). Using 138 local Ghanaian food items, the study adapted the NRF9.3 into NRF11.3 and determined its reliability, sensitivity, specificity and optimal cut-off point for classifying

Ghanaian foods. The NRF11.3 was found to discriminate between healthy and less healthy food items as classified by the WHO NPM for Africa. Out of the 83 foods/beverages identified as healthy by the WHO model (acting as the "reference standard"), 71, were also classified by the new NRF11.3 index as healthy (a sensitivity of 85.5%). The NRF11.3 correctly classified 32 out of the 48 unhealthy foods, representing a specificity rate of 66.7 %. Further, convergent validity of the NRF11.3 index was conducted using a survey of Expert Nutrition Professionals. The NRF11.3 index achieved good agreement with the rankings of the Experts (Spearman correlation coefficient of $R_s = 0.549$, $p < .0001$). This work highlights the specific nutrients (qualifying and disqualifying nutrients) that could be included in the Ghana-facing NPM. Given the coexistence of malnutrition in all its forms, such nutrients will include essential as well as limiting micronutrient and macronutrients. Local and regional evidence show that population diets are deficient in selected micronutrients – including but not limited to: Vitamin A, thiamine. Vitamin B-12 and Calcium, iron, iodine, and zinc (Ayensu et al 2020; Harika et al 2017; Laar et al 2009). Abdul-haq (2022) recently prioritized 11 nutrients to encourage (Potassium, Dietary Fibre, Protein, Vitamin A, Vitamin C, Calcium, Iron, Vitamin E, Folate, Magnesium, Zinc) and the disqualifying nutrients/nutrients to limit have typically included - fat (saturated or total), sugar (total or added) and sodium for consideration in a Ghanaian NPM.

Of note, we did not consider the prioritized three NPM as superior to the others, but as those most amenable to the current needs of the HD4HL Project. It's also worthy of note that, aside from the technical considerations outlined, identification of the most potentially relevant from these top three models will consider additional variables such as economics, logistics, feasibility, and pragmatics (including willingness of the NPM developers to contribute to the adaptation process). Engagement with the developers of these top three NPMs will explore among others, their readiness to support the development of the Ghana NPM.

4.1 Strengths and limitations

There are a number of strengths that should be noted for this study. A systematic approach, with predetermined criteria, was followed to identify suitable nutrient profiling models for inclusion. The study team consulted widely, both with food and nutrition experts in Ghana, as well as international nutrient profiling model experts to ensure a rigorous study design was followed, and that the proposed nutrient profiling model would be suitable for the intended policies in Ghana. This project chose the approach of selecting suitable existing nutrient profiling models for adaptation. An open and transparent process, driven by clear guiding principles set a priori was used. However, very few nutrient profiling models have been developed for Africa, or low- and middle-income countries more broadly. The three nutrient profiling models identified as most appropriate to include have been developed in high income countries. It is possible that some criteria in the nutrient profiling models selected may not align well with the resource limited settings of a middle income country such as Ghana, and may result in some challenges with implementation. Several other credible NPMs could have been eligible, but for the double-duty inclusion criterion. For this reason, the NPM developed by the WHO for the WHO Africa region (WHO, 2019), the Chilean 'stop sign' warning label (Reyes et al, 2019), and the recently developed NPM in South Africa (Frank, et al, 2021) were excluded. This process of prioritization preceded local/context-specific validation of the NPMs.

5.0 Conclusions

Based on the criteria outlined, three unique score-based NPMs have been selected. Toward adapting one of the models for use by Ghana, the adapted model will undergo different forms of validity testing. Whilst this preliminary finding may not be informative for Ghanaian regulators who wish to use the models for country-specific applications, it does provide relevant insights to the M3T's work. As part of the process of deciding which model to adapt and implement within a jurisdiction, further validation of the model specific to the application, population and the Ghana legislative framework will need to be conducted. The Ghanaian government has proposed to use NPM in their food-based policies.

6.0 References

Ayensu J, Annan R, Lutterodt H, Edusei A, Peng LS (2020) Prevalence of anaemia and low intake of dietary nutrients in pregnant women living in rural and urban areas in the Ashanti region of Ghana. PLoS ONE 15(1): e0226026. https://doi.org/10.1371/journal.pone.0226026

Charrondière, U. R., Vincent, A., & Grande, F. (2020). FAO/INFOODS Food Composition Table for Western Africa (2019): user guide & condensed food composition table= Table de composition des aliments FAO/INFOODS pour l'Afrique de l'Ouest (2019): guide d'utilisation & table de composition des aliments condensée.

De Graft Aikins, A., Addo, J., Ofei, F., Bosu, W. K., & Agyemang, C. (2012). Ghana's burden of chronic non-communicable diseases: future directions in research, practice and policy. *Ghana medical journal*, *46*(2), 1-3.

Drewnowski, A., Amanquah, D., & Gavin-Smith, B. (2021). Perspective: how to develop nutrient profiling models intended for global use: a manual. *Advances in Nutrition*, *12*(3), 609-620.

Eyeson, K. K., & Ankrah, E. K. (1975). Composition of foods commonly used in Ghana

Factors associated with suboptimal intake of some important nutrients among HIV-positive pregnant adolescents from two Ghanaian districts. Journal of the Ghana Science Association. Vol 11; no. 2, 2009

FAO. 1983. World Food Security: A Reappraisal of the Concepts and Approaches. Director General's Report. Rome.Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L., Rauber, F., ... & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. *Public health nutrition*, *22*(5), 936-941.

FAO, IFAD, WFP, UNICEF, WHO, 2020. The State of Food Security and Nutrition in the World 2020. 1300 Transforming food systems for affordable healthy diets. Rome, FAO

Frank, T., Thow, A. M., Ng, S. W., Ostrowski, J., Bopape, M., & Swart, E. C. (2021). A fit-for-purpose nutrient profiling model to underpin food and nutrition policies in South Africa. *Nutrients*, *13*(8), 2584.

FULGONI, V. L., 3RD, KEAST, D. R. & DREWNOWSKI, A. 2009. Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. *J Nutr,* 139, 1549-54.

Ghana Statistical Service (GSS) (2015), Ghana Health Service (GHS), ICF International. Demographic and Health Survey 2014. Rockville: GSS, GHS, and ICF International.

Harika, R., Faber, M., Samuel, F., Kimiywe, J., Mulugeta, A., & Eilander, A. (2017). Micronutrient Status and Dietary Intake of Iron, Vitamin A, Iodine, Folate and Zinc in Women of Reproductive Age and Pregnant Women in Ethiopia, Kenya, Nigeria and South Africa: A Systematic Review of Data from 2005 to 2015. *Nutrients, 9*(10). doi: 10.3390/nu9101096

Laar, A. K., Ampofo, W. K., Tuaklil, J. M., Wonodi, C., Asantel, R. K., & Quakyi, I. A. (2009).

Labonté, M. È., Poon, T., Gladanac, B., Ahmed, M., Franco-Arellano, B., Rayner, M., & L'Abbé, M. R. (2018). Nutrient profile models with applications in government-led nutrition policies aimed at health promotion and noncommunicable disease prevention: a systematic review. *Advances in Nutrition*, *9*(6), 741-788.Drewnowski, A. (2017). Uses of nutrient profiling to address public health needs: from regulation to reformulation. *Proceedings of the nutrition society*, *76*(3), 220-229.

Maillot, M., Sondey, J., Braesco, V., & Darmon, N. (2018). The simplified nutrient profiling system (SENS) adequately ranks foods in relation to the overall nutritional quality of diets: a validation study. *Eur J Clin Nutr, 72*(4), 593-602. doi: 10.1038/s41430-018-0104-3

Mozaffarian, D., El-Abbadi, N. H., O'Hearn, M., Erndt-Marino, J., Masters, W. A., Jacques, P., ... & Micha, R. (2021). Food Compass is a nutrient profiling system using expanded characteristics for assessing healthfulness of foods. *Nature Food*, *2*(10), 809-818.

Ofori-Asenso, R., Agyeman, A. A., Laar, A., & Boateng, D. (2016). Overweight and obesity epidemic in Ghana—a systematic review and meta-analysis. *BMC public health*, *16*(1), 1-18.

ONQI: The Science Behind The Scores". nuval.com. Archived from the original on 2017-07-22. Retrieved 2020-04-27.

Reyes, M., Garmendia, M. L., Olivares, S., Aqueveque, C., Zacarías, I., & Corvalán, C. (2019). Development of the Chilean front-of-package food warning label. *BMC public health*, *19*(1), 1-11.
Santos, M., Rito, A. I., Matias, F. N., Assunção, R., Castanheira, I., & Loureiro, I. (2021). Nutrient profile models a useful tool to facilitate healthier food choices: A comprehensive review. *Trends in Food Science & Technology*, *110*, 120-131.
Scarborough, P., Kaur, A., Cobiac, L., Owens, P., Parlesak, A., Sweeney, K., & Rayner, M. (2016). Eatwell Guide: modelling the dietary and cost implications of incorporating new sugar and fibre guidelines. *BMJ open*, *6*(12), e013182
Tognon, G., Beltramo, B., Schilpzand, R., Lissner, L., Roodenburg, A. J., Don, R., ... & Smorenburg, H. (2021). Development of the Choices 5-Level Criteria to Support Multiple Food System Actions. *Nutrients*, *13*(12), 4509.
UK Government Office for Science. Foresight Report 2007. Tackling Obesities: Future Choices. Available from: https://www.gov.uk/government/collections/tackling-obesities-future-choices#project-report.
United States Department of Health and Human Services/Department of Agriculture. Dietary Guidelines for Americans, 2015–2020. Available from: http://www.health.gov/dietaryguidelines/dga2015/document/default.htm. \
WHO 2010. Nutrient profiling: Report of a WHO/IASO Technical Meeting, London, United Kingdom 4–6 October 2010. [Internet]. [Accessed 2021 Feb 24]. Available from: https://www.who.int/nutrition/ publications/profiling/WHO_IASO_report2010.pdf?ua=1.
World Health Organization. (2019). Nutrient Profile Model for the WHO African Region: a tool for implementing WHO recommendations on the marketing of foods and non-alcoholic beverages to children.
Watson, Elaine (13 November 2017). "Goodbye NuVal... and good riddance?". FoodNavigator-USA. William Reed Media Inc. Retrieved 2019-10-27.
Xiong, Amy (2017-11-03). "Yale researcher's ratings service discontinued". *Yale Daily News*. Retrieved 2019-10-27.

8.0 Appendices

Appendix 1: Guiding principles for the development and implementation of the Ghana NPM

- **Principle 1:** Context-specific, evidence-driven and aligned with Ghana's public health and nutrition policies/ food regulations, as well as with relevant WHO guidance and Codex guidelines.
- **Principle 2:** A single national system should be developed to improve its application, monitoring, and impact.
- **Principle 3:** Mandatory nutrient declarations, labelling on food packages required for the NPM should be informed by the requisite political, economic and legal feasibility analyses
- **Principle 4:** Continued improvements or adjustments of the NPM should be informed and supported by monitoring and review processes.
- **Principle 5:** The aims, scope and principles of the NPM (and associated policies), as well as data informing the NPM should be transparent and easily accessible.
- **Principle 6:** The NPM should respond to the multiple forms of malnutrition (including diet-related NCDs, micronutrient deficiencies etc)
- **Principle 7:** The development of the NPM should be food systems-centered – avoiding implementation actions only directed at the consumer level; relevant to multiple levels and sectors – driving healthier diets, nutrition and sustainability
- **Principle 8:** Government-led and government-owned – government should lead the multi-sectoral stakeholder engagement process
- **Principle 9:** The NPM should be interpretive (based on symbols, colors, words or quantifiable elements) and understandable to all population subgroups
- **Principle 10:** Uptake of the NPM should be encouraged across all eligible packaged foods – preferably through regulatory means (voluntary application is not recommended).
- **Principle 11:** Early, meaningful, and sufficient engagement with all food systems actors/ stakeholders
- **Principle 12:** Baseline data should be collected to support monitoring and evaluation of the outcomes and impact of the NPM and its associated policies.
- **Principle 13:** Conflict of interest declarations shall be mandatory for all M3T members