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A Preference-Oriented Multi-Criteria Decision Model for Stunting-Prevention Food Basket Ranking using AHP-TOPSIS

Alvin Muhammad 'Ainul Yaqin[1], Mifthahul Janna Rosyid[1], Vridayani Anggi Leksono[2], Amanda Dwi Wantira[3*]

[1)] Systems Modeling and Optimization Research Group, Department of Industrial Engineering, Institut Teknologi Kalimantan, Balikpapan, Indonesia
[2)] Department of Industrial Engineering, Institut Teknologi Kalimantan, Balikpapan, Indonesia
[3)] Department of Logistics Engineering, Institut Teknologi Kalimantan, Balikpapan, Indonesia
Email: alvinyaqin@lecturer.itk.ac.id, miftahuljanna25@gmail.com, anggi.leksono@lecturer.itk.ac.id, amanda.dwi@lecturer.itk.ac.id*
*Corresponding author

Abstract: It is necessary to give concentrated attention to the issue of stunting by implementing appropriate nutrition initiatives to prevent stunted physical and mental development. Optimal food availability is one effective strategy for preventing it. However, it often disregards preferences that guarantee pleasure, dietary diversity, and compatibility with individual tastes. In this paper, we show a two-step multi-criteria decision model. The AHP is used to figure out the criteria weights, and the TOPSIS method ranks food basket options based on how close they are to the ideal solution. The efficacy of our strategy was subsequently evaluated in Balikpapan, a prominent urban center in Indonesia grappling with the issue of stunting. The evaluation's findings were as follows: nutritional value (27%) was the most significant factor, knowledge of the food ingredients (18%), variety of foods made from the food ingredients (17%), ease of preparation, cooking, and storage (15%), cost (12%), and child preference (11%). The findings indicated that food basket 3, priced at Rp209,857 and yielding 1,854.96 kcal, consisted of rice weighing 3.63 kg, duck egg weighing 1.16 kg, milkfish weighing 0.65 kg, tuna weighing 0.06 kg, cauliflower weighing 0.17 kg, kale weighing 3.46 kg, and dragon fruit weighing 1.87 kg. In addition to nutrition and cost, this study highlights that considering preferences can enhance the appeal of food baskets.

Keywords: Food basket, ranking, stunting, preferences, AHP, TOPSIS.

Introduction

Malnutrition-induced stunting is a significant issue in numerous developing countries, marked by stunted physical growth in children. Pediatric undernutrition is when a child's daily consumption of energy and nutrients is insufficient to meet their requirements, leading to insufficient physical development and lower stature compared to their peers. Stunting has a profound impact on physical and mental development, particularly in children under five, greatly impeding their growth and cognitive progress [1]. The phenomenon is shaped by a confluence of child-specific, parental, socioeconomic, and environmental dimensions, encompassing malnutrition, breastfeeding habits, family income, parental height, and sanitation [2]. The detrimental impact of stunting on children's productivity and cognitive development necessitates implementing preventive measures [3]. The prevalence of stunting has a substantial impact on both mothers and children, leading the government to adopt a range of preventive measures and regulations. These include delicate and tailored treatments that specifically target pregnant women, breastfeeding moms, households, and adolescent girls [4].

Two strategies are employed to carry out interventions that prevent stunting: sensitive and specific approaches. Sensitive interventions are designed to enhance the economic well-being of families, increase access to pure water, and enhance sanitation systems. Specific interventions are designed to enhance the nutritional status of children by providing fortified foods and supplements, including folic acid, calcium, zinc, and vitamin A, as well as balanced protein and energy supplements. Furthermore, families are provided with ready-to-eat dishes to augment their food intake over an extended period [3].

The need to supply nutritious food through programs such as food baskets during emergencies and disasters has been addressed by several researchers employing various techniques. A food basket is a compilation of nutrient-rich food products given to persons to enhance their nutritional condition, encompassing a range of food commodities [5]. Montenegro and colleagues [6]. Proposed an ideal food basket to efficiently supply vital nutrients to individuals below the poverty threshold. The concept was developed based on the population's essential dietary requirements using linear programming methodologies. Reference: Hernández *et al.* [7]. presented an innovative method of goal programming to create a food menu that meets nutritional requirements while adhering to the principles of the Mediterranean diet. Peters and colleagues [8]. This study employed mixed-integer linear programming to develop food baskets as a prompt solution to address food requirements during natural catastrophes and emergencies in many nations, including Iraq, Yemen, and areas impacted by the El Nino phenomena. Koenen and colleagues [9]. Proposed a linear programming-based diet optimization model to attain nutritional sufficiency. Moor *et al.* [10] developed a novel optimization model for food assistance operations during humanitarian crises, integrating the factor of procurement price uncertainty. The study's technique enables efficient dietary decision-making by employing a straightforward approach. In their study, Vermeulen *et al.* [11] used a fundamental healthy food basket model to assess the cost and affordability of essential nutritious foods in South Africa and Kenya. In their study, Ghahremani-Nahr *et al.* [12] refined the minimal freshness of a food basket by constructing a distribution network that accounts for unpredictable food demand and capacity conditions. The nutritionally sufficient, health-promoting, culturally appropriate, and cost-effective food basket for a low-income Estonian household was developed by Lauk *et al.* [13] using a linear programming methodology.

Multi-criteria decision approaches were employed in previous research to optimize the meal selection process. Santos *et al.* [14] employed linear programming optimization to decrease food expenses while simultaneously meeting the nutritional requirements of workers in Brazil. Furthermore, this study employed an analytic hierarchy process (AHP) to assess the optimal lunch options according to employee satisfaction. Abuabara *et al.* [15] used Analytic Hierarchy Process (AHP) and linear programming to create weekly meal plans tailored to family preferences in response to the COVID-19 epidemic. This study aims to develop an ideal dietary regimen tailored to the preferences of individual families. Vijh *et al.* [16] employed the Analytic Hierarchy Process (AHP) and entropy computation to determine the most suitable dietary regimen among three menu options for individuals with hypertension. The order of preference technique based on resemblance to the ideal solution (TOPSIS) was employed by Showafah *et al.* [17] to suggest a menu of complementary foods that include carbs, proteins, and fats. This was done by considering feedback from beneficiaries regarding their preferences, dislikes, and food allergies. The correlation between nutritional requirements and the negative consequences of COVID-19 was examined by Marti *et al.* [18] using TOPSIS statistical software.

Nevertheless, most studies on food requirements are carried out in times of crisis, such as calamities and the COVID19 pandemic. However, a limited number of studies have specifically addressed the reduction of stunting by sufficient provision of nourishing food. It is necessary to adopt a comprehensive strategy that addresses not just the nutritional requirements of children but also considers their food choices. Furthermore, prior research often employs a single-method methodology and fails to incorporate multi-criteria decision-making procedures to comprehensively tackle nutritional sufficiency and food acceptability among beneficiary groups.

This study aims to design and execute an ideal food basket intervention program in Balikpapan, a prominent city in Indonesia, to address the inefficiency of past attempts to decrease stunting. As of 2022, the prevalence of stunted children under the age of five in Balikpapan was 10.8%. By 2023, this percentage had only marginally declined to 6.68%. [19]. This underscores the pressing necessity for more efficient initiatives to expedite the decrease of stunting in the region. The primary objective of this study is to identify the most suitable basket for enhancing the nutritional well-being of persons. This will be achieved by considering the preferences of both mothers and children to deliver nutritional sufficiency, enjoyment, cultural appropriateness, and practical convenience. This study suggested a multi-criteria decision-making approach, combining the Analytic Hierarchy Process (AHP) and TOPSIS. Chen [20] demonstrated that integrating the Analytic Hierarchy Process (AHP) and TOPSIS can enhance decision-making, particularly in intricate scenarios. The present study has determined that the AHP-TOPSIS integrated model exhibits superior stability and reliability compared to the individual use of AHP or TOPSIS. This is evident from its consistent provision of reliable results in sensitivity analysis, even when input weights vary.

The suggested method operates in two stages: the initial stage employs the Analytic Hierarchy Process (AHP) to compute the weights of six pertinent criteria. The analysis of food basket data focuses on two main factors: cost and nutritional content. The next four criteria are determined based on the preferences of the mother and child, encompassing factors such as the simplicity of preparation, cooking, and storage, the range of dishes produced from the components, the level of familiarity with the foodstuffs, and the preferences of the kid. The second stage employs the TOPSIS method to determine the most efficient food basket from the assessed options. This research illustrates the usefulness of AHP and TOPSIS methodologies to identify the optimum food basket, which is vital in combating child stunting. The adaptability and practicality of these approaches highlight their capacity to guide focused and efficient nutrition interventions in varied situations.

Methods

AHP

The Analytic Hierarchy Process (AHP) is a decision-making technique that streamlines intricate situations by decomposing them into smaller, more controllable elements through pairwise comparisons. Integrating subjective and objective information enables decision-makers to assess the significance of many criteria and alternatives. The Analytic Hierarchy Process (AHP) incorporates consistency checks to minimize bias and allocates weights to each criterion according to these comparisons, reflecting their relative significance. Subsequently, these weights are merged with the scores assigned to each choice to generate a comprehensive score, facilitating efficient ranking. Citation 21.

TOPSIS

TOPSIS is a method that evaluates alternatives by calculating their proximity to two benchmarks: the positive ideal solution (S_i^+) and the negative ideal solution (S_i^-). The preferred option must be close to the positive ideal solution and far from the negative ideal solution. The popularity of TOPSIS in many fields, including procurement, manufacturing, financial analysis, and others, can be attributed to its simplicity and robust mathematical basis [22].

Proposed Approach

To identify the optimal food basket, this approach combines two multi-criteria decision-making techniques, namely AHP and TOPSIS. Consumer preferences significantly influence food decision-making by facilitating tailored suggestions that accommodate specific preferences, dietary limitations, and nutritional requirements. Consequently, this enhances consumer acceptability and pleasure, fosters trust, promotes regular usage, and guides users toward making healthier decisions [23]. Etminaniet *et al.* [24]. The importance of customizing meal recommendations to suit individual health circumstances and tastes was underscored.

Data was gathered on various food baskets designed to meet the daily nutritional requirements of youngsters and subsequently assessed according to prescribed standards. Thus, this study employs six factors to choose the most suitable food basket: cost, nutritional content, simplicity of preparation, cooking and storage, diversity of foods derived from the ingredients, knowledge of the ingredients, and individual choice of the child. The affordability and nutritious content cater to financial and health requirements, while the simplicity of preparation, cooking, and storage, as well as the wide range of food options, guarantee convenience and dietary adaptability. Thorough knowledge of the food ingredients enhances user comfort and acceptance, thereby facilitating the integration of the basket contents into everyday routines. The architecture of the suggested model is structured in the following manner.

Collecting Data

First, we acquired different food baskets. Compile a variety of prospective food basket choices that are specially tailored to combat stunting. It is important that these options encompass a variety of daily nutritional values and weekly prices. Secondly, we gather research data using questionnaires. Administer and collect surveys from mothers to learn their preferences. The questionnaire should encompass data regarding the preferred food types selected based on their ease of preparation, cooking, and storage, the range of foods derived from these ingredients, the level of acquaintance with these items, and the preferences of the child. The AHP hierarchy is depicted in Figure 1.

AHP Modelling

The AHP hierarchy facilitates the identification of the optimal food basket by considering various significant parameters. The primary goal of the first level is to meticulously choose the optimal food basket. The second tier comprises assessment factors such as cost, nutritional content, simplicity of processing, cooking and storage, range of customizable meals, knowledge of the components, and child choice. The third tier comprises an array of food options (food baskets 1, 2, up to n food baskets) that are assessed according to these criteria. Each alternative is evaluated based on each criterion, and the given weights to the criteria are utilized to choose the alternative that most effectively meets the broader goal of picking the optimal food basket. The next step we employ the AHP hierarchy to provide weights to criterion. Utilizing the AHP to assess the relative significance of each criterion in the problem hierarchy. This entails allocating weights to the criteria by considering pairwise comparisons, in which the decision maker evaluates the relative importance of each criterion. The presented weights indicate the relative significance of each criterion within the comprehensive decision-making process. Then we conduct pairwise comparisons to analyse the relative significance of each criterion by conducting pairwise comparisons. This stage entails assessing each pair of criteria to ascertain their relative degree of importance. This analysis yields a comparison matrix to calculate the criteria weights. Then we apply normalization to the decision matrix. Normalize the choice matrix to standardize the value of each alternative concerning the criteria, assuring that they are expressed on a consistent scale. The procedure enables equitable comparison across many criteria and precise consolidation of outcomes.

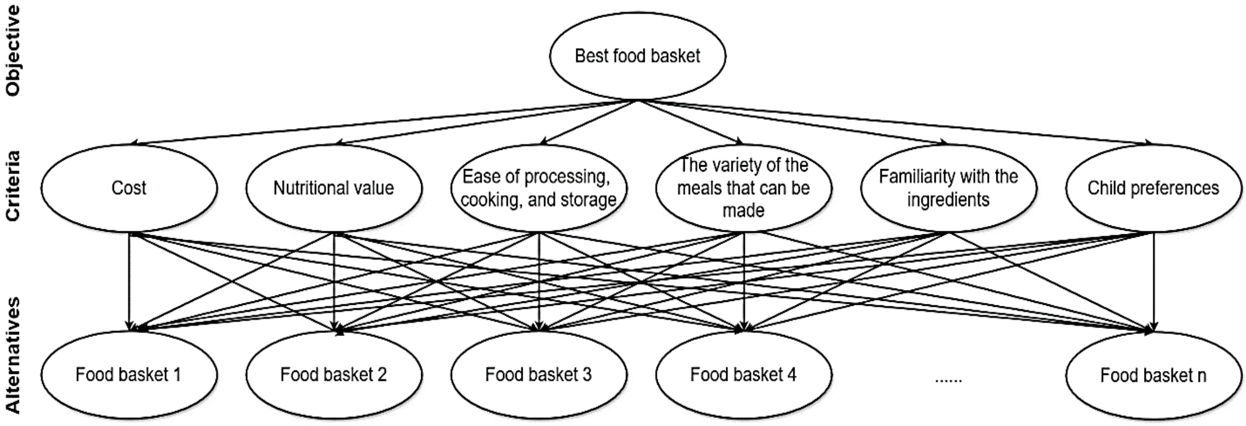

Figure 1. A hierarchical decision model that outlines the criteria and alternatives for selecting the optimal food basket

The weight calculation is assigned to each criterion based on the pairwise comparison matrix. This entails extracting weights from the normalized matrix by analytical methods, which indicate the relative significance of each criterion in the assessment procedure. To validate the trustworthiness of paired comparisons by examining the consistency ratio, we evaluate the consistency ratio. It is necessary to attain a consistency ratio below 0.1 in the AHP to advance to the following stage. Should the ratio surpass 0.1, revert to the process of collecting questionnaire data. After obtaining the weight of each criterion, we determine the weights for each criterion using the AHP results. It is crucial that these weights precisely represent the significance of each criterion in the decision-making process to effectively assess and rank the food basket alternatives using TOPSIS.

TOPSIS Calculation

In the TOPSIS procedure, first we calculate the positive and negative ideal solutions. The objective is to ascertain each criterion's optimal positive and negative solutions. The positive ideal solution corresponds to the optimal value associated with each criterion, whereas the negative one corresponds to the least favourable value. The algorithms for determining the positive ideal solution and negative ideal solution are

$$S_i^+ = \sqrt{\sum_{j=1}^{m}\left(v_{kj} - v_j^+\right)^2}, k = 1, \dots, n \quad (1)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m}\left(v_{kj} - v_j^-\right)^2}, k = 1, \dots, n \quad (2)$$

where S_i^+ (S_i^-) denotes the distance of alternative i from the positive (negative) ideal solution, v_{kj} denotes the weighted normalized value of alternative $k$concerning criterion j, v_j^+ (v_j^-) denotes the positive (negative) ideal solution for criterion j, k denotes the index for alternatives, n denotes the total number of criteria, and m denotes the number of alternatives.

Then we measure the relative proximity of each food basket alternative to the ideal solutions. The formula for a relative proximity is

$$\varphi_i = \frac{S_i^-}{S_i^- + S_i^+} \quad (3)$$

where φ_i denotes the relative proximity of alternative i from the ideal solution and $0 < \varphi_i < 1$.

This measurement is important for ranking food baskets. The food basket alternatives should be ranked according to their proximity to the optimal solution. Comparing overall scores helps determine the most appropriate choice, aiding decision-making.

Sensitivity Analysis

At the end we performed a sensitivity analysis. A sensitivity analysis must be conducted to assess the reliability of the results. This entails analysing the impact of alterations in criteria weights or input data on the ranking of the food basket options. Sensitivity analysis guarantees the dependability and consistency of the results across many parameters.

Results and Discussions

Data

This research necessitates diverse data to adequately tackle stunting through food basket interventions. First and first, it is necessary to establish the minimal nutritional needs, encompassing both macronutrient and micronutrient requirements, for children between the ages of 6 months and two years. Furthermore, the research encompassed ten distinct food basket designs, each characterized by a precise combination of basic foods, main meals, veggies, and fruits, accompanied by detailed information on pricing and calorie content. Thirdly, the study gathered data on selecting these food basket designs by administering questionnaires to lactating moms.

The Recommended Dietary Allowances (RDAs) are numerical figures that represent the average daily intake of specific nutrients that all persons with specified characteristics, such as age, gender, physical activity level, and physiological condition, should meet to sustain optimal health. [25]. This study utilized the Recommended Dietary Allowances (RDAs) to ascertain the minimal nutritional needs of children between 6 months and two years old. Table 1 presents children's dietary needs between the ages of 6 months and two years.

Table 1. Recommended daily minimum nutritional intake for children aged 6-24 months

Nutrition	Requirement	Unit
Water	≥ 1150	mg
Energy	≥ 1350	kcal
Protein	≥ 20	g
Fat	≥ 45	g
Carbohydrate	≥ 215	g
Fibre	≥ 19	g
Calcium	≥ 650	mg
Iron	≥ 7	mg
Zink	≥ 3	mg
Vitamin A	≥ 400	mcg
Vitamin B1	≥ 0.5	mg
Vitamin B2	≥ 0.5	mg
Vitamin B3	≥ 6	mg
Vitamin B6	≥ 0.5	mg
Vitamin B12	≥ 1.5	mcg
Vitamin C	≥ 40	mg
Vitamin D	≥ 15	mcg
Folate	≥ 160	mcg

Source: [25]

Furthermore, this study compiled statistical data on the nutritional content of all dietary commodities. These summaries comprehensively examine the nutritional composition of each category, offering a valuable understanding of their role in a well-rounded diet. An exhaustive summary is included in Table 2.

Table 1 demonstrates the suggested minimum daily nutritional consumption for children between 6 and 24 months, and Table 2, which provides a summary of nutrients and nutrients categorized by food type, we developed food baskets. Each food basket comprises four fundamental elements: staple foods, main courses, vegetables, and fruits. By the recommendations of the Indonesian Ministry of Health, the composition places greater focus on staple and main foods (33% and 17%) as well as vegetables and fruits (33% and 17%).

Table 2. Nutritional summary per 100 grams for all food commodities across the four food groups

Cost (IDR) and Nutrition Type (unit)	Mean	S.D.	Median	Min	Max	Mean	S.D.	Median	Min	Max
	Staple food					Main dishes				
Price (100 gr)	1,975	1,084	1,600	1,200	3,500	5,735	3,597	5,000	2,000	15,000
Water (g)	68	12	66	57	83	70	11	74	45	88
Energy (kcal)	128	48	137	65	174	151	73	132	67	298
Protein (g)	2	1	2	1	3	18	7	17	3	29
Fat (g)	0	0	0	0	0	8	7	7	0	25
Carbohydrates (g)	30	12	32	14	40	3	4	2	0	11
Fibre (g)	1	2	1	0	4	1	3	0	0	14
Calcium (mg)	46	29	44	17	77	157	332	68	2	1.422
Iron (mg)	1	0	1	0	1	4	4	3	0	16
Zinc (mg)	0	0	0	0	1	16	59	1	0	247
Vitamin A (mcg)	2	4	0	0	7	911	3.414	55	0	14.154
Vitamin B1 (mg)	0	0	0	0	0	0	0	0	0	2
Vitamin B2 (mg)	0	0	0	0	0	0	1	0	0	3
Vitamin B3 (mg)	1	0	1	1	1	4	4	4	0	14
Vitamin B6 (mg)	0	0	0	0	0	0	0	0	0	1
Vitamin B12 (mcg)	0	0	0	0	0	7	14	3	0	59
Vitamin C (mg)	17	13	19	0	31	6	18	0	0	69
Vitamin D (mcg)	0	0	0	0	0	12	24	3	0	82
Folate (mcg)	22	4	23	17	27	73	152	10	1	588
	Vegetables					Fruits				
Price (100 gr)	3,786	2,285	3,500	1,000	8,000	3,786	2,285	3,500	1,000	8,000
Water (g)	76	27	90	12	95	76	27	90	12	95
Energy (kcal)	110	128	42	19	364	110	128	42	19	364
Protein (g)	5	6	3	1	23	5	6	3	1	23
Fat (g)	3	8	1	0	34	3	8	1	0	34
Carbohydrates (g)	15	20	6	1	69	15	20	6	1	69
Fibre (g)	3	2	2	0	8	3	2	2	0	8
Calcium (mg)	91	88	57	2	293	91	88	57	2	293
Iron (mg)	2	2	2	0	8	2	2	2	0	8
Zinc (mg)	1	1	0	0	3	1	1	0	0	3
Vitamin A (mcg)	122	169	31	0	478	122	169	31	0	478
Vitamin B1 (mg)	0	0	0	0	1	0	0	0	0	1
Vitamin B2 (mg)	0	0	0	0	0	0	0	0	0	0
Vitamin B3 (mg)	2	2	1	0	8	2	2	1	0	8
Vitamin B6 (mg)	0	0	0	0	1	0	0	0	0	1
Vitamin B12 (mcg)	0	1	0	0	5	0	1	0	0	5
Vitamin C (mg)	28	32	14	0	103	28	32	14	0	103
Vitamin D (mcg)	0	0	0	0	1	0	0	0	0	1
Folate (mcg)	111	170	50	0	625	111	170	50	0	625

In this study, energy was evaluated according to the nutritional value standards for each food basket. As an illustration, the initial food basket comprises 576 kcal of energy derived from 3.42 kg of yam, 147.26 kcal from 0.69 kg of chicken egg, 11.39 kcal from 0.03 kg of chicken liver, 195.08 kcal from 1.04 kg of anchovy, 155.94 kcal from 0.31 kg of coconut milk, 84.23 kcal from 3.10 kg of chayote, and 281.64 kcal from 1.76 kg of banana, yielding a total of 1,451.57 kcal per day. This computation was performed on all available food basket options, as indicated in Table 3.

A potential approach for the government would be to develop these food baskets as a component of a targeted initiative targeting moms during the breastfeeding phase. Maternal involvement in the production of the baskets is absent, as they are instead recipients of food baskets supplied by the government. This initiative can potentially serve as a very efficient means of assistance for mothers during this given timeframe. Table 3 summarizes 10 different food basket designs, each designed to offer food for one week. A well-balanced combination of staple foods, side dishes, vegetables, and fruits is included in each basket under the recommended nutritional requirements.

The caloric value of these baskets varies between 1,451.57 and 1,771.67 kcal (mean: 1,738.85, standard deviation: 133.08), guaranteeing that the child's daily energy requirements are fulfilled. The cost of the food basket ranges from IDR 144,175 to IDR 561,641, with a mean of IDR 288,197 and a standard deviation of 121,961.806. Furthermore, many essential macronutrients, several varieties of fish and poultry, and an extensive selection of vegetables and fruits provide a varied nutritional consumption. Although meal plan one may be the optimal selection based on nutritional value and cost, this study will also consider individual preferences to identify the most suitable meal plan.

Table 3. Ten alternative food baskets arranged according to recommended food commodity weights, with each basket comprising 33% staple foods, 17% main dishes, 33% vegetables, and 17% fruits

No.	Food Basket	Staple Foods (Weight)	Main Dishes (Weight)	Vegetables (Weight)	Fruits (Weight)	Cost (IDR)	Nutritional Value (Kcal)	Graphical Illustration
1	Food basket 1	Yam (3.42 kg)	Chicken egg (0.69 kg), chicken liver (0.03 kg), anchovy (1.04 kg)	Coconut milk (0.31 kg), siamese pumpkin (3.10 kg)	Banana (1.76 kg)	144,175	1,451.57	
2	Food basket 2	Yam (3.52 kg)	Duck egg (1.11 kg), milkfish (0.64 kg), tuna (0.06 kg)	Water spinach (3.52 kg)	Banana (1.81 kg)	185,379	1,663.55	
3	Food basket 3	Rice (3.63 kg)	Duck egg (1.16 kg), milkfish (0.65 kg), tuna (0.06 kg)	Cauliflower (0.17 kg), water spinach (3.46 kg)	Dragon fruit (1.87 kg)	209,857	1,854.96	
4	Food basket 4	Rice (3.67 kg)	Duck egg (1.32 kg), milkfish (0.53 kg), tuna (0.05 kg)	Cassava leaf (2.02 kg), mung beans (0.02 kg), tomato (1.63 kg)	Dragon fruit (1.89 kg)	218,839	1,929.8	
5	Food basket 5	Rice (3.63 kg)	Chicken (0.85 kg), long-jawed mackerel (0.18 kg), pangas catfish (0.84 kg)	Cassava leaf (2.27 kg), tomato (1.36 kg)	Dragon fruit (1.87 kg)	241,316	1,888.18	
6	Food basket 6	Cassava (3.53 kg)	Chicken (0.97 kg), long-jawed mackerel (0.41 kg), pangas catfish (0.44 kg)	Cassava leaf (1.07 kg), tomato (2.46 kg)	Melon (0.68 kg), pear (1.14 kg)	266,799	1,701.5	
7	Food basket 7	Cassava (3.60 kg)	Chicken (1.01 kg), catfish (0.84 kg)	Mung bean (0.52 kg), tomato (3.08 kg)	Melon (0.24 kg), pear (0.34 kg), watermelon (1.28 kg)	272,216	1,793.7	
8	Food basket 8	Cassava (3.54 kg)	Chicken (1.04 kg), catfish (0.78 kg)	Broccoli (1.85 kg), carrot (1.09 kg), long bean (0.24 kg), mushrooms (0.35 kg)	Watermelon (1.82 kg)	328,755	1,649.09	
9	Food basket 9	Potato (3.57 kg)	Chicken (0.82 kg), quail egg (1.02 kg)	Longs bean (0.87 kg), mushroom (2.70 kg)	Snake fruit (1.84 kg)	452,993	1,684.43	
10	Food basket 10	Potato (4.20 kg)	Chicken (0.98 kg), snakehead fish (1.18 kg)	Kidney bean (1.67 kg), mushroom (2.53 kg)	Pineapple (0.32 kg), snake fruit (1.84 kg)	561,641	1,771.67	

Table 4. Respondent demographics (n = 35)

Category	Total	Percentage	Category	Total	Percentage	Category	Total	Percentage
Husband's age			Wife's age			Weaning age		
≤ 30 y.o.	16	46%	≤ 30 y.o.	20	57%	6-12 months	20	57%
≤ 40 y.o.	10	29%	≤ 40 y.o.	12	34%	13-18 months	8	23%
≤ 50 y.o.	9	26%	≤ 50 y.o.	3	9%	19-24 months	7	20%
Husband's education			Wife's education			Marriage age		
Middle school	1	3%	Middle school	1	3%	≤ 5 years	18	51%
High school	23	66%	High school	22	63%	≤ 10 years	9	26%
Diploma	0	0%	Diploma	1	3%	≤ 15 years	2	6%
Bachelor's degree	10	29%	Bachelor's degree	10	29%	≤ 20 years	3	9%
Master's degree	1	3%	Master's degree	1	3%	≤ 25 years	3	9%
Husband's job			Wife's job			Number of children		
Civil servant	9	26%	Civil servant	2	6%	1	10	29%
Self-employed	13	37%	Employee	2	6%	2	16	46%
Employee	13	37%	Housewife	31	89%	≥3	2	6%

Table 5. The weights of the criteria for food basket selection

Criteria	Weight
Nutritional value	27%
Familiarity with the ingredients	18%
Variety of foods made from the ingredients	17%
Ease of preparation, cooking, and storage	15%
Cost	12%
Child preferences	11%

Furthermore, we administered a questionnaire to evaluate the preferences for food baskets. This questionnaire was tested in a posyandu (integrated service post) located in Balikpapan, namely at Posyandu Nusa Indah. Approximately 60 family registrations are served by this institution, which now provides help to around 35 moms throughout the supplemental feeding phase. These mothers receive regular services weekly. Considering the geographical limitations and the comparability in the characteristics of these mothers, we inferred that their preferences were expected to be comparable, which is why we chose them as the subjects of this study.

Out of the 35 survey responses gathered, 50% of the participants had children aged between 6 and 12 months and had been married for less than five years. The couple's cumulative age was below 30 years old. This falls within the typical range of reproductive ages in Indonesia, which frequently spans from 22 to 24 years old. This suggests that over 50% of young couples start a family during their early to mid-20s. [26]. Most of the participants and their spouses have successfully finished secondary education, aligning with the statistic that roughly 91.38% of Indonesian high school graduates are gainfully employed. [27]. Most lactating women are homemakers, whereas their husbands are employed in many industries.

Ranking Results

The initial stage in choosing the most suitable food basket is to ascertain the relative importance of each criterion. The weights of each criterion were determined using the Analytic Hierarchy Process (AHP), and the resulting weights for each criterion at this stage are provided in Table 5.

The findings of the AHP weighting indicate that breastfeeding moms in this study placed the nutritional value of the food basket as their highest priority, with a weight of 27%. Profound knowledge of the ingredients (18%) and the diversity of dishes prepared from those sources (17%) were noteworthy, indicating a preference for well-rounded and dependable culinary options. The significance of ease of preparation, cooking, and storage is underscored by its 15% weight, therefore emphasizing the necessity for convenience in food preparation. Although cost (12%) and children's preferences (11%) were also considered, their impact on decision-making was minimal.

Table 6. Positive ideal solution S_i^+, negative ideal solution S_i^-, relative proximity φ_i, and ranking of the food basket alternatives

Food Basket Alternative	S_i^+	S_i^-	φ_i	Rank
Food basket 3	0.013	0.048	0.780	1
Food basket 5	0.016	0.045	0.731	2
Food basket 4	0.018	0.047	0.720	3
Food basket 2	0.020	0.047	0.698	4
Food basket 1	0.024	0.052	0.684	5
Food basket 7	0.020	0.039	0.667	6
Food basket 6	0.024	0.038	0.608	7
Food basket 8	0.034	0.029	0.462	8
Food basket 9	0.040	0.023	0.364	9
Food basket 10	0.052	0.018	0.257	10

Consistent with the findings of Blešić *et al.* [28], the results indicate that cost ranks lowest among the selection criteria. The assessment revealed that customers prioritize preference aspects such as quality, flavor, and cultural relevance over cost. Furthermore, the research revealed that certain persons derive pleasure from a diverse range of food choices, inspiring them to allocate resources towards memorable meals rather than being only concerned with cost. Similar circumstances may be relevant to our case, as the mothers primarily served as beneficiaries of the food provision. This receiver position mitigates the significance of cost in their decision-making process. However, their primary emphasis lies on the taste and nutritional composition of the food. Cost considerations become more prominent when these mothers manufacture their own food baskets autonomously, aiming to reproduce the same composition while effectively managing their financial limitations.

Questionnaire results revealed that the primary determinant of choice was nutritional value, closely followed by familiarity with the contents rather than cost. Preference for food selection based on familiarity with the ingredients outweighed cost considerations. This discrepancy can be ascribed to divergent culinary preferences among the participants. Thus, although cost remains significant, the choice of ingredients has emerged as a more critical determinant in selecting decisions. In a subsequent phase, the criteria weights were utilized to choose the optimal food basket using the TOPSIS approach. At last, the ranking results are displayed in Table 6.

This analysis revealed that Food Basket 3 obtained the highest ranking due to its optimal balance between closeness to the optimal answer and distance from the worst solution, surpassing all other options. This basket possesses the smallest positive ideal solution, signifying its proximity to the ideal solution and the negative ideal solution, indicating its considerable distance from the worst-case situation. Therefore, this yields the maximum relative proximity value (). Meal basket three is priced at Rp 209,857 and has 1,854.96 kcal. It consists of rice (3.63 kg), duck eggs (1.16 kg), milkfish (0.65 kg), tuna (0.06 kg), cauliflower (0.17 kg), kale (3.46 kg), and dragon fruit (1.87 kg). Food Basket 1 ranks seventh in terms of nutritional value. Food basket 10 received the lowest ranking, suggesting that price had minimal impact on food choice; instead, preference for food content was more determining. This choice is attributed to the popularity, diversity, ease of preparation, and inherent favourability of the contents of food basket three among children.

Sensitivity Analysis

Sensitivity analysis refers to the evaluation of how variations in parameters or criteria weights impact the final choice. The aim is to quantify how the ranking of alternatives changes as criteria or input values changes, assuring the decision's consistency and robustness. This work presents a sensitivity analysis conducted at the last step to examine the correlation between the weights assigned in the Analytic Hierarchy Process (AHP) and the calculated closeness in the Topological Penetration Simulation (TOPSIS). The ranking results were evaluated by applying weight adjustments to all six criteria to detect significant changes. The sensitivity analysis is depicted in Figure 2.

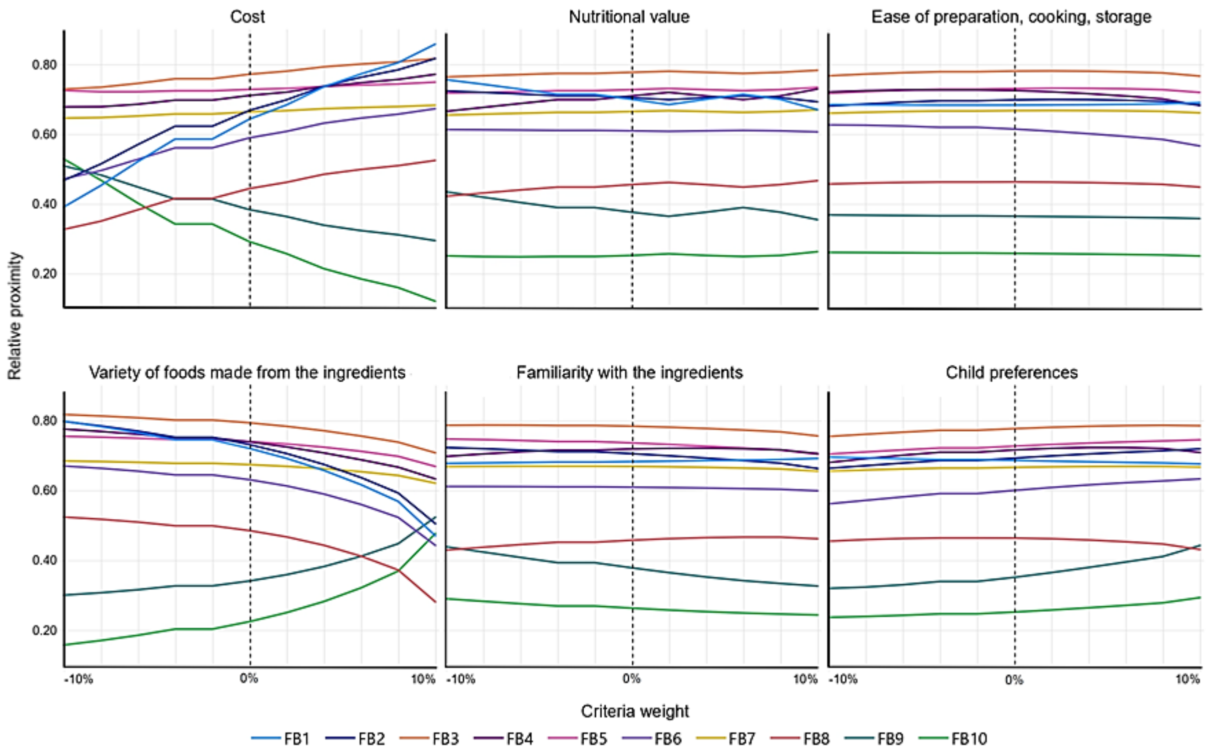

Figure 2. Sensitivity analysis exploring the impact of weight adjustments on food basket ranking. Each criterion's weight was systematically adjusted by ± 2%, resulting in 11 different weight combinations per criterion. The x-axis shows the percentage change in weights, where 0% represents the initial weights. The y-axis indicates the resulting food basket rankings

Adjustments were performed in Figure 2 by implementing 2% increments and reductions for each criterion. Insignificant changes are observed in the graphs pertaining to nutritional value, simplicity of preparation, cooking and storage, acquaintance with the ingredients, and kid preference. Significantly, while cost was assigned a lesser importance in the Analytic Hierarchy Process (AHP) study, the sensitivity analysis revealed that a slight modification in its weighting could result in a substantial alteration in the ranking of the food basket, as demonstrated in the cost graph. Furthermore, notable modifications were seen in the meal variations generated from the grocery chart. Considering the substantial influence of meal fluctuations, it is evident that even a minor weight modification might yield significant results. However, the mean ranking across all charts indicated that food basket 3 remained in its foremost place without any changes. Hence, the optimal choice was established as food basket 3, comprising 3.63 kilograms of rice, 1.16 kg of duck eggs, 0.65 kg of milkfish, 0.06 kg of tuna, 0.17 kg of cauliflower, 3.46 kg of kale, and 1.87 kg of dragon fruit.

Conclusions

This study emphasizes the need to tackle stunting in children under five using efficient nutrition measures, such as offering well-portioned food baskets. While prior studies have frequently neglected beneficiaries' choices, taking these preferences into account can guarantee satisfaction, cultural suitability, and practical convenience. The present study examines the preferences of mothers and children when choosing food baskets to prevent stunting. The research employs a multi-criteria decision-making model that combines the Analytic Hierarchy Process (AHP) and Top-Ranking Software Integration (TOPSIS). During the initial phase, AHP allocates weights to six criteria: affordability, nutritional effectiveness, simplicity of preparation, cooking and storage, diversity of meals produced, familiarity of components, and kid preference. During the second phase, TOPSIS evaluated and determined the top food baskets according to established criteria. Findings from the Analytic Hierarchy Process (AHP) technique indicated that nutritional value was the primary factor (27%), followed by knowledge of the ingredients (18%), diversity of meals prepared from the ingredients (17%), simplicity of preparation, cooking, and storage (15%), cost (12%), and kid preference (11%). Therefore, by taking into account preferences, it is possible to achieve a balance between the predominant emphasis on cost in food and nutrition basket design. This, in turn, may enhance the acceptance and efficacy of tailored solutions to prevent stunting. Following the TOPSIS analysis, food basket three was the most suitable option. It comprises rice (3.63 kg), duck egg (1.16 kg), milkfish (0.65 kg), tuna (0.06 kg), cauliflower (0.17 kg), kale (3.46 kg), and dragon fruit (1.87 kg).

The findings indicate that when creating food baskets, it is essential to prioritize aspects such as simplicity of preparation, particularly in rural regions where refrigeration and storage facilities are restricted and costly. Specifically, the food basket in these regions should incorporate a greater variety of easily prepared, cooked, and stored goods. Conversely, metropolitan regions with superior availability of these amenities provide greater adaptability in incorporating many kinds of cuisine that may necessitate more intricate recipe preparation. Future studies should focus on building a comprehensive approach for creating ideal food baskets using mathematical programming techniques. This approach should prioritize the identification of the optimal combination of meals to fulfill particular nutritional requirements, considering parameters such as budget, food availability, and distribution logistics. The objective is to design a food basket that fulfills nutritional requirements and adheres to financial and logistical limitations. Furthermore, it is recommended that future studies investigate approaches to enhance the effectiveness of food basket distribution by strategically selecting distribution locations to optimize logistical operations. This will guarantee that food assistance can be deployed to people requiring it faster and more precisely. Implementing these measures will enhance food distribution schemes' efficiency and offer recipients more effective assistance.

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