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Development and validation of a nutritional education model for malnourished preschool children in Malaysia

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ABSTRACT

Malnutrition in children is a serious public health concern that can lead to developmental delays, stunted growth, speech difficulties, and cognitive impairments, often resulting in long-term disabilities. This study aimed to develop and validate a comprehensive nutritional education model to address malnutrition among Malaysian preschool children. The model was designed in alignment with policies and guidelines from the Malaysian Ministry of Education (MOE) and the Ministry of Health (MOH) to ensure its relevance and practicality. Using a Design and Development Research (DDR) approach, the study was conducted in three phases. In Phase One, semi-structured interviews with four teachers and three mothers of malnourished preschoolers were used to gather information on educational needs. Phase Two involved a focus group discussion with five experts to identify key components of the model, followed by the Fuzzy Delphi Method (FDM) with six experts to refine these elements. In Phase Three, the Nominal Group Technique (NGT) with five experts was used to confirm the model's applicability. The final model consists of three main components—home, school, and community—comprising eight, five, and four elements, respectively. This model offers a structured and context-specific approach to nutritional education and serves as a practical tool for educators and policymakers in addressing early childhood malnutrition in Malaysia.

1. Introduction

Malnutrition remains a critical issue affecting children globally, particularly in developing countries, including Malaysia. The issue impairs physical growth, cognition, and development in children. Furthermore, malnourished children are at increased risk of being classified as children with special needs. The impacts of malnutrition might also perpetuate a poverty and poor health cycle, necessitating intervention (Ooi et al., 2023).

In this study, a comprehensive nutritional education model targeting malnourished Malaysian preschool children is proposed. The suggested model aimed to create a coherent and effective educational framework to address the nutritional requirements of the vulnerable population. Policies outlined by the Malaysian Ministry of Education (MOE) and the Ministry of Health (MOH) were also incorporated.

A significant coexistence of undernutrition and overnutrition, commonly termed the 'dual burden' of malnutrition, has been observed in Malaysian children between one and five years old. This phenomenon suggests that some children have inadequate nutrient intake, leading to stunting or wasting, whereas others have an excess that contributes to obesity. Predominant risk factors contributing to undernutrition in children within the age group include inadequate dietary intake that fails to meet basic nutritional requirements and persistent feeding issues, potentially hindering proper growth and development (Lee et al., 2022), revealing broader obstacles in improving nutrition quality and eating habits. Consequently, targeted interventions and improvements in early childhood nutrition in Malaysian public health are vital.

Malnutrition negatively affects development in children (Allen and Saunders, 2023; Siddiqa et al., 2024). Malnutrition and acute malnutrition also hinder physical growth, brain development, motor-sensory skills, and learning ability (Saleem et al.,

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2021). Malnourished children also frequently exhibit low energy, are susceptible to illnesses and anaemia due to weakened immune systems, and lack interest in playing, learning, and socializing with peers (Allen and Saunders, 2023; De and Chattopadhyay, 2019; Saleem et al., 2021). Accordingly, Malaysia has integrated the Social Protection Program under the National Social Policy in 2003. The initiative provides training, education, and awareness raising to enhance nutrition knowledge and promote healthy eating practices among individuals within the B40 bracket. The B40 represents the bottom 40% of income earners, typically consisting of low-income families potentially facing financial challenges and requiring financial aid and social support from the government. Nevertheless, the Coronavirus-2019 (COVID-19) pandemic has minimized the social protection Malaysia offers compared to its high-income counterparts (Rahman et al., 2024).

In a report United Nations Children's Fund (UNICEF) highlighted that the Malaysian Social Protection Program was in the form of cash transfers to protect low-income (B40) households affected by the COVID-19 pandemic from poverty and food insecurity (UNICEF, 2020). Nevertheless, global research indicated that long-term nutritional benefits can only be achieved when the initiatives are well-aligned with nutrition-focused educational interventions to mitigate the malnutrition crisis plaguing the B40 category. The MOE has also implemented the Supplementary Food Program (RMT) for primary school students from the B40 group. Nonetheless, the food quality inadequately addresses the requirements of children suffering from malnutrition and acute malnutrition. As such, malnutrition remains a vital concern, exacerbated by COVID-19, urgently necessitating a targeted nutritional education model focusing on solving the malnutrition issues affecting preschool children.

The first objective of this study was to identify the need for a nutrition education model. The proposed model should be centered on malnourished preschoolers to understand the context and challenges the children encounter in accessing effective nutrition education. Secondly, this study aimed to design and develop a comprehensive nutrition education model for malnourished preschool students based on the consensus provided by nutrition and early childhood education experts, ensuring the suggested model is relevant and suitable for the target population. Finally, the current study evaluated the applicability of the developed model by referencing expert opinions and consensus to ensure its practical implementation and effective function within nutrition education.

2. Literature review

The COVID-19 pandemic that began in late 2019 had notable impacts on worldwide nutrition, particularly on vulnerable populations, including low-income and marginalized communities. Disrupted food supply chains and decreased access to nutritious food have significantly worsened malnutrition, specifically among preschool children. Extensive surveys conducted by international organizations, such as UNICEF, the World Health Organization (WHO), and the World Bank Group, to establish malnutrition prevalence and trends among children (WHO, 2024) revealed the inadequate and unsatisfactory progress of current initiatives addressing malnutrition. The programs are significantly behind attaining the targets set by the WHO for 2025 and the 2030 Sustainable Development Goals (SDGs), highlighting the urgency for more effective intervention strategies.

The considerable food price hikes in 2022 compounded the persistent COVID-19 pandemic. The matters exacerbated malnutrition issues, particularly among preschool children from low-income families, disproportionately impacted by economic fluctuations. A survey by UNICEF (2021), "Families on the Edge," demonstrated the direct and significant impacts of economic hardships on the respondents' food access and consumption patterns. Families facing loss or reduced income exhibited behavioral modifications regarding food access, where most adopted more conservative food spending practices. Alarmingly, an average 9% decrement in food expenditure was observed even in households that retained employment, but they maintained their overall monthly household spending at pre-pandemic levels (UNICEF, 2021). The outcomes revealed a broader trend of food insecurity emerging due to the pandemic from the critical resource reallocation in response to financial instability.

Parents express concerns about their children's educational requirements and ability to procure sufficient income to provide adequate nutrition, even with the gradual recovery of the national economy (Dattilo et al., 2020). Nevertheless, the beneficiaries of the provisions remain limited. Urban B40 households also reported increasing challenges in attaining satisfactory nutritional standards for their children from the ongoing inflationary pressures. The situation raises significant questions about the nutritional security of families still struggling to provide a diet sufficient for the healthy growth of their children.

Nutritional education programs mainly aim to improve parents' knowledge and attitudes about healthy eating (Collado-Soler et al., 2023). However, these efforts are not strongly reflected in key policy documents, such as the revised National Preschool Curriculum Standards (Kurikulum Standard Prasekolah Kebangsaan, KSPK) introduced in 2017. This curriculum does not include clear strategies to teach young children about nutrition or promote positive attitudes towards healthy eating. Introducing correct nutritional information at an early age can help shape children's understanding and behaviors, especially those from low-income (B40) families who are more likely to suffer from

undernutrition and food insecurity. Building a strong foundation in nutrition during early childhood can lead to lifelong healthy eating habits, which are important for overall well-being. Therefore, nutrition education should be part of preschool programs and supported at home (Vitale and Coccia, 2023). Research also shows that promoting healthy eating habits early in life can have long-term positive effects, helping raise healthier and stronger future generations (Schmitt et al., 2019).

A requirement analysis for developing a balanced nutrition teaching module revealed that specific educational modules potentially significantly enhance understanding and attitudes toward nutrition among children, critically shaping their long-term dietary habits. The educational initiatives provide critical food selection knowledge and promote active engagement, encouraging children to adopt healthier eating behaviors early. For instance, ToyBox Malaysia and the Southeast Asian Nutrition Surveys (SEANUTS) were introduced to indirectly improve nutrition by targeting childhood obesity. The strategies failed to provide solutions for malnourished children.

Although ToyBox Malaysia was an inexpensive, school-based intervention program against childhood obesity conducted throughout 10 European nations, the Malaysian initiative was limited to the students of KEMAS kindergartens. The project was also not centered on nutritional education (Reeves et al., 2018). Similarly, SEANUTS, the first large-scale nutritional study on Malaysian children, did not have frameworks for increasing and improving healthy eating habits among children. The situation urgently requires innovative and comprehensive school-based educational models tailored to malnourished children.

Childhood obesity and general nutrition have been the predominant focus of existing initiatives (Sotiraki et al., 2022). Available educational interventions targeting the unique requirements of children from low-income families (B40) facing malnutrition risks are insufficient. Direct and curriculum-based initiatives nurturing early nutritional understanding and positive attitudes among preschoolers are also unavailable. Effective learning involving children and educators in classrooms might be attained with a comprehensive educational model. Developing models engaging preschoolers to learn about healthy eating habits and balanced nutrition is crucial for fostering nutritional knowledge and promoting lasting nutritional alterations, particularly within the B40 community. Children empowered with the knowledge and skills to make informed dietary choices might also lead healthier lives away from the cycle of malnutrition, enabling them to thrive in their future endeavors.

3. Research methodology

Quantitative and qualitative techniques were adopted in this study. A notable understanding of the complexities of nutrition education for preschoolers, particularly the malnourished demographic, was procured. The proposed model was developed and evaluated in three phases. The applicability of the model in real-world settings was also assessed (2).

3.1. Phase 1: Semi-structured interviews

The educators and parents interviewed in the present study offered detailed and diverse perspectives on nutrition education-related obstacles. Four preschool teachers and three mothers of malnourished preschoolers were provided with a semi-structured survey in the first phase. Key themes regarding knowledge, awareness, and interests of preschool teachers and parents on nutrition education were obtained through thematic analysis, forming the basis for the subsequent procedures in the current study.

3.2. Phase 2: Focus group discussion and fuzzy Delphi method

The second phase of this study consisted of focus group discussion (FGD) and the Fuzzy Delphi method (FDM). During the FGD, five nutrition and early childhood education experts focused on identifying the components essential to developing the proposed nutrition education model. The data were then subjected to thematic analysis. Meanwhile, critical segments in the suggested model were determined via a structured questionnaire during the FDM. The phase ensured systematic and organized data collection. Six experts established the validity and relevance of the developed model to the target population during the FDM. The method was applied due to its capability to obtain detailed and flexible feedback through Fuzzy logic in uncertain settings (Özok, 2024). Triangular fuzzy numbers and defuzzification were then employed to interpret the expert consensus effectively. This study set a threshold value (d) of 0.2 (Ariffin et al., 2018) and over 75% consensus (Harvey and Holmes, 2012). Clarity and consistency were ascertained by calculating the threshold value (d) with Eq. 1.

$$d(\bar{m},\bar{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \quad (1)$$

A fuzzy score (A) reflecting the collective opinion of the experts was obtained through defuzzification. Only values under 0.5 α-cut were accepted (Bodjanova, 2006). Eq. 2 was employed during defuzzification to procure a rigorous analytical model.

$$A_{max} = \frac{1}{3}(a_1 + a_m + a_2) \quad (2)$$

3.3. Phase 3: Nominal group technique

The nominal group technique (NGT) conducted during the final phase of this study assessed the

applicability of the developed model. Five early childhood education experts evaluated the proposed model through a structured questionnaire. The experts were selected based on the specific requirements outlined in this study, ensuring directly relevant expertise.

The third phase was primarily performed to procure expert consensus on the components of the suggested model. The phase evaluated the potential effective implementation of the model in preschool nutrition education. The consensus provided by the experts was quantified with Microsoft Excel to calculate voting scores. A predetermined acceptance threshold of 70% or higher was then employed to interpret the obtained values, which aligned with the attribute established by McMillan et al. (2016). The approach objectively determined the applicability of the model.

4. Results

4.1. Phase 1: Semi-structured interviews

The interviews with teachers and parents in Phase 1 revealed several vital factors for designing a nutrition education model for preschool children (Table 1). In this study, the respondents were labelled with specific codes to ensure the confidentiality of their identities. The current study employed the letter 'T' to denote the teacher respondents, while the letter 'P' refers to the mothers (parents). For example, T1 denotes Teacher 1, and P1 denotes Parent 1. A total of four teachers (T1 to T4) and three mothers (P1 to P3) participated as part of the study sample. One of the teachers (T1) stated, "For me, it is good for children to start from school, especially at the preschool level. It is more about activities. The response highlighted the importance of integrating engaging activities into nutritional education at an early age. Meanwhile, another respondent teacher (T2) expressed the necessity for resources, stating, "Teachers need to have modules and training so that we, as teachers, know what is required for us to teach." The teacher underscored that professional development and structured training are required to equip educators with the knowledge and skills to deliver effective nutrition education.

A respondent parent (P3) emphasized that guidance is critical, "So, if there are guidelines or early models, especially for new parents, it would be beneficial. Perhaps even during pregnancy, there should be information about this module, so they already know what to do. It would be great if there were." The statement indicated a demand for comprehensive resources that facilitate parental understanding of nutritional requirements and practices since pregnancy. Another parent (P1) also underscored the value of a framework applicable by parents to evaluate their children's nutrition, stating "I feel it is necessary for us and parents to be able to see the framework of the model, to assess the nutritional status of our children—whether they are receiving adequate nutrients or not." The insights revealed that structured resources and teacher training are necessary to support parents and educators in promoting better nutrition practices for children.

Table 1: Summary of key findings from interviews

Theme	Key finding
Awareness	Low understanding of nutritional needs among parents
Educational resources	Lack of accessible materials for teachers
Engagement	Need for more interactive programs

4.2. Phase 2: FGD and FDM

During the FGD, several critical elements were proposed by the panel of experts, which were vital for developing the proposed nutrition education model. The criteria particularly emphasized the role of teachers. The panel stated that fostering a positive relationship with food among students is vital, highlighting how educators can facilitate the connection through activities and lessons. Furthermore, increasing awareness of balanced nutrition among teachers was essential, as the knowledge directly affects their ability to successfully educate children on healthy eating habits.

The experts suggested that providing teachers with training and resources could effectively promote maternal nutrition awareness among parents, as they understand that a mother's dietary selections significantly influence her children's nutritional outcomes. The discussion also highlighted that empowering teachers with the necessary knowledge and skills to educate families on healthy eating practices might result in a significant reduction in malnutrition.

During the FGD in this study, the panels proposed that teachers engage in community initiatives that foster interactions with food and advocate hands-on activities and healthy feeding practices in classrooms. The elements reflect the crucial role teachers have in nurturing a nutrition education culture. They can also contribute to equipping children and families with the tools necessary for healthier dietary choices and improved nutritional status. Accordingly, the experts established three primary components: home, school, and community (Fig. 1).

Other than FGD, the primary focus in phase two was designing and developing the proposed model. The FDM results demonstrated a notable consensus among the experts regarding the components in the suggested model. Fig. 2 illustrates the suggested nutrition education model for malnourished preschoolers, detailing the three main components and their respective elements.

Based on Table 2, the overall average of each element evaluated by the experts recorded threshold values (d) under 0.2, indicating their acceptance by the panel. Elements 1, 2, 3, 4, 5, and 7 documented a 0.000 threshold value (d), while elements 6 and 8

were 0.085 and 0.255, respectively. In the triangular fuzzy number criteria for expert consensus percentages, each element received agreement from the experts, recording over 75%. The data aligned with the criteria recommended by Harvey and Holmes (2012). Expert consensus was also achieved for defuzzification, where the obtained α-cut values exceeded 0.5 as recommended by Bodjanova (2006). The results indicated that the panel attained a consensus in accepting the elements.

All five elements under the school category record threshold values (*d*) under 0.2, as listed in Table 3. The findings revealed that the study experts agreed and accepted all components. Each element also achieved an expert consensus of 100%, exceeding the 75% predetermined threshold. The defuzzification values for the elements in the school component are also presented in Table 3. Elements 1 through 5 documented a 0.800 α-cut defuzzification value, which was over the 0.5 threshold. The data indicated that the panel accepted the elements in the proposed model.

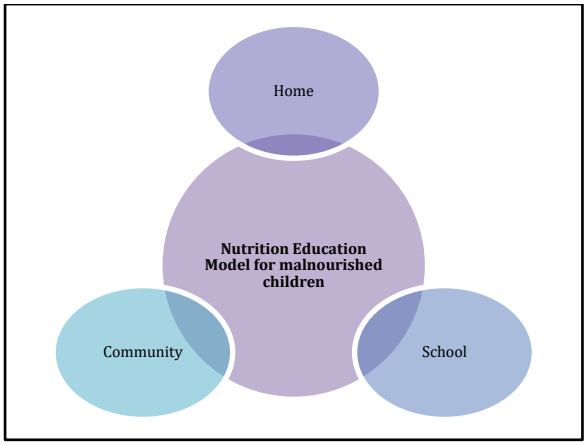

Fig. 1: The three principal components in the suggested nutrition education model for malnourished preschool children

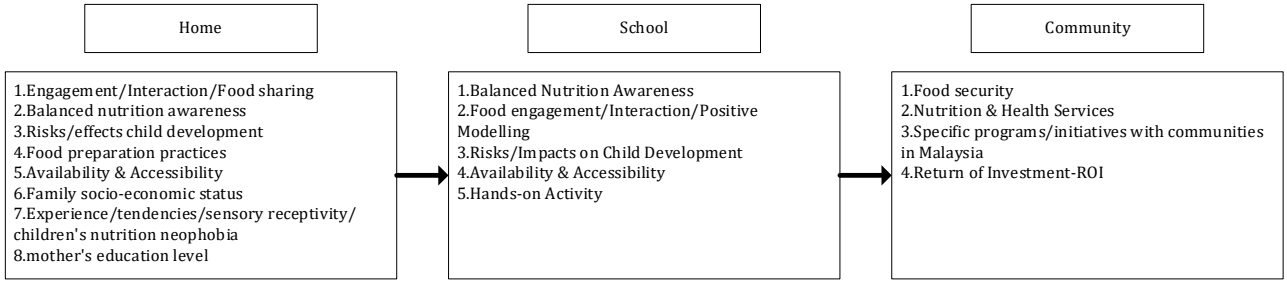

Fig. 2: The proposed nutrition education model for preschool children experiencing malnutrition

Table 2: The home element

No.	Item or element	Triangular fuzzy number conditions		Fuzzy evaluation process conditions				Expert agreement	Accepted element	Ranking
		Threshold value (d)	Expert group agreement (%)	m1	m2	m3	Fuzzy score (A)			
1	Engagement/interaction/food sharing	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
2	Balanced nutrition awareness	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
3	Risks/effects on child development	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
4	Food preparation practices	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
5	Availability and accessibility	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
6	Family socio-economic status	0.085	100.00	0.567	0.767	0.967	0.767	Accept	0.767	7
7	Experience/tendencies/sensory receptivity/children's nutrition neophobia	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
8	Mother's education level	0.255	83.33	0.500	0.700	0.900	0.700	Accept	0.700	8

Table 3: The school component

No.	Item or element	Triangular fuzzy number conditions		Fuzzy evaluation process conditions				Expert agreement	Accepted element	Ranking
		Threshold value (d)	Expert group agreement (%)	m1	m2	m3	Fuzzy score (A)			
1	Balanced nutrition awareness	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
2	Food engagement/interaction/positive modelling	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
3	Risks/impacts on child development	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
4	Availability and accessibility	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
5	Hands-on activity	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1

According to Table 4, the threshold (*d*) values for elements 1, 2, 3, and 4 were recorded as 0.000. All four elements also achieved 100% expert consensus. The acceptance demonstrated by the panel met the primary requirements of the triangular fuzzy number criteria. The defuzzification values, ranging between 0.7 and 0.8, also reflected expert consensus on the proposed elements, resulting in their 'Accepted' status.

Table 4: The community element

No.	Item or element	Triangular fuzzy number conditions		Fuzzy evaluation process conditions				Expert agreement	Accepted element	Ranking
		Threshold value (d)	Expert group agreement (%)	m1	m2	m3	Fuzzy score (A)			
1	Food security	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
2	Nutrition and health services	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
3	Specific programs/initiatives with communities in Malaysia	0.000	100.00	0.600	0.800	1.000	0.800	Accept	0.800	1
4	Return on investment (ROI)	0.000	100.00	0.567	0.767	0.967	0.767	Accept	0.800	1

4.3. Phase 3: NGT

The final phase of this study focused on assessing the applicability of the developed model. The third phase employed the NGT and involved five expert practitioners. Table 5 summarizes the assessment overview of the seven core items. Based on the findings, the experts assigned the 'Accepted' status to all items, documenting average scores between 84% and 96%. The significant scores validated that the development of the proposed model successfully met its objectives. Furthermore, the model offers a clear and structured framework for nutrition education designed for malnourished preschool children.

Table 5: The overall usability assessment of the model

No.	Assessment of the overall usability of the model	Experts					Score	Percent (%)	Status
		P1	P2	P3	P4	P5			
1	Can the suggested model aid preschool teachers in planning nutritional education through the proposed elements?	4	4	5	5	5	23	92	Accept
2	Is the developed model suitable as a reference source for knowledge on the nutrition of malnourished preschool children?	5	4	5	5	5	24	96	Accept
3	Does the developed model clearly show the relationship between elements that contribute to knowledge about nutrition for malnourished preschool children?	4	4	5	5	5	23	92	Accept
4	Is the developed model a suitable reference source for fostering an accepting attitude towards nutrition among preschool children suffering from malnutrition?	4	4	5	5	4	22	88	Accept
5	Does the proposed model demonstrate the relationship between elements that nurture an accepting attitude towards nutrition in malnourished preschoolers?	5	4	4	5	4	22	88	Accept
6	Does the developed model provide a clear overall picture of nutrition education in aiding preschool children suffering from malnutrition?	4	4	5	5	5	23	92	Accept
7	Does the proposed model offer a clear overview of nutrition education in fostering an accepting attitude among preschool children experiencing malnutrition?	4	4	4	5	4	21	84	Accept

5. Discussion

Developing a comprehensive nutrition education model for malnourished children is essential in addressing an ongoing public health challenge. The proposed model is also particularly timely as early childhood nutrition is critical in determining long-term health outcomes. The model offers an inclusive approach by considering various perspectives and practical and evidence-based strategies. The opinions of diverse stakeholders, including preschool teachers, parents, and early childhood education and nutrition experts, were also involved.

The proposed model in this study was defined based on the information gained during the first phase. Meanwhile, the principal components of the model were refined according to the expert opinions offered during FGD and FDM in the second phase. The final procedure, NGT, ascertained the practical application of the developed model.

The teachers interviewed regarded structured resources, such as teaching modules, as vital in nutritional interventions involving children, as they might face challenges in delivering consistent, high-quality nutrition knowledge without such resources. Providing professional development and training can also empower teachers with the skills necessary to effectively disseminate nutritional knowledge, preventing restricted success due to inadequate training (Collado-Soler et al., 2023). The educators also stressed the importance of integrating nutrition education into daily preschool activities, aligning existing evidence on introducing and reinforcing healthy eating habits during early childhood (Schmitt et al., 2019). Early guidance was also the principal element stated by the parents interviewed in this study. Ideally, starting during pregnancy, nutritional guidance is essential to nurturing healthy eating habits. Another insight is clear and accessible frameworks for assessing children's nutritional health to enable the parents to monitor and support their children's nutrition at home, per the findings reported by Vitale and Coccia (2023).

The panel of experts in the current study agreed on incorporating several elements as core components of the proposed model, such as nutritional awareness, food security, and promoting balanced meals. The components aligned with the findings Kirk et al. (2021) noted. The data also revealed the myriad of socio-economic and cultural parameters influencing nutrition practices, particularly in low-income families. The theoretical and practical soundness of the suggested model was validated following the rigorous and systematic key theme identification during FDM. Involving practitioners in model development to establish actual situation viability is vital (McMillan et al., 2016). The model suggested in this study and its components attained significant approval from the experts, who documented consensus between 84%

and 96%. The results indicated the feasibility and readiness of the proposed model for implementation in real-world settings. The teacher training, curriculum integration, and community involvement were also notably accepted by the panel, as they are essential for successful nutrition education programs in preschools.

The nutrition education model proposed in the current study provides a valuable framework for addressing the nutritional requirements of preschool children, particularly those facing malnutrition risks. The holistic approach of the suggested model, integrating home, school, and community components, is crucial in advocating sustainable eating habits. The developed model might also offer information on future nutrition education initiatives and policy development strategizing to address childhood malnutrition. Nevertheless, contextual adaptation and further evaluations in real-world settings are necessary. Ascertaining the scalability and effects of the developed model through pilot studies, real-world validation, and adaptability to different educational contexts and age group assessments are also vital. Nonetheless, the model has several limitations. The framework might document variations when involving different cultures and resources. The success of nutrition education programs is significantly correlated to local factors, such as community support, resource availability, and cultural attitudes toward nutrition, requiring adapting the suggested model to local contexts, specifically in diverse geographical settings. Longitudinal assessments determining the effectiveness of the interventions in improving children's nutritional status and behavior over time are vital (Kirk et al., 2021). The practical influence of the suggested model in real-world settings was also restricted as pilot tests and control groups were not conducted, necessitating consideration in future studies.

6. Conclusion

A comprehensive nutrition education model targeting malnutrition among preschool children was successfully developed in this study. The framework boasts a holistic, multi-stakeholder approach, which includes schools, parents, and communities. Balanced nutrition education is also integrated into the preschool curriculum with teacher training, clear guidance for parents, and community collaboration, providing enhanced support. The practical and research-founded framework is a basis for elevating early childhood nutrition to mitigate malnutrition and promote healthier lifelong habits.

The adaptability of the developed model presents opportunities and challenges. The model is predominantly flexible and adaptable to various educational and cultural contexts. The model was also developed by involving diverse stakeholders, including teachers, parents, and experts. Nevertheless, the successful implementation of the developed model relies upon the availability of local resources, community support, and alignment of the components in the model with the unique nutritional requirements and cultural practices of each setting. Communities consisting of varying socio-economic conditions might require different strategies to engage parents and ensure consistent access to nutritious foods. Similarly, cultural norms on food selections could influence nutrition education messages that effectively resonate with the target audience.

The application of the proposed model faces notable limitations, even though it demonstrated adaptability. Based on the specific cultural, economic, and institutional contexts of each community, the applicability of the model in diverse settings may vary. Nutrition education interventions frequently face barriers concerning local resource availability, community engagement, and local dietary habits. Consequently, further contextual adaptation is necessary to ensure relevance and success in different regions of the proposed model, particularly in rural or resource-limited areas. Furthermore, the current study focused on the usability of the model rather than its effectiveness in real-world settings. Further empirical analysis, including pilot studies and longitudinal assessments, to validate its effects on children's health outcomes, is required, even with the experts' positive feedback on the components of the model. Determining the long-term effects of nutrition education programs on children's eating behaviors and overall health is also critical. Moreover, the absence of control groups in this study prevented definitive conclusions from being drawn on the causal effects of the suggested model on malnutrition or related well-being.

As the model was designed to focus on preschool-aged children, it may not directly address the requirements of older children or other vulnerable populations at risk of malnutrition. Consequently, future studies could explore the adaptability of the developed model in primary schools or other educational settings to expand its potential in combating malnutrition across diverse age groups. Although the integration of home, school, and community components makes the proposed model well-suited for addressing issues, such as food insecurity in low-income families, it could face challenges in areas with limited community engagement or low parental involvement levels.

The nutrition education model developed in this study provides a promising solution for addressing preschool malnutrition. Nevertheless, the full effects of the developed model can only be assessed through continued research and real-world assessments. Pilot studies, long-term evaluations, and adaptation in broader settings are also essential to determine the scalability and diverse applicability of the suggested model. Following validation, the proposed model also offers the potential to contribute to national policies and educational reforms, setting a precedent for including nutrition education as a core component of early childhood curricula. Ultimately,

the developed model could facilitate nurturing healthier and more resilient future generations by equipping children with the knowledge and skills necessary to make informed, nutritious food choices.

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Compliance with ethical standards

Ethical considerations

The present study was conducted following ethical guidelines and gained approval from the Human Research Ethics Committee of Sultan Idris Education University. All participants also provided informed consent.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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