WHO ICDS-SNP OPTIMIZATION TOOL DOCUMENTATION

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WHO - HCM DOCUMENTATION

INTRODUCTION:

The nutrition supplementation program (SNP) implemented through ICDS Anganwadi centres offers two types of provisions for children based on their age: "take-home-rations" (THR) and "hot-cooked-meals" (HCM). These provisions vary in content across different states but typically include staples like rice, wheat, lentils or soya bean, and oil and sugar. In some cases, they may also contain milk and eggs. The goal is to provide 500 Kcal and 12 to 15 g of protein through THR and HCM. However, due to limited dietary diversity and an emphasis on cereals and legumes, the current SNP often fails to meet these nutritional recommendations. Furthermore, the provisions are deficient in sufficient fat and essential micronutrients.

This tool aims to address this issue by developing optimized provisions for THR and HCM tailored to each state's specific needs. The tool uses mathematical modelling techniques to meet the nutrient requirements mandated by ICDS and incorporates forward-looking criteria for fat and essential micronutrients. The focus will be on using locally available foods to cater to the region's food preferences while considering the budget allocated by the Government of India. This optimization tool will play a crucial role in identifying and implementing improved nutritional provisions to benefit the children in these programs, thereby enabling policy makers to make decisions regarding policies related to Nutrition and Food. The tool can be used as a reference to arrive at decisions regarding the food item combinations that can be used in HCM and in THR.

DATASETS USED:

Data Collection – In order to comprehend the existing provisions of the nutrition supplementation program (SNP) for different age groups (6 months to 3 years, 3 years to 6 years, pregnant, and lactating women), comprehensive data was gathered from all over India. This data covered 30 states, with 2 districts selected from each state, and 2 Anganwadi centres chosen from each district. The information collected included details on the current practices such as the weekly menu, "take-home-rations" (THR) packets provided for various age groups, budget allocation for different age groups, fortified food items list, market prices during different seasons, as well as nutrition and budget guidelines for all states.

Recipe Data – The recipes gathered from the field were made consistent in terms of the raw ingredient quantities and serving sizes. The nutrient composition for these recipes has been given with respect to IFCT 2017 [2]. The standardization process involved collaboration with the local satellite centres. Moreover, the suggested recipes provided by the satellite centres were taken into account as well.

If there are any new recipes or ingredients that users wish to include, they have the flexibility to add them to the database at any time. This allows them to use these new recipes for optimization purposes. Once a new recipe or ingredient is added, it will be incorporated into the database for the respective state, ensuring its availability for future use.

Food price – The market prices specific to each state have been gathered from local wholesale and retail markets. Additionally, the subsidized cost of ingredients has been obtained from district officials. Users can modify the cost information for different states as needed and save those changes for future reference.

Nutrient Guidelines – The nutrition requirements considered are based on the ICDS guidelines, specifically for Energy, Protein, and Fat with a 10% tolerability (Table 1,2) [1]. Users have the option to either add their own nutrition requirements or adjust the existing ones as per their needs. This feature allows for optimization based on personalized guidelines, making it convenient to compare between the old and new nutritional standards.

Fortification - The ingredients such as oil, rice, whole wheat flour, salt and milk have been displayed as fortified [1], the user has the option to change it as and when required (Table 3).

SAM - The tool also allows the user to develop a meal plan for severely acute malnourished (SAM) children. This is achieved either by providing 1-2 snacks or slightly increasing the quantities of hot cooked meals or both.

Budget –In accordance with the ICDS guidelines, we are conducting optimization with a budget of 8 RS. for children and 12 RS. for pregnant and lactating women and for SAM children. The focus of the optimization process is to find the most cost-effective solutions.

In cases where the optimal solution is not achievable within the allocated budget, the model will provide the next best and least costly alternative. This step allows us to assess the affordability of the options and find the most suitable solution that aligns with the budgetary limitations.

OPTIMIZATION MODEL

METHOD:

The primary goal is to create a linear programming algorithm that can generate an optimal weekly menu for beneficiaries of different age groups. The menu will include a main meal and morning snacks, and it will be based on the user's selection of recipes. The crucial aspect is to ensure that the menu meets the nutrient guidelines set by ICDS [1] while remaining within the allocated ICDS budget for each beneficiary.

OBJECTIVE FUNCTION:

To optimise the nutrient allocation, linear programming was employed. This method involves optimising a linear objective function under a set of linear inequalities or equations known as constraints. These constraints establish the limitations of the problem at hand. The objective function, representing the quantity to be maximized or minimized, aligns with the optimization objective. In our case, the primary objective of the linear programming model was to determine the optimal variable values that minimize the cost of the diet. The diet cost, which served as our objective, is expressed as a linear function.

$$Minimize\ Total\ Cost = min\{\sum_{i=1} Q_i \times C_i\}$$

where Q_i is the serving size of recipe i and C_i is the cost per unit of recipe i.

CONSTRAINTS:

The recipes have been classified into three categories: A, B, and C. Each recipe is presented in terms of the feasible quantity suitable for a child. It is allowed for any recipe to be increased up to 1.5 times of the reported values as the maximum allowable quantity for the child. Recipes categorized as B mostly consist of gravies, while those in category C are primarily side dishes. In addition to these categories, there are also two specific types of foods: "additional" and "compulsory" foods. The "additional" foods complement various dishes and can be paired with anything, like chutneys. On the other hand, the "compulsory" options include Egg, milk, and milk powder, which are mandatory components for certain meals.

In order to address the limitations inherent in the main objective function, it is crucial to employ mathematical expressions. The primary constraint revolves around fulfilling the nutrition recommendations specified in the ICDS guidelines for various beneficiary age groups. To ensure a balanced approach, we used the Tolerable Upper Limit (TUL) of nutrient intake as constraints for the maximum daily nutrient intake. This requirement necessitates that the optimized menu aligns precisely with the ICDS nutrient guidelines for the listed Macro nutrients while also ensuring that none of the listed nutrients surpass their respective TUL values.

OPTIMAL HCM:

By utilizing the linear programming method, we can obtain an optimal cost diet plan that meets the required nutrition guidelines while adhering to all constraints. The optimal diet is presented in various formats to ensure user-friendly comprehension.

The model provides all possible combinations of a daily meal that fulfils the daily nutrient guidelines. Users can then create a weekly menu by repeating these combinations. They have the flexibility to use the same combinations for all days or six different combinations for each of the six days.

The Radar chart displays the ratio of Nutrition intake to the recommendations. The pie chart illustrates the percentage proportion of each food group in the daily diet. Cost calculations are provided for an individual's daily, weekly, monthly, and yearly requirements.

The average nutrient intake per day is represented using three colours: green indicates meeting more than 60% of the recommended value, orange signifies meeting 30-60% of the recommended value, and red indicates less than 30% of the recommended value.

Weekly nutrient analysis is depicted through a line chart, showcasing variations in macro-nutrient intake throughout the week, along with fat energy and protein energy ratios.

The additional foods section allows users to include extra items like fruits and other accompaniments to enhance taste and combinations. All values are recalculated based on the added additional food.

An export option enables users to save a copy of the weekly menu, along with all other calculations, for future reference.

Advanced results, such as food group contributions towards nutrients and costs, as well as food group-wise ingredient contributions, are displayed using stacked bar diagrams. These visualizations assist users in understanding which food groups contribute most to each nutrient and which ingredients contribute significantly to the cost.

Policy makers can leverage this information to determine where nutrition and cost are focused, and potentially, they can consider subsidizing commonly used ingredients that contribute significantly to the cost when the optimal cost exceeds the fixed budget.

Python version 3.8.3 and the “Pulp” package was used for linear optimization. PyCharm, html, Java script, CSS and GitHub has been used for the Development of the web-application and hosting

Table 1 : Nutrition Recommendation

Nutrients	child(1-3)yrs	child(3-6)yrs	Pregnant Women	Lactating Women
Energy (kcal)	400	400	600	600
Protein (g)	15	15	22	22
Fat (g)	15	15	22	22

Table 2 : Nutrition Recommendation for SAM children

Nutrients	child(1-3)yrs	child(3-6)yrs
Energy (kcal)	700	800
Protein (g)	25	25
Fat (g)	25	25

Table 3 :Fortified Foods

Nutrients	Rice	Whole Wheat Flour	Milk	Salt
Iron (mg)	4.25	4.25		85
Folic Acid (mcg)	12.5	12.5		
Vitamin B12 (mcg)	0.125	0.125		
Vitamin A (mcg)			75	
Iodine (ppm)				15

REFERENCES:

1. India. “The Gazette of India.” New Delhi:Published by Authority, 25th January, 2023
2. Longvah, T., et al. *Indian Food Composition Tables*. Hyderabad, Telangana State, India: National Institute of Nutrition, Indian Council of Medical Research, 2017. Print.

WHO -THR DOCUMENTATION

INTRODUCTION:

The nutrition supplementation program (SNP) implemented through ICDS Anganwadi centers offers two types of provisions for children based on their age: "take-home-rations" (THR) and "hot-cooked-meals" (HCM). These provisions vary in content across different states but typically include staples like rice, wheat, lentils or soya bean, and oil and sugar. In some cases, they may also contain milk and eggs. The goal is to provide Energy, Protein and Fat along with some micronutrients through THR and HCM. However, due to limited dietary diversity and an emphasis on cereals and legumes, the current SNP often fails to meet these nutritional recommendations. Furthermore, the provisions are deficient in sufficient fat and essential micronutrients.

This tool aims to address this issue by developing optimized provisions for THR and HCM tailored to each state's specific needs. The tool uses mathematical modeling techniques to meet the nutrient requirements mandated by ICDS and incorporates forward-looking criteria for fat and essential micronutrients. The focus will be on using locally available foods to cater to the region's food preferences while considering the budget allocated by the Government of India. This optimization tool will play a crucial role in identifying and implementing improved nutritional provisions to benefit the children in these programs, thereby enabling policy makers to make decisions regarding policies related to Nutrition and Food. The tool can be used as a reference to arrive at decisions regarding the food item combinations that can be used in HCM and in THR.

DATASETS USED:

Data Collection - In order to comprehend the existing provisions of the nutrition supplementation program (SNP) for different age groups (6 months to 3 years, 3 years to 6 years, pregnant, and lactating women), comprehensive data was gathered from all over India. This data covered 30 states, with 2 districts selected from each state, and 2 Anganwadi centers chosen from each district. The information collected included details on the current practices such as the weekly menu, "take-home-rations" (THR) packets provided for various age groups, budget allocation for different age groups, fortified food items list, market prices during different seasons, as well as nutrition and budget guidelines for all states. Any new ingredient can be added to the database by the user at any point of time to use the new ingredient for optimization. The added ingredient will be added to the recipe database for the corresponding state.

Ingredients - The displayed ingredients in the tool and its corresponding nutrients were obtained from IFCT 2017[2].

Nutrient Guidelines - The nutrition requirements considered are based on the ICDS guidelines (Table 1,2) [1], specifically for Energy, Protein, and Fat with a 10% tolerability. Users have the option to either add their own nutrition requirements or adjust the existing ones as per their needs. This feature allows for optimization based on personalized guidelines, making it convenient to compare the old and new nutritional standards.

Fortification - The ingredients such as oil, rice, whole wheat flour, salt and milk have been displayed as fortified [1], the user has the option to change it as and when required (Table 3).

SAM - The tool also allows the user to develop a THR for severely acute malnourished (SAM) children. This is achieved by providing a snack along with the packet. Any new snack can be added to the database by the user at any point of time to use the new snack for optimization.

Food price - The price assigned to each ingredient was an average aggregated from the market survey conducted during the data collection phase, encompassing all the states. The subsidized cost of the ingredients has been collected from the district officials. The user can always edit the cost across states and save it for future.

Budget - In accordance with the ICDS guidelines, we are conducting optimization with a budget of 8 RS. for children and 12 RS. for pregnant and lactating women and for SAM children. The focus of the optimization process is to find the most cost-effective solutions.

OPTIMIZATION MODEL

METHOD:

To fulfill the recommended nutrition guidelines for ICDS beneficiaries, as outlined by the Integrated Child Development Services (ICDS) [1] (Table 1,2), the optimization of 3 dietary nutrients in daily food intake was taken into consideration namely Energy (kcal), Protein (g) and Fat (g). The utilization of this tool has allowed for the optimal fulfillment of these nutrient requirements. As nutrient recommendations differ across age groups, separate optimization processes were conducted for each specific group.

Furthermore, it is important to note that a healthy diet not only encompasses meeting these nutrient needs but also emphasizes the significance of dietary diversity. To maintain a varied diet, the tool has incorporated over 500 food items, which have been categorized into 9 food groups: Cereals, Millets, Grain Legumes, Nuts and Oil Seeds, Egg and Egg Products, Milk & Milk products, Sugars, Edible Oil and Fats, and Fruits. This categorization aims to ensure the inclusion of diverse food choices in diets.

OBJECTIVE FUNCTION:

To optimize the nutrient allocation, linear programming was employed. An optimization model had been built for two types of THR, namely whole foods and blended premix. We optimize a linear objective function under a set of linear inequalities or equations known as constraints. These constraints establish the limitations of the problem at hand. The objective function, representing the quantity to be maximized or minimized, aligns with the optimization objective. In our case, the primary objective of the linear programming model was to determine the optimal variable values that minimize the cost of the diet. The diet cost, which served as our objective, is expressed as a linear function.

$$Minimize\ Total\ Cost = min\{\sum_{i=1} Q_i \times C_i\}$$

where Q_i is the quantity of raw food item i and C_i is the cost per unit of raw food item i.

CONSTRAINTS:

To capture the limitations placed on the main objective function, it is essential to utilize mathematical expressions. These limitations encompass various aspects, such as food group constraints, which guarantee the inclusion of at least one food item from the selected groups within the optimal diet. Furthermore, restrictions on the minimum and maximum quantities within each food group were implemented for whole foods and blended premix separately. Similarly, certain ingredients were subjected to quantity restrictions at the food item level. Additionally, a consistent cereal to pulse ratio of 2:1 was maintained across all age groups. The tool also has the provision to add specific cereals or millets or both that need to compulsorily appear in the final diet plan. Each of the specified compulsory foods will have a different THR packet.

OPTIMAL THR:

Using the linear programming method, we can get the optimal THR product which meets the nutrition guidelines by satisfying all the constraints.

An export option enables users to save a copy of the THR product, along with all other calculations, for future reference.

The ratio of the Nutrition intake to the recommendation has been displayed in the Radar chart. The pie chart shows the percentage proportion of each of the food groups in a daily diet. Cost calculation gives the cost needed for the individual for a day, Week, Month and Year. The average nutrient met per day has been given in 3 different colors where green indicates more than 80% met, Orange indicates 50-80% met and red indicates less than 50% met.

Python version 3.8.3 and the “Pulp” package were used for linear optimization. PyCharm, html, Java script, CSS and GitHub have been used for the Development of the web-application and hosting.

Table 1 : Nutrition Recommendation

Nutrients	child(6-12)m	child(1-3)yrs	child(3-6)yrs	Pregnant Women	Lactating Women
Energy (kcal)	200	400	400	600	600
Protein (g)	8	15	15	22	22
Fat (g)	10	15	15	22	22

Table 2 : Nutrition Recommendation for SAM children

Nutrients	child(6-12)m	child(1-3)yrs	child(3-6)yrs
Energy (kcal)	400	700	800
Protein (g)	15	25	25
Fat (g)	15	25	25

Table 3 : Fortified Foods

Nutrients	Rice	Whole Wheat Flour	Milk	Salt
Iron (mg)	4.25	4.25		85
Folic Acid (mcg)	12.5	12.5		
Vitamin B12 (mcg)	0.125	0.125		
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