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RESEARCH ARTICLE

Locally sourced supplementary feeding programs as a strategic intervention to address weight faltering in children: insights from a primary health center study

Deby Aprilia Haryani[1], Qorry Amanda[2], Novita Sabjan[3]

[1] Primary Health Center (Puskesmas) Ajibarang I, Health Office of Banyumas Regency, Central Java, Indonesia
[2] Department of Histology, Faculty of Medicine, Universitas Islam Sultan Agung, Semarang, Central Java, Indonesia
[3] Health Office of Banyumas Regency, Central Java, Indonesia
*Correspondence: Deby Aprilia Haryani, Address: Primary Health Center (Puskesmas) Ajibarang I, Health Office of Banyumas Regency, Central Java, Indonesia 56163, Email address: dokterdeby@gmail.com

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ABSTRACT

Pemberian Makanan Tambahan (PMT), a supplementary food program using local ingredients, is a targeted intervention to address toddler malnutrition and weight faltering in Indonesia. Despite its widespread implementation, the long-term efficacy of the 14-day PMT program in sustaining growth recovery remains to be determined. This study aimed to evaluate the impact of a 14-day PMT intervention on weight gain and growth stability in children aged 6–59 months experiencing weight faltering. A prospective cohort study was conducted from May to August 2024 at Primary Health Center (Puskesmas) Ajibarang 1 in Banyumas, Central Java, Indonesia. The intervention consisted of 11 snacks and 3 main meals to meet 30–50% of daily caloric needs. Anthropometric measurements, including body weight (BW) and mid-upper arm circumference (MUAC), were collected pre- and post-intervention. 120 children participated, with baseline averages of 11.2 ± 1.5 kg for BW and 13.4 ± 1.7 cm for MUAC. Significant improvements were observed post-intervention, with averages of 12.9 ± 1.2 kg (BW) and 15.0 ± 1.4 cm (MUAC). A moderate positive correlation was identified between BW gain and MUAC (Spearman analysis). In conclusion, the PMT program effectively improves BW and MUAC in children at risk of growth faltering, highlighting its potential as a scalable intervention. These findings emphasize the importance of tailored nutritional programs during early childhood, a critical period for ensuring long-term health and developmental benefits. Advocacy and policy reforms are essential to support consistent implementation and global accessibility of nutritional interventions.

1. Introduction

Childhood malnutrition remains a pervasive global health challenge with profound implications for growth, development, and overall well-being. The World Health Organization estimates that approximately 149 million children under five years of age are stunted due to malnutrition, which adversely affects their cognitive and physical health. Weight faltering—a critical marker of malnutrition—occurs when a child's weight drops through two or more centile spaces on growth charts, indicates low weight-for-height/length, or reflects a failure to achieve catch-up growth from low birth weight (Willacy *et al.,* 2016). This condition can arise from insufficient caloric intake, feeding difficulties, improper formula preparation, chronic illnesses, or nutrient malabsorption (Homan, 2016).

Weight faltering poses both immediate and

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long-term risks. Short-term consequences include compromised immunity and prolonged hospitalization, while long-term outcomes encompass cognitive delays, reduced academic performance, stunted growth, diminished economic potential in adulthood, and elevated mortality risk (Cooke *et al.,* 2023). Since the first 1,000 days of life are critical for growth and development, timely and effective nutritional interventions are essential to prevent or reverse weight faltering (Mertens *et al.,* 2023).

The Supplementary Local-Based Ingredient Food Provision, known as *Pemberian Makanan Tambahan* (PMT) is a targeted intervention implemented in Indonesia to address malnutrition among vulnerable groups, including toddlers and pregnant women. Effective PMT programs combine nutritious food provision with caregiver education, emphasizing breastfeeding support, feeding practices, and hygiene promotion (Kemenkes-RI, 2023). According to the Regulation of the Director General of Public Health No. HK.02.02/B/1622/2023, PMT explicitly addresses nutritional deficiencies, low body weight, and weight faltering in toddlers. Primary Health Center (Puskesmas) Ajibarang 1 in Banyumas, Central Java, Indonesia adopted this framework, implementing a 14-day PMT intervention to meet the immediate nutritional needs of children under five exhibiting weight faltering.

Despite the program's potential, its long-term impact on sustained growth recovery remains unclear. While the 14-day intervention addresses acute weight faltering, whether this duration is sufficient to ensure stable growth beyond the intervention period is uncertain. Existing research predominantly focuses on broader nutritional strategies, leaving a gap in understanding the effectiveness of localized PMT programs. This study aims to fill this gap by evaluating the adequacy of the 14-day PMT intervention in promoting weight gain and sustained growth among children at risk of malnutrition.

2. Materials and Methods

This observational, prospective cohort study was conducted over 4 months (May to August 2024) to assess the effectiveness of local supplementary feeding (PMT) in addressing weight faltering among children aged 6–59 months in the service area of Primary Health Center (Puskesmas) Ajibarang 1, Banyumas, Indonesia.

2.1. Study Design and Phases

The study was divided into three distinct phases:

a. Detection Phase (May–June): Children with weight faltering were identified using body weight (BW) data from the *SiGiziTerpadu* platform. Weight data were cross-referenced with standardized growth charts to determine if growth patterns were normal or indicative of weight faltering.
b. Intervention Phase (July): Children whose parents provided informed consent participated in a 14-day PMT program. The intervention included 11 nutrient-rich snacks and 3 main meals to meet 30–50% of the child's daily caloric needs. Anthropometric measurements were taken twice during this phase: after one week of PMT (PMT1W) and at the end of the 14 days (PMT2W).
c. Post-Intervention Follow-Up (August): One month after the intervention, anthropometric measurements, including body weight, height, and mid-upper arm circumference (MUAC), were collected to evaluate the sustainability of growth improvements.

2.2. Participants

This study enrolled 120 children aged 6–59 months, all identified as experiencing weight faltering based on growth chart assessment using body weight (BW) trends and mid-upper arm circumference (MUAC) measurements. Weight faltering was defined as weight dropping across two or more centile lines or falling below the normal growth trajectory. Parental consent was required for participation.

2.3. Intervention and Measurements

The PMT program provided culturally appropriate, locally sourced food to address nutritional deficiencies. Weight gain during the intervention was the primary outcome, and success was defined as alignment with normal growth curves on standardized charts. Post-intervention measurements assessed sustained improvements in growth parameters.

Anthropometric data were collected at three key time points: (1) Baseline (before intervention), (2) During intervention (after one week and at the end of two weeks), and (3) Post-intervention (one month after conclusion).

2.4. Statistical Analysis

Data were analyzed using SPSS 24.00. Descriptive statistics summarized baseline characteristics and intervention outcomes. Paired T-tests were used to compare pre-and post-intervention anthropometric measurements, with statistical significance at $p < 0.01$. Effect sizes were calculated to assess the magnitude of weight, height, and MUAC changes, providing insights into the PMT program's effectiveness in improving nutritional status and promoting sustained growth.

Table 1. Weight and UAC of the study population (n=120)

Time Point	BW (kg)	MUAC (cm)
May	11.2 ± 1.5	13.4 ± 1.7
June	11.3 ± 1.4	13.6 ± 1.6
PMT1W	11.8 ± 1.4[a]	14.0 ± 1.6 [a]
PMT2W	12.3 ± 1.3[b]	14.5 ± 1.5 [b]
After Intervention	12.9 ± 1.2[c]	15.0 ± 1.4 [b]

Note: Different superscripts (a, b, c) indicate significant differences ($p < 0.01$) between time points

3. Results

3.1. Body weight and mid-upper arm circumference of the study population during the 3 phases of observation

Table 1 shows the body weight (BW) and mid-upper arm circumference (MUAC) of the study population during the 3 phases of observation. During the detection Phase in May and June, the average of BW and MUAC are 11.2 ± 1.5 kg, 13.4 ± 1.7 cm, and 11.3

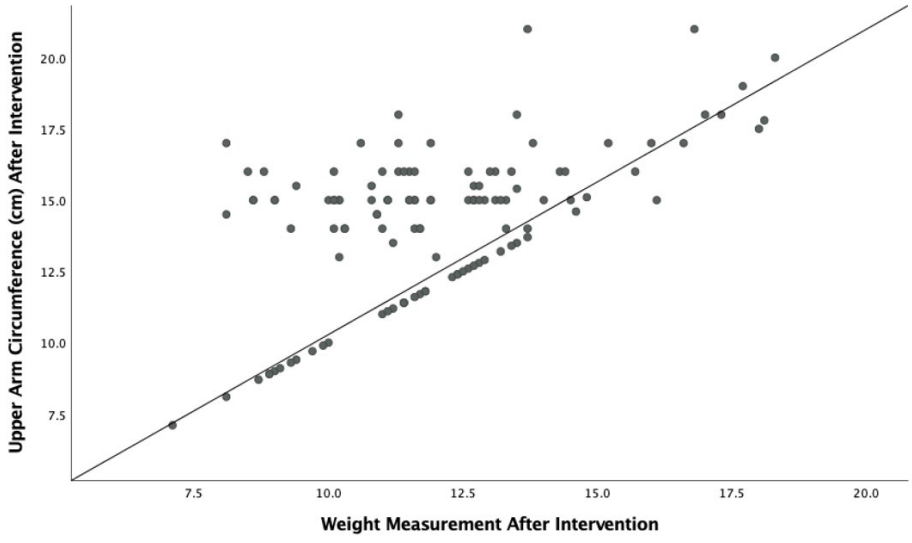

Figure 1. The scatter plot of the relationship between body weight and mid-upper arm circumference after 14 days PMT intervention

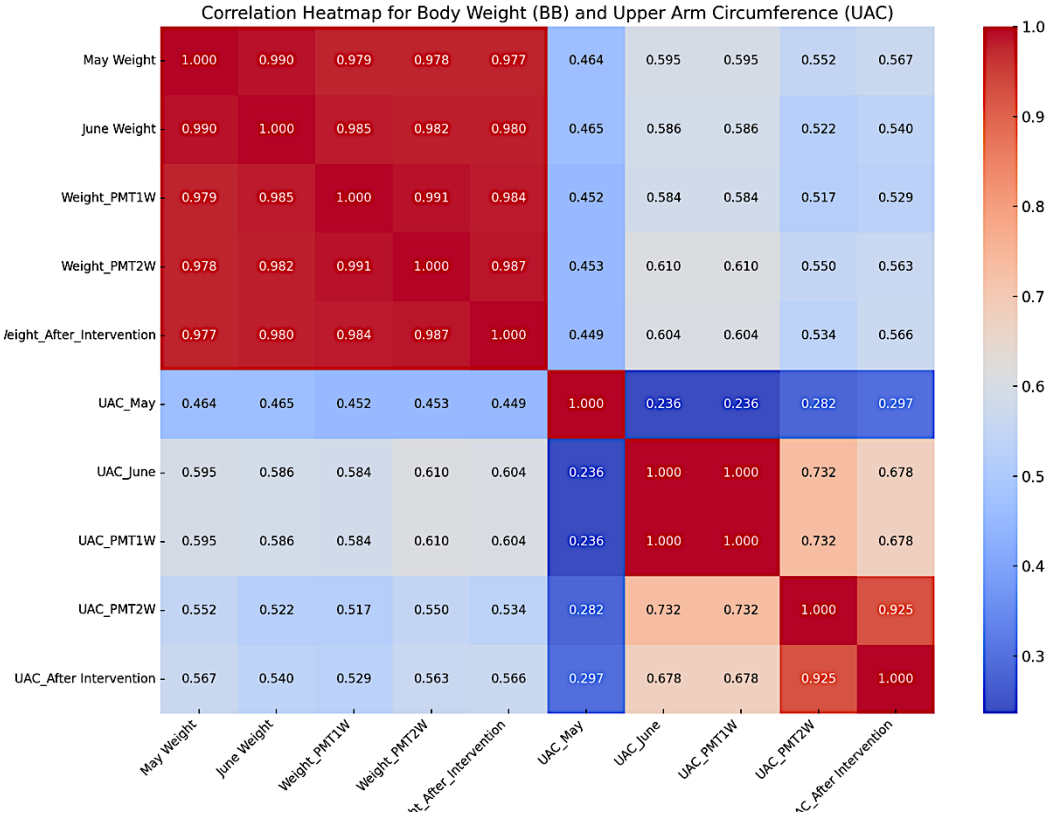

Figure 3. The heatmap of the correlations between between body weight and mid-upper arm circumference after 14 days PMT intervention

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± 1.4 kg, 13.6 ± 1.6 cm, respectively, confirming the critical need for nutritional intervention. By the end of the first week (PMT1W), 82% of children demonstrated weight gain. The mean weight increased to 11.8 ± 1.4 kg, and MUAC to 14.0 ± 1.6 cm. In the second week of intervention (PMT2W), the positive trend continued, with 79% of participants showing significant weight gain by the second week, reaching an average weight of 12.3 ± 1.3 kg and MUAC of 14.5 ± 1.5 cm. After the 14-day intervention, post-intervention measurements (August) indicated sustained growth improvements, even without continued supplementation. BW increased to 12.9 ± 1.2 kg, and MUAC reached 15.0 ± 1.4 cm. Despite the absence of further PMT, 59% of children maintained significant growth gains. Paired statistical tests confirmed the significance of observed growth improvements of BW and MUAC: baseline to PMT1W ($p < 0.001$), PMT1W to PMT2W ($p < 0.001$), and PMT2W to post-intervention ($p < 0.001$).

3.2. The relationship between body weight and mid-upper arm circumference

A Spearman correlation analysis revealed a moderate positive relationship between BW gain and MUAC. The scatter plot shows a positive correlation between post-intervention body weight (x-axis) and upper arm circumference (MUAC) (y-axis) among children, with most data points clustering along the trendline (Figure 1). A few outliers, particularly those weighing over 15 kg and MUAC above 20 cm, suggest response variability, potentially due to baseline health or dietary factors. The heatmap (Figure 2) displays the correlation matrix between BW and MUAC across different time points during the intervention. Strong correlations (r> 0.75) between measurements at consecutive time points indicate consistent growth trends. Moderate correlations (r>0.5) between BW and MUAC suggest a link between weight gain and improved nutritional status, though other factors may contribute to the observed changes.

4. Discussion

The PMT program demonstrated significant short-term and sustained benefits in addressing weight faltering. Children gained weight and improved their nutritional status, as reflected in mid-upper arm circumference (MUAC), indicating improvements in body composition and overall health. These findings align with prior studies highlighting the efficacy of caloric supplementation in reversing growth stagnation (Trehan, 2015). The sustained growth observed after the intervention highlights the residual effects of PMT on nutritional recovery. The additional 500 kcal per day provided during the 14-day intervention was approximately 7,000 kcal, sufficient to support a weight gain of nearly 0.9 kg. Notably, post-intervention improvements suggest that PMT may trigger a cascade of metabolic and developmental changes supporting ongoing growth (Shi *et al.,* 2023).

The PMT program provided an additional 500 kcal per day through a nutritionally balanced supplement comprising fortified flour, sugar, vegetable oil, and milk powder, designed to address children's energy and micronutrient needs (Shim *et al.,* 2020). Over the 2-week intervention period, this additional caloric intake equated to approximately 7,000 kcal, theoretically sufficient for a weight gain of 0.9 kg, given that 7,700 kcal are required for a 1 kg increase. Remarkably, continued weight gain was observed during the week following the intervention, underscoring PMT's residual impact on nutritional recovery. Similar findings in other studies have demonstrated that short-term caloric interventions can catalyze sustained improvements in nutritional status (Jen, 2019).

Factors influencing individual responses to PMT include metabolic rate, initial nutritional status, and physical activity levels. Severely malnourished children may exhibit faster weight gains due to a higher caloric deficit, while active children may expend more energy, moderating weight increases (Arora *et al.,* 2019). This highlights the need for personalized interventions based on metabolic and activity profiles.

Weight gain is a pivotal marker for evaluating nutritional interventions, reflecting an intact absorptive function of the intestinal epithelium. The increase in weight observed in this study suggests effective nutrient absorption, highlighting the critical importance of intervening during the weight-faltering stage before potential damage to the intestinal villi occurs (Montoro-Huguet *et al.,* 2021; Shinsugi *et al.,* 2020). MUAC, a complementary parameter, tracks changes in muscle and subcutaneous fat, offering a reliable indicator of nutritional recovery (Zhu *et al.,* 2020). Improved muscle mass and fat stores reflect better energy balance and metabolic health, aligning with overall growth outcomes. MUAC's strong correlation with BMI and weight gain further validates its use in monitoring recovery and assessing the efficacy of nutritional interventions (Binns *et al.,* 2015; Khatri, 2020).

The PMT program exemplifies a scalable intervention that can be integrated into primary healthcare systems to address malnutrition in vulnerable populations. Successful implementation of PMT in countries such as Indonesia and India has demonstrated significant improvements in child growth outcomes (Black, 2023). However, inconsistent policy enforcement remains a challenge. Reports, including one by UNICEF (2019), emphasize that despite the availability of

PMT programs, malnutrition rates remain alarmingly high, underscoring the need for sustained efforts and improved implementation strategies (Ruel, 2013).

This study provides valuable insights into PMT's short-term and sustained impacts but has certain limitations. The relatively small sample size and geographic specificity may limit the generalizability of findings. Additionally, the 3-week intervention period may only partially capture the long-term effects of sustained nutritional support. Another limitation was the absence of pre-intervention assessments to rule out red flags in 18% of non-responsive children, which might have influenced outcomes. Future research should focus on evaluating long-term impacts across diverse populations and investigating individual variations in response to PMT.

5. Conclusion

Locally Sourced Supplementary Feeding Programs, or Pemberian Makanan Tambahan (PMT), are effective interventions for improving body weight and mid-upper arm circumference (MUAC) in children at risk of growth faltering. These findings underscore the critical importance of implementing tailored nutritional programs to address growth faltering during early childhood, a vital window for long-term health and developmental benefits. Future research on the long-term impacts of PMT across diverse populations, along with a deeper understanding of factors influencing individual responses, will be essential. Equally important is the need for advocacy, policy support, and reforms to ensure consistent implementation and accessibility of nutritional interventions globally.

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Conflict of interest

All authors have no conflict of interest in this article.

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