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Original Article

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Effectiveness of a 90-day local food-based supplementary feeding program in improving nutritional status among undernourished toddlers: A pre-experimental study

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ABSTRACT

Introduction: Malnutrition is a significant global health issue, particularly in Indonesia. The Sragen District is a priority area for malnutrition prevention. Various nutrition programs, including a 90-day local food-based supplementary feeding program (PMT), were conducted. This study aimed to evaluate the effectiveness of this program in improving anthropometric outcomes in stunted or wasted toddlers.

Methods: We conducted a pre-experimental study with a one-group pretest-posttest design without a control group in the Plupuh sub-district, Sragen District, Central Java. The sample consisted of 163 stunted or wasted toddlers enrolled in a 90-day PMT program. Nutritional status was determined using Z-scores calculated using the WHO Anthro application. Weight and length/height were measured at baseline and repeated every four weeks until the end of the 90-day intervention period. Data were analyzed using paired t-tests, and effect sizes were calculated using Cohen's d.

Results: After the intervention, the mean weight increased by 1.53 kg and the mean height by 1.33 cm ($p < 0.05$). The Z-scores for weight-for-age, height-for-age, weight-for-height, and BMI-for-age improved significantly across all age groups ($p < 0.05$). Changes in nutritional status were observed in 50.92% of respondents based on weight-for-age measurements. The distribution curves for all the indices shifted toward the reference population. The intervention had a medium effect on weight gain (Cohen's d = 0.631) and a small effect on height gain (Cohen's d = 0.181).

Conclusions: A 90-day supplementary feeding program using locally sourced foods significantly improved the weight and height of undernourished toddlers. Program sustainability requires strengthening family and community involvement through nutrition education and training in local food processing.

Keywords: local food, malnutrition, nutritional status, supplementary feeding

Introduction

Stunting is a major nutritional problem worldwide. This indicates malnutrition, wasting, and being underweight (Verma and Prasad, 2021). Approximately 148 million children under five years of age were stunted by 2022. The global prevalence decreased from 40.2% in 1990 to 22.3% in 2022. The prevalence of stunted children under five years of age is still high in Africa and South East Asia, above 30% (World Health Organization, 2024).

Indonesia ranks third in terms of the number of malnutrition cases in Southeast Asia. Data from the Indonesian Health Survey 2023 show that stunting among Indonesian children under five years of age is approximately 21.5% (Health Development Policy

Agency, 2024). This figure has decreased from the 2013 and 2018 Basic Health Research data, which were 29.5% and 29.7%, respectively (Andriani *et al.*, 2023).

Malnutrition is associated with increased mortality and morbidity in children under five. Approximately 17% of under-five deaths are related to stunting, which is caused by diarrhea or pneumonia (Vaivada *et al.*, 2020). Malnutrition has both short- and long-term impacts. Long-term malnutrition can lead to neurodevelopmental, cognitive, and behavioral changes, as well as mental health impacts through complex mechanisms. This will impact children's abilities and achievements in the future (Kirolos *et al.*, 2022). Research in Surabaya shows that children with stunting have a greater risk of experiencing developmental delays in the first three years of life. They experience delays in non-language visual-motor and language skills compared to those in unstunted children (Mustakim *et al.*, 2022).

Sragen District has the highest stunting rate in Central Java (32.4%), driven by poverty and limited dietary diversity. Although Indonesia's national stunting rate is 21.5%, localized interventions are critical for high-burden areas (Wulandari and Suparti, 2022; UNICEF and Ministry of Health, 2023). The target of reducing stunting to 14% by 2024 is challenging to achieve (UNICEF and Ministry of Health, 2023). Various efforts continue to be made to reduce the incidence of stunting, including providing additional food for toddlers who are at risk of malnourishment. It is a key effort to achieve Sustainable Development Goal (SDG) target 2.2.1, which aims to eliminate all forms of malnutrition by 2025, including stunting and wasting in children under five (World Health Organization, 2024, 2025).

A wide variety of plants thrive in Indonesia, making it a highly promising source of nutritious foods. Each region has unique food sources and a variety of processed foods. Locally available foods provide a varied spectrum of nutrients that may better meet the complex nutritional demands of undernourished children than imported foods. Furthermore, these meals are more geographically and economically accessible, allowing easier program implementation. Importantly, the utilization of local foods increases sustainability because communities can continue to follow comparable dietary practices when the program ends.

Sragen is the second-largest food-producing region in Central Java. Optimizing the use of local food sources is key to reducing malnutrition (Fetriyuna *et al.*, 2021; Amadou and Lawali, 2022). The government implemented a supplementary feeding program for malnourished toddlers, utilizing local ingredients to prepare traditional foods. The nutritional quality of locally produced foods, including various animal and vegetable sources, is expected to meet the nutritional demands of toddlers and improve their nutritional status.

The Plupuh sub-district government implemented a 90-day local food-based supplementary feeding intervention (PMT) for toddlers who were stunted or wasted. The 90-day PMT program in Sragen included routine monitoring, during which weight and length measurements were collected at baseline, throughout the intervention period, and post intervention. However, these data have not been comprehensively analyzed to evaluate the program's effectiveness. This study is the first to systematically evaluate the program's impact on undernutrition outcomes in this population. This study aimed to measure the effectiveness of this local food-based supplementary feeding program on the nutritional status of toddlers.

Materials and Methods

Study Design and Setting

A key limitation of this study is the absence of a control group, which should be acknowledged. We conducted a pre-experimental study with a one-group pretest-posttest design without a control group to determine the effectiveness of a 90-day local food–based supplementary feeding program in improving anthropometric outcomes among stunted or wasted toddlers. The study did not include a control group because all malnourished toddlers in Plupuh were enrolled in this government program, making it ethically and practically impossible to have a non-intervention comparison group in the study. This program was implemented from August to October 2023, spanning 90 days and funded by the Special Allocation Fund for Health Operational Assistance. The target population was children under five years of age with a weight-for-age or length-for-age z-score of less than two standard deviations below the mean.

The children received supplementary food made from locally sourced foodstuffs, processed and distributed by three public kitchens managed by the cadres. Meals were served concurrently daily, with at least one full meal each week and the remainder as typical snack meals.

The design and preparation of PMT recipes were socialized to the cadres through cooking demonstrations. The Indonesian Ministry of Health has provided recipes based on the nutritional adequacy rate for children under five years of age. The intervention consisted of a 90-day supplementary feeding program, with toddlers receiving one daily serving. Each serving provided 200–450 kcal, with a Protein-to-Energy Ratio (PER) ranging from 10–16%, ensuring adequate energy and protein content tailored to the nutritional needs of stunted and wasted toddlers. The supplementary food was administered under the direct supervision of trained community health workers (cadres) who resided in the same villages as the participants to ensure adherence to the program. The health workers observed the children during feeding and recorded their daily compliance. Compliance data were

systematically collected and reviewed during the intervention period.

Anthropometric outcomes (weight and length/height) were assessed at baseline and subsequently every four weeks until the end of the 90-day intervention, allowing for longitudinal monitoring of changes. Anthropometric measurements were conducted by trained community health workers. Weight was measured using a calibrated digital scale (accuracy 0.1 kg), and length (for children under 24 months) or height (for children ≥ 24 months) was measured using a calibrated stadiometer (accuracy 0.1 cm). All equipment was calibrated prior to the start of data collection and was checked regularly throughout the study period.

The 17 locally based PMT menus are Fruit Pudding, Meatball Dumplings, Paklay Fish Rubuk Rice, Fruit Salad, Sun Soup, Solo Strait, Vegetable Fried Rice, Chicken Gadon, Cheese Shrimp Nugget, Catfish Balls, Tofu Chicken Sausage, Dimsum, Quail Egg Chicken Soup Rice, Chicken Porridge, Rainbow Meatballs, Banana Smoothies, and Guava Juice. The basic ingredients of the menus varied, including fruits, vegetables, protein sources such as fish, chicken, eggs, shrimp, and beef, and carbohydrate sources such as rice or potatoes, all sourced from local food sources. In addition, the mothers of the children received education and counseling on nutrition and healthy eating, as well as cooking demonstrations. Maternal education and household wealth were recorded but not controlled for due to data limitations.

Population and Sample

The population consisted of toddlers with stunting or wasting in the Plupuh Subdistrict, Sragen Regency, Central Java. The study participants were all stunted or wasted children (n=163) who received a 90-day supplementary nutrition program based on local food and had complete anthropometric data. Children were included if they were diagnosed with stunted growth and/or wasted based on WHO growth standards and participated in the full 90-day intervention. Stunting was defined as a height-for-age Z-score < -2.00, whereas wasting was defined as a weight-for-height Z-score < -2.00. Children with chronic illnesses or congenital abnormalities that could affect growth were excluded from the study.

Table 1. Subject characteristic

Characteristics	Number of Respondent (n)	Percentage (%)
Sex		
Male	78	47.6%
Female	86	52.4%
Age		
≤23 m.o	27	16.6%
24-35 m.o	66	40.4%
36-47 m.o	44	27.0%
48-59 m.o	26	16.0%

m.o = months old

Data Collection and Analysis

Health professionals and cadres measured the children's weight and height before and after the first, second, and third months of the intervention. Participants were recruited from the existing program registry in Sragen, and all eligible children who met the inclusion criteria were enrolled. The researcher gained access to the data after obtaining permission from the program manager. Z-score calculations were performed using the WHO Anthro application. The analyses were conducted using IBM SPSS version 23. A paired t-test was conducted to compare the z-scores before and after supplementary feeding. The difference test was significant at $p<0.05$. Cohen's d was calculated for continuous outcomes and used to estimate effect size.

Ethical Clearance

This study was approved by the Faculty of Medicine Ethics Committee of Universitas Islam Indonesia (number 3/Ka). Kom.et/70/KE/III/2024. Previously, the child's parents had been informed about this program and had expressed their willingness to participate. The program was designed with the child's comfort in mind, ensuring that it posed no danger or stress to either the child or the parents. There was no obligation to participate in this program, and participants were permitted to withdraw at any time during the program.

Results

The study involved 163 toddlers from the beginning to the end of intervention. No participant withdrew from the study. Most subjects were 24-35 months (40.4%) and female (52%). Table 1 presents the age and sex characteristics of the 163 toddlers involved in this study.

Table 2. Comparison of z-score before and after PMT program implementation by age group

	Z-score							
	Weight for Age		Height for Age		Weight for Height		BMI for Age	
	Before	After	Before	After	Before	After	Before	After
Ages								
All	-2.80	-2.18	-3.18	-2.82	-1.42	-0.82	-1.00	-0.45
≤ 23 m.o	-2.27	-1.58	-3.07	-2.23	-1.19	-0.82	-0.74	-0.47
24-35 m.o	-2.83	-2.13	-2.97	-2.65	-1.66	-0.91	-1.28	-0.55
36-47 m.o	-3.00	-2.48	-3.35	-3.20	-1.40	-0.70	-0.91	-0.25
48-59 m.o	-2.93	-2.42	-3.40	-3.04	-1.06	-0.83	-0.68	-0.54
Sex								
Boys	-2.85	-2.24	-3.29	-2.97	-1.61	-0.93	-1.11	-0.48
Girls	-2.74	-2.12	-3.05	-2.66	-1.20	-0.71	-0.87	-0.42

m.o = months old

Table 3. Number of children who have improved nutritional status after 90 days of intervention

Indicator	Frequency	Percentage
Height-for-Age	35	21.47%
Weight-for-Age	83	50.92%
Weight-for-Height	53	32.51%
BMI-for-Age	33	20.25%

Table 4. Bivariate analysis of mean z-scores before and after intervention

Indicator	Before	After	*p-value*
Z score for Weight-for-Age	-2.80	-2.18	<0.001
Z score for Height-for-Age	-3.18	-2.82	0.003
Z score for Weight-for-Height	-1.42	-0.82	<0.001
Z score for BMI-for-Age	-1.00	-0.45	0.009

The average body weight of toddlers showed a significant increasing trend ($p < 0.05$) (Figure 1). The results showed that after the three-month local PMT intervention, toddlers experienced an average weight gain of 0.38 kg in the first month, 0.43 kg in the second month, and 0.72 kg in the third month, with a total increase in body weight of 1.53 kg (16%). The range of weight change at the end of the intervention, compared with the baseline, was 0–2.6kg [95% CI (-0.829)- (-0.671)] (Table 5). The average body weight increased from 9.35 kg before the intervention to 10.88 kg after 90 days of supplementary feeding. The trend of increasing body length is shown in Figure 2. The average body length increased from 81.84 cm to 83.17 cm after the intervention.

Table 2 presents z-score data before and after 90 days of local supplementary feeding, categorized by age groups. The z-scores for weight-for-age, height-for-age, weight-for-height, and body mass index-for-age increased in all age groups of children. As indicated by the findings presented in Table 2, the preliminary analysis revealed that, on average, the children had low weight-for-height (weight-for-age Z-score: < -2.00) and stunting (height-for-age Z-score: < -2.00), except for the 6- to 11-month age group. In the 6- to 11-month age group, the BMI-based z-score was less than -2.00. The mean height of children under five years of age also increased by 1.33 cm (1.63%) from the baseline (Figure 2). The height change at the end of the intervention ranged from 0 to 20 cm [95% CI (-1.853) -(-0.857)]. The increase in height was significant ($p<0.05$). The intervention also increased the length-for-age z-scores in all age groups. The increase in

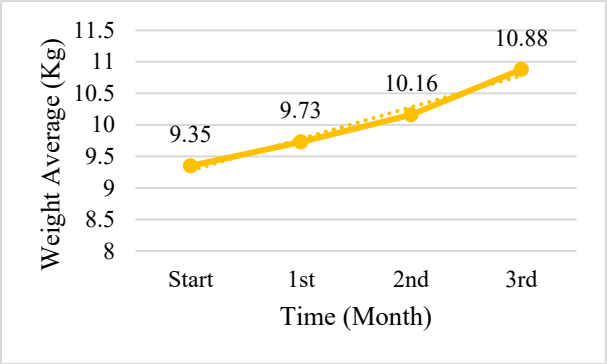

Figure 1. Trends in Changes in Average Weight of Toddlers

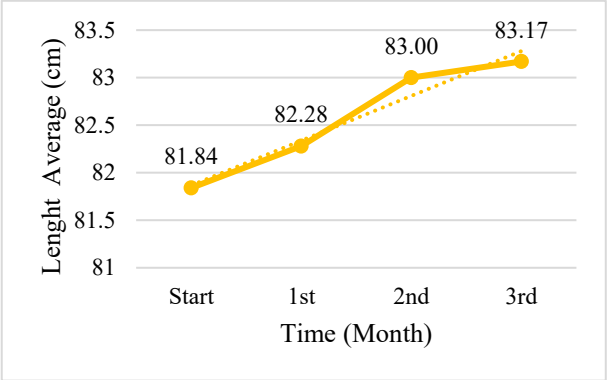

Figure 2. Trends in Changes in Average Toddler Body Length

length and z-score after the intervention was significant ($p <0.05$).

Changes in the nutritional status of each child did not always accompany changes in the average z-score values. In this study, 35 children (21.47%) experienced changes in nutritional status based on height-for-age z-scores, 83 (50.92%) based on weight-for-age z-scores, 53 (32.51%) based on weight-for-length z-scores, and 33 (20.25%) based on body mass index-for-age z-scores. After 90 days of feeding intervention, 21.47% of infants were no longer stunted and 50.92% of children were no longer wasted. Others remained in the same nutritional status category despite an increased z-score (Table 3).

The z-score distribution graphs based on the Length-for-age, Weight-for-age, Weight-for-length, and BMI-for-age indices showed improvement. The graph after the intervention showed a shift to the right, approaching the standard graph (Figures 3 and 4).

Table 5: The effects of the intervention on the toddlers's weight and height

	Mean	Confidence Interval 95% Lower	Confidence Interval 95% Upper	p-value	Cohen's d
Body Weight*		-0.829	-0.671	<0.001	0.631
- before	9.35				
- after 1 month	9.73				
- after 2 months	10.16				
- after 3 months	10.88				
Body Length**		-1.853	-0.857	<0.001	0.181
- before	81.84				
- after 1 month	82.28				
- after 2 months	83.00				
- after 3 months	83.17				

*Kilogram
**centimeters

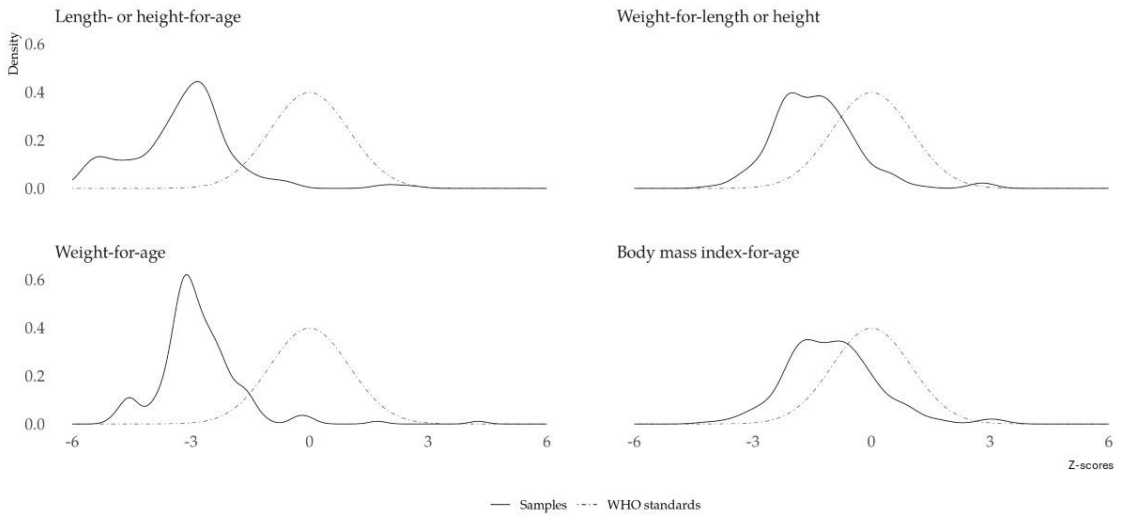

Figure 3. Z-score distribution by index before intervention

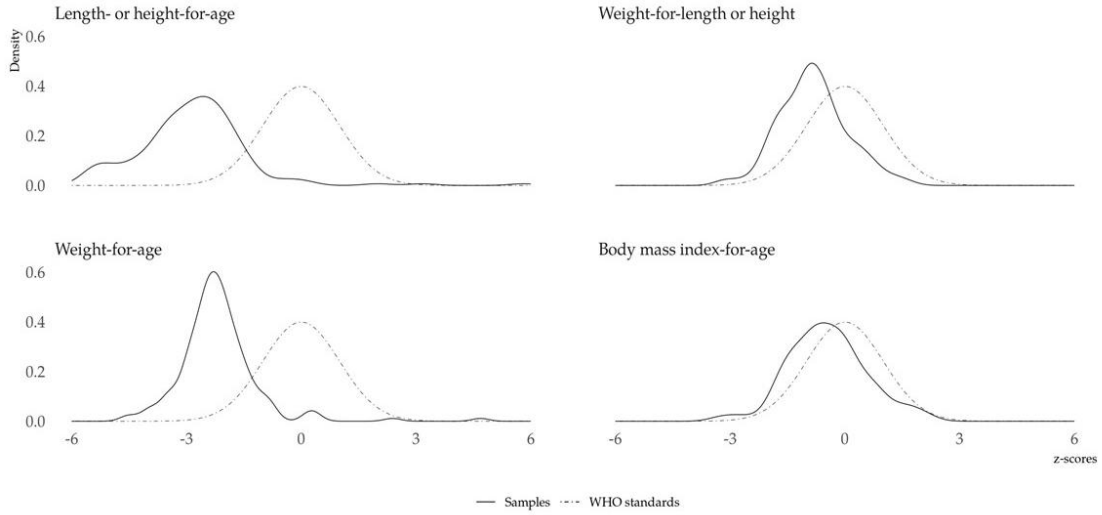

Figure 4. Z-score distribution by index after intervention

Table 4 shows that there were significant differences between the mean Z-score of weight for age ($p<0.001$), Z-score of height for age ($p=0.003$), Z-score of weight for height ($p<0.001$), and Z-score of BMI for age ($p=0.009$) before and after the 90-day PMT. The intervention demonstrated a medium effect on weight gain (Cohen's d = 0.631) and a small effect on height gain (Cohen's d = 0.181) (Table 5).

Discussions

The findings of this study indicate that toddlers who received supplemental feeding for 90 days showed significant changes in their weight and height. Additionally, there was a substantial increase in the average z-score based on Weight for Height, BMI, and weight for height ($p < 0.05$).

Regarding weight gain, the results of this study align with those of previous research in Puskesmas Nanga, which demonstrated that providing local supplemental feeding, such as sweet potatoes, bananas, and moringa, for 30 days was effective in restoring the weight of undernourished toddlers (Nelista & Fembi, 2021). Similarly, a study of 397 toddlers in Tangerang found a significant increase in weight after 14 days of local supplemental feeding (Rahmawati, Sudiarti, and Fitri, 2023). In addition, a study by Masri et al. found that providing supplemental feeding for three months, combined with nutrition counseling, significantly increased weight, whereas supplemental feeding alone did not have the same effect (Masri, Sari, and Yensasnidar, 2020).

The average weight Z-score for age measurement changed from -2.8 to -2.18 across all age groups. This indicates that the intervention had a positive impact on the nutritional status of children under five years of age. A total of 83 (50.92%) toddlers had improved nutritional status based on weight-for-age. Previous research suggests that providing malnourished toddlers with biscuits for 90 days can significantly improve their weight ($p < 0.05$) (Chairunnisa, Darlis, and Ismah, 2018).

The analysis showed an increase in Height for Age Z-score from -3.18 to -2.82 or by 0.36. A child's growth and development are influenced by the number of calories consumed as well as the nutritional composition of the food they consume, including calories, protein, vitamins, and minerals (Irwan & Lalu, 2020). The variety of foods consumed moderately is associated with a reduced risk of stunting in children, particularly those containing protein, calcium, milk, and meat (Mahmudiono, Sumarmi, and Rosenkranz, 2017). However, nutrient-rich intake can also be obtained from foods commonly consumed and readily available by the community. A study showed that PMT in the form of nuggets made from tempeh can significantly increase the height of children aged 24-59 months (Susianto *et al.*, 2023). Providing local supplementary food with 17 alternating menus in this study is expected to fulfill the variety of diets and nutrients needed for child weight and height gain. In addition to the amount and composition, the variety of food must be considered. Research shows that children aged 6-23 months who consume five or more food groups and three types of protein have a lower risk of stunting (Krasevec *et al.*, 2017). The source of food ingredients also needs to be taken into consideration. Research in Cambodia indicates that consuming animal-sourced foods can reduce the risk of stunting and wasting (Darapheak *et al.*, 2013). Providing a combination of various animal-sourced foods, such as milk, fish, meat, and eggs, has more prevention benefits than consuming only one of them. However, this is often constrained by price or geography. People from lower socioeconomic backgrounds or those living in certain areas often face challenges in accessing animal foods. Therefore, government efforts should focus on ensuring good food distribution and controlling market prices. Education and promotion on the utilization of local food must be done (Headey, Hirvonen, and Hoddinott, 2018; Kim *et al.*, 2019).

The 90-day local food supplementation intervention in this study also improved the weight-for-height z-score (from -1.42 to -0.82) and BMI z-score by age (from -1.00 to -0.45). Previous research has shown that supplementation with high protein, micronutrients, plant polyphenols, and omega-3 fatty acids for 23 weeks can improve the BMI z-score by age. The intervention also improved cognitive function, cerebral blood flow, and hemoglobin levels in children from West Africa (Roberts *et al.*, 2020).

The intervention's moderate effect on weight gain (Cohen's d = 0.631) was likely due to the direct impact of increased energy and protein intake on weight recovery, whereas the smaller effect on height gain (Cohen's d = 0.181) was consistent with the long-term, linear nature of growth, which necessitates sustained nutritional improvement over a sufficient time period. These findings support the recommendation to increase the use of local foods to promote adherence and sustainability. Direct supervision by community health workers is also likely to increase compliance, which influences observed outcomes.

Local meals typically represent the diversity and abundance of food resources in a region. Local foods comprise nutritional components of both animal and vegetable origins that are readily available in a particular region. Local food sources, preparation, and presentation are typically culturally acceptable and may have been passed down through generations (Marinda *et al.*, 2023). Utilizing local food is beneficial for increasing the variety of food types to overcome malnutrition. However, it also plays a role in maintaining the balance of ecosystems in an area and ensuring food safety (Amadou & Lawali, 2022). Utilizing local food is a form of support for local communities that make a living by providing local food, such as farmers, breeders, and fishermen.

In addition to supplementary food, the pattern and type of food consumed by the family play a significant role in determining the nutritional status of children. Habits and culture influence this (Fan, 2016; Sadiq *et al.*, 2024).

Other factors related to the nutritional status of children under five include infectious diseases such as fever, cough, cold, and diarrhea. Infections, especially chronic ones, can lead to malnutrition. Similarly, malnutrition can make children susceptible to infections. Not only that, but malnutrition also increases the severity and mortality of childhood infections, such as pneumonia (Scrimshaw & SanGiovanni, 1997; Farhadi & Ovchinnikov, 2018; Walson & Berkley, 2018; Kirolos *et al.*, 2021; Schneider, 2023; Morales *et al.*, 2024; Palmer, Bedsaul-Fryer and Stephensen, 2024).

Malnutrition is also influenced by environmental conditions, particularly during pregnancy and childhood. Maternal health, nutritional status, and dietary intake during pregnancy should be considered. Various conditions that inhibit the supply of nutrients, oxygen, and hormones can impair fetal and child development (Gentner & Leppert, 2019). The environment in which children grow up, for example, children from low-income families and growing up in slums or rural areas, are more prone to infections, increasing the risk of malnutrition. Fluctuations in global food availability and supply require the optimal utilization of local food sources, which are typically more economical and conveniently available (Johnson & Brown, 2014; Gentner & Leppert, 2019; Mahapatra *et al.*, 2021).

This study has some limitations, including the use of a pre-experimental pretest and posttest design without a control group, which may restrict the ability to conclude cause-and-effect relationships. The investigation did not consider other factors that could significantly impact children's nutritional status, such as maternal education, wealth index, general health problems, and food

consumed outside this program. Future studies should incorporate randomized controlled trials and cost-effectiveness analyses to validate our findings.

Conclusion

The results of this study suggest that foods derived from local ingredients and prepared as traditional dishes can help address child nutrition issues in the community. Several markers improved during the 90-day supplementary feeding period, including the z-scores for weight-for-age, height-for-age, weight-for-height, and BMI-for-age. Food diversification involves the exploration and documentation of nutrient-rich local food sources. Preservation of traditional local foods and education on proper food processing are likely to boost engagement and increase the likelihood of program success. The overall program to combat malnutrition should involve various sectors and layers of society.

Providing education and training on optimal food processing techniques for mothers is crucial to ensure the continuity of feeding practices after the program has concluded. The objectives of this initiative are threefold: to promote sustainability, enhance family autonomy, and reduce reliance on government assistance. All of these must be integrated with monthly monitoring of child growth. Partnerships with farmer cooperatives are essential to reduce food costs.

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Declaration Of Generative Artificial Intelligence (AI) Use

We confirm that artificial intelligence (AI) tools were used in the development of this manuscript. The authors carefully utilized Grammarly to check grammar, spelling, and fundamental language refinement in English. No AI tool was used for content generation, scientific writing, data analysis, interpretation, or any other substantive aspect of the research. All authors reviewed the work and accepted full responsibility for its final content.

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Availability of data and materials

"The datasets generated and analyzed during the current investigation are not publicly available due to ethical constraints on the confidentiality of the participants. However, anonymized data may be obtained from the corresponding author upon reasonable request and with sufficient ethical permission."

Authors' contributions

Concept and design: All authors. Data collection: AAD, FNBR, RAFK, SAF, RHA, NSNN, DC Statistical analysis: AAD, FNBR, RAFK, SAF, RHA, NSNN, TK Analysis and interpretation: AAD, FNBR, RAFK, SAF, RHA, NSNN, DC, TK, DC. Writing the article: All authors. Critical revision of the manuscript: TK. Final approval of the article: All authors. Obtained funding: TK, UU. Overall responsibility: All authors.

Declaration of Interest

The authors declare no conflicts of interest.

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