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Child protein score as an indicator of stunting risks

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Abstract

Background: Stunting remains a major nutritional problem in Indonesia, with a prevalence of 19.8%. One of the key determinants of linear growth in young children is protein quality; however, dietary assessments have largely focused on intake quantity or food diversity, while the biological quality of protein is rarely considered.

Purpose: To develop and validate the Toddler Food Protein Score (TFPS) as a practical instrument for assessing protein quality and examining its association with stunting risk.

Methods: A cross-sectional study was conducted among 109 children aged 6–59 months attending primary health centers, recruited through consecutive sampling. The sample consisted of 49 stunted and 60 non-stunted children. Stunting status was determined using height-for-age z-scores, while protein quality was assessed using the TFPS derived from a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Data analysis included chi-square tests, logistic regression, and ROC curve analysis.

Results: The prevalence of stunting was 44.9%, and TFPS scores were significantly lower among stunted children than non-stunted children (2.4 ± 1.1 vs. 3.9 ± 1.2 ; $p < 0.001$). ROC analysis yielded an AUC of 0.79 (95% CI: 0.71–0.87; $p < 0.001$) with a cut-off ≤ 3 . Multivariate logistic regression showed that children with TFPS ≤ 3 had a 3.3-fold higher risk of stunting (OR = 3.30; 95% CI: 1.50–7.50; $p = 0.004$).

Conclusion: The TFPS is a valid, discriminative, and practical tool that has potential for use as a stunting risk screening instrument in primary healthcare settings.

Keywords: Animal-Source Protein; Protein Quality; Stunting; TFPS; Young Children.

INTRODUCTION

Stunting remains one of the major nutritional problems among children under five in developing countries, including Indonesia. The World Health Organization (WHO) and UNICEF reported that the global prevalence of stunting remains high, with more than one-third of cases occurring in South Asia and Southeast Asia (World Health Organization, 2024). In Indonesia, the 2024 Indonesian Nutritional Status Survey recorded a stunting prevalence of 19.8% (Ministry of Health of the Republic of Indonesia, 2025). This condition underscores stunting as a significant public health issue requiring serious attention and comprehensive interventions.

Stunting is defined as a failure of linear growth due to chronic undernutrition, particularly within the first

1,000 days of life (Septariana, Faron, Fathonah, Tasqiya, Nuraisyah, Lestari, & Fitriyah, 2024). Its impact goes beyond impaired physical growth, as it is also associated with delayed cognitive development, reduced learning capacity, lower productivity in adulthood, and increased risk of degenerative diseases (Imeldawati, 2025; Maharani & Wulandari, 2025; Susilowati, Rachma, Khotimah, Bunayyah, & Zumara, 2025). Thus, preventing stunting has broad implications not only for health but also for education and human resource development.

One of the key determinants contributing to stunting is inadequate protein intake, both in terms of quantity and quality (Tamrin & Abri, 2025). Protein is an essential macronutrient required for tissue

formation, enzyme and hormone production, immune function, and brain development (Gilbert & Schlenker, 2023). Previous studies have shown that children with higher proportions of animal protein in their diets have better linear growth compared to those whose protein intake is dominated by plant-based foods (Cahyani & Firmansyah, 2025; Paramitha, Rahayu, Lufar, Arifiana, & Rosidi, 2025; Saputri, Abdullah, Akhriani, & Marthalena, 2025). Regular consumption of animal protein sources such as eggs, fish, meat, and milk has been found to be protective against stunting (Erdysta, 2024; Arruan, 2024). However, dietary patterns in Indonesia are still largely dominated by cereals and tubers, with relatively low contributions from animal protein due to economic constraints, food availability, and cultural preferences (Nafi'uzzuddin, Khoiriyah, & Maula, 2025).

Existing methods for assessing protein intake have primarily focused on quantity. Daily protein adequacy is usually measured against the Recommended Dietary Allowance (RDA). Other indicators, such as the Dietary Diversity Score (DDS), assess food variety but are not specific to protein quality (Patel & Preedy, 2022). Biochemical methods, such as serum albumin or blood urea nitrogen measurement, although accurate, are not feasible in population-based surveys due to high costs and laboratory requirements (Kardinan, Karmawati, Siswanto, Samsudin, Trisawa, Maris, & Tarigan, 2025). This reveals a gap between practical field needs and the availability of instruments to assess protein quality.

RESEARCH METHOD

This study used an analytic observational design with a cross-sectional approach. The research was conducted at the working area of Puskesmas Kemalo Abung, Lampung, Indonesia, from July 2025 to August 2025. Number and method of taking research subjects/tools and materials. The study population consisted of all children aged 6–59 months residing in the research area. A total of 109 children were recruited using consecutive sampling, comprising 49 stunted and 60 non-stunted children. Inclusion criteria were: (1) children aged 6–59 months, (2) complete anthropometric data (weight, length/height), and (3) parental consent to participate. Exclusion criteria were children with congenital disorders or chronic infectious diseases that could affect growth.

Structured questionnaire on respondent characteristics; covering age, sex, mother's education level, parental occupation, and family size. This instrument was developed by the researchers based on the Demographic and Health Survey (The DHS Program, 2025), SPMB adapted from the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) developed by Willett (2013) and modified to incorporate the Indonesian local food list (Kemenkes, 2020b). It was designed to assess both the frequency and quality of protein intake. The SPMB scoring system was based on three main components: total protein adequacy, the proportion of animal protein to total protein, and the weighted quality of protein sources based on consumption frequency. It also considered the percentage contribution of animal protein to overall intake, as well as the diversity of plant-based protein sources that complement essential amino acids, particularly lysine and methionine (FAO, 2018). SPMB was classified into three categories: Good (5–6), Moderate (3–4), and Poor (0–2), anthropometric measurement tools; including a length board (precision 0.1 cm) for children under 24 months, a microtoise (precision 0.1 cm) for children aged 24 months or older, and digital scales (precision 0.1 kg). Nutritional status was assessed using WHO Anthro software (2006 standard). Length-for-age (LAZ) and height-for-age (HAZ) indices were calculated, and children were classified as stunted if their LAZ/HAZ z-score was < -2 SD and Data collection was carried out by trained enumerators, including equipment calibration prior to use, to ensure consistency and reliability of measurements. Structured interview guidelines were also applied to maintain consistency in parental responses.

Data collection was carried out by trained enumerators through structured interviews with mothers or caregivers and direct anthropometric measurements. All anthropometric equipment was calibrated prior to use to ensure accuracy and reliability (Citerawati, 2022). Structured interview guidelines were applied to maintain consistency in parental responses. Data from dietary intake questionnaires were processed to calculate SPMB scores, while anthropometric data were analyzed using WHO Anthro software.

Data were processed and analyzed using a computer-based statistical program. Univariate

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analysis was conducted to describe respondent characteristics and SPMB distribution. Bivariate analysis employed chi-square tests to examine the relationship between SPMB and stunting status. Multivariate logistic regression was performed to control for confounding factors and determine whether SPMB was an independent determinant of stunting risk. Discriminant validity of the SPMB was

further assessed using ROC curve analysis to determine sensitivity and specificity.

Ethical considerations: This study received ethical approval from the Health Research Ethics Committee of Poltekkes Kemenkes Tanjung Karang, with certificate number 365/KEPK-TJK/V/2025.

RESEARCH RESULT

Table 1. Characteristics of Respondents (N= 109)

Variable	Results
Age (Mean±SD)(Range)(Month)	(40.68 ± 6.17) (6-59)
Stunting (n/%)	
Yes	49/44.9
No	60/55.1
Gender (n/%)	
Male	56/51.4
Female	53/48.6
Mother's Education	
Good	63/57.8
Poor	28/25.7

Table 1 indicates that the proportion of stunted children was higher among families with lower maternal education and lower socioeconomic status, although further analysis is required to determine the statistical significance of these differences. The distribution of SPMB scores showed that most children were in the moderate category (43.1%), followed by the poor (31.2%) and good (25.7%) categories. Bivariate analysis demonstrated that children with low SPMB scores (≤ 3) were at greater risk of stunting compared to those with higher scores. The chi-square test revealed a significant association between SPMB and stunting status ($p < 0.001$). Logistic regression analysis further showed that children with SPMB ≤ 3 had a 3.3-fold higher risk of being stunted after adjusting for maternal education, socioeconomic status, history of infection, and sanitation conditions.

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Tanjung Karang Health Polytechnic

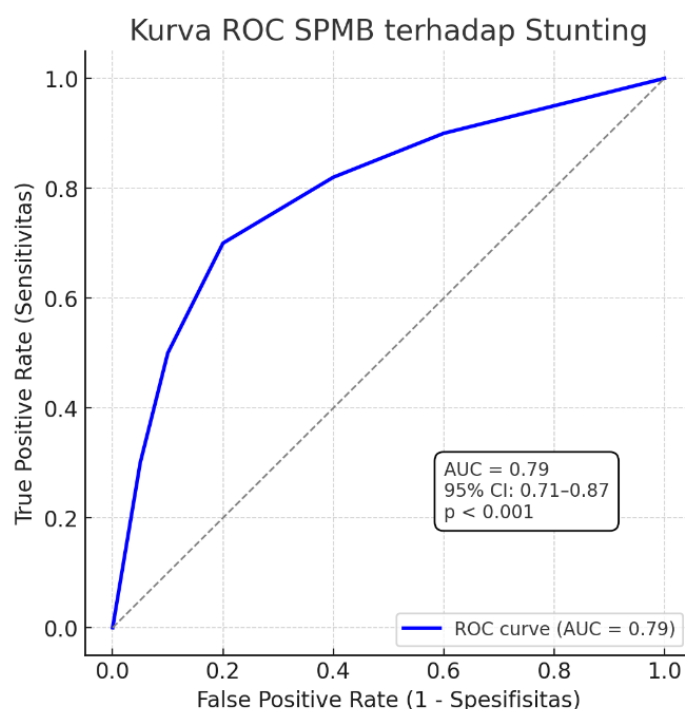
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Table 2. Association of SPMB With Stunting Among Children

SPMB	Stunted n (%)	Non-stunted n (%)	p-value
Good (5–6)	5 (10.2)	23 (38.3)	<0.001
Moderate (3–4)	20 (40.8)	27 (45.0)	
Poor (0–2)	24 (49.0)	10 (16.7)	

ROC curve analysis showed that the SPMB had good discriminatory ability in predicting the risk of stunting, with an AUC value of 0.79 (95% CI: 0.71–0.87; $p < 0.001$). According to Çorbacioğlu & Aksel (2023), an AUC value of 0.70–0.80 is categorized as fair discrimination, while 0.80–0.90 is considered good. Thus, the AUC value of 0.79 indicates that the SPMB is reasonably appropriate for use as a screening tool. The optimal cut-off point was ≤ 3 , providing the best balance between sensitivity and specificity (Figure 1).

**Figure 1. ROC Curve of SPMB in Stunting Prediction**

DISCUSSION

The findings of this study reaffirm that both the quantity and quality of protein—particularly animal-source protein play a crucial role in supporting children's linear growth. Children who consume a higher proportion of animal-source protein tend to exhibit better growth outcomes. These results are consistent with Indonesian studies reporting that regular consumption of animal-source foods, especially eggs and meat, reduces the risk of stunting (Iswara & Syafiq, 2024; Latief, Lantara, Bamahry, & Darma, 2024; Meilasari & Adisasmito, 2024). International evidence similarly indicates that higher

intake of animal-source protein is associated with improvements in early childhood linear growth (Haile & Headey, 2023; Khonje & Qaim, 2024; Xiong, Wu, Hu, Xu, Li, Kong, & Li, 2023).

Various methods have been used in child nutrition research to assess protein intake, yet each has notable limitations. The Protein Adequacy Ratio evaluates only total protein sufficiency without accounting for differences in protein quality across sources (Heerschop, Biesbroek, Daas, Kuijsten, Gurinović, Geleijnse, & van't Veer, 2025). The Animal-to-Plant Protein Ratio emphasizes the relative

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contribution of animal versus plant protein (Drewnowski & Hooker, 2025), but it does not consider total adequacy or consumption frequency, which better reflects daily exposure. Both methods may be less sensitive within dietary contexts dominated by cereals and tubers (Ministry of Agriculture of the Republic of Indonesia, 2024).

In contrast, the SPMB incorporates three key dimensions: total protein adequacy, the proportion of animal-source protein, and weighted quality scores derived from consumption frequency of various protein sources. This more holistic approach makes the SPMB a comprehensive, context-specific, and practical tool that more accurately reflects stunting risk at the community level. As such, the SPMB overcomes and in some respects surpasses the limitations of existing assessment methods.

From an implementation perspective, the SPMB holds strong potential for use in primary health services such as posyandu as a rapid screening instrument. It can also be integrated into nutritional surveillance systems, evaluations of animal-source protein-based interventions, and community-based intervention studies. Developing a mobile application could further facilitate automated scoring and provide more precise follow-up recommendations for health workers.

This study has several limitations. First, assessing protein intake using an SQ-FFQ may introduce recall bias (Ardiyanti & Diana, 2025). Second, the scoring weights for local protein sources are partly assumption-based and therefore require validation using amino acid composition data and protein status biomarkers. Third, the cross-sectional design limits the ability to establish causality (Maier, Thatcher, Grover, & Dwivedi, 2023). Future research is recommended to adopt longitudinal designs (Elliott, Keown-Stoneman, Birken, Jenkins, Borkhoff, & Maguire, 2022), include larger and more diverse populations, and validate the scoring system against laboratory-based reference methods.

Overall, this study strengthens evidence that protein quality particularly animal-source protein is an important determinant of children's linear growth. The SPMB demonstrates strong potential as a practical and contextually relevant screening tool. To enhance its precision and applicability, future studies should conduct external validation across diverse regions in Indonesia, refine scoring weights based on local food

characteristics, and test the integration of the SPMB within community-based digital nutrition monitoring systems.

CONCLUSION

The SPMB proved to be a valid and practical tool for assessing protein intake quality in children and demonstrated fair discriminatory ability in identifying those at risk of stunting. A cut-off score of ≤ 3 was associated with more than a threefold increased risk of stunting, underscoring the critical role of protein quality, particularly from animal sources, in supporting linear growth. The SPMB can be applied as a simple screening instrument in community settings and holds strong potential to guide early nutritional interventions.

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Child protein score as an indicator of stunting risks

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