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CHILD PROTEIN SCORE AS AN INDICATOR OF STUNTING RISK

Skor Protein Makanan Balita sebagai Indikator Risiko Stunting

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ABSTRACT

Stunting remains a major nutrition problem in Indonesia with a prevalence of 19.8% (SSGI, 2024). Protein quality is crucial for linear growth, yet assessments usually focus on intake quantity or diversity rather than biological value. This study aimed to develop and validate the Child Protein Score (SPMB) as a practical tool to assess protein quality and its link to stunting. A cross-sectional study was conducted among 109 children aged 6–59 months in the working area of the Kemalo Abung Public Health Center, North Lampung, using consecutive sampling. The sample consisted of 49 stunted and 60 non-stunted children. Stunting was defined by height-for-age z-score, and SPMB was calculated using a Semi Quantitative Food Frequency Questionnaire (SQ-FFQ). Data were analyzed with chi-square, logistic regression, and ROC curve. Stunted children showed lower SPMB compared to non-stunted (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 cut-off ≤3, and logistic regression showed a 3.3-fold higher risk of stunting in children with TFPS ≤3 (OR = 3.30; 95% CI: 1.50–7.50; p = 0.004). The SPMB proved valid, discriminative, and practical, supporting its use as a screening tool for stunting risk in primary care.

Keyword: *child; protein quality; SPMB; stunting*

ABSTRAK

Stunting masih menjadi masalah gizi utama di Indonesia dengan prevalensi 19.8% (SSGI, 2024). Salah satu faktor penting pertumbuhan linear balita adalah kualitas protein, namun penilaian asupan selama ini lebih menekankan jumlah konsumsi atau keberagaman pangan, sementara kualitas biologis jarang diperhitungkan. Penelitian ini bertujuan mengembangkan dan memvalidasi Skor Protein Makanan Balita (SPMB) sebagai instrumen praktis penilaian kualitas protein serta hubungannya dengan risiko stunting. Penelitian cross-sectional dilakukan pada 109 balita usia 6–59 bulan di wilayah puskesmas Kemalo Abung, Lampung Utara melalui consecutive sampling, terdiri dari 49 balita stunting dan 60 tidak stunting. Status stunting ditentukan berdasarkan z-score TB/U, sedangkan kualitas protein diukur menggunakan SPMB dari kuesioner Semi Quantitative Food Frequency Questionnaire (SQ-FFQ). Analisis meliputi uji chi-square, regresi logistik, dan kurva ROC. Proporsi stunting sebesar 44.9%, dengan skor SPMB lebih rendah pada balita stunting dibanding tidak stunting (2.4 ± 1.1 vs 3.9 ± 1.2; p < 0.001). Uji ROC menunjukkan AUC 0.79 (95% CI: 0.71–0.87; p < 0.001) dengan cut-off ≤3, dan regresi logistik multivariat memperlihatkan risiko stunting 3.3 kali lebih tinggi pada skor SPMB ≤3 (OR = 3.30; 95% CI: 1.50–7.50; p = 0.004). SPMB terbukti valid, diskriminatif, dan praktis sehingga berpotensi digunakan sebagai alat skrining risiko stunting di layanan kesehatan dasar.

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Kata Kunci : balita; kualitas protein; SPMB; stunting

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 (WHO-UNICEF, 2024). In Indonesia, the 2024 Indonesian Nutritional Status Survey recorded a stunting prevalence of 19.8% (Kemenkes, 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 et al., 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 et al., 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 et al., 2025; Saputri et al., 2025). Regular consumption of animal protein sources such as eggs, fish, meat, and milk has been found to be protective against stunting (Erdysta, 2024; Eunike 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'Izzuddin et al., 2025).

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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 (Puspita et al., 2025). This reveals a gap between practical field needs and the availability of instruments to assess protein quality.

To bridge this gap, the SPMB was developed as a simple, field-ready tool that integrates both the quantity and quality of protein intake among children under five. Unlike existing approaches, the Protein Adequacy Score (PAQS) focuses solely on total intake relative to recommended values and does not differentiate the biological quality of protein sources. The Dietary Diversity Score (DDS) also fails to capture protein-specific quality, as it emphasizes the number of food groups consumed rather than amino acid profiles or source contributions. Meanwhile, biochemical indices of protein quality such as DIAAS and PDCAAS provide highly accurate assessments based on digestible indispensable amino acids, but they require laboratory analysis, sophisticated food composition data, and technical capacity that make them unsuitable for routine use in community-level settings. In contrast, the SPMB offers a practical and context-specific alternative by combining total protein adequacy, the proportion of animal-source to plant-based protein, and the weighted quality of commonly consumed local foods. This structure enables the SPMB to better reflect the real dietary patterns of children in low-resource settings and makes it feasible for use by community health workers during routine nutrition screening. Based on the existing evidence and methodological gaps in assessing protein intake quality among young children, this study sought to address the need for a simple, context-specific, and field-ready indicator. Therefore, the present study aimed to develop and validate the Skor Protein Makanan Balita (SPMB) as a practical assessment tool that integrates both the quantity and quality of protein intake. Furthermore, this study examined the

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association between SPMB scores and stunting among children aged 6–59 months. The central hypothesis was that children with lower SPMB scores, particularly those reflecting inadequate total protein and low proportions of animal-source protein would have a significantly higher risk of stunting compared to those with higher scores.

METHOD

Design, place and time

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. The minimum required sample size was calculated using a two-proportion formula with an anticipated effect size based on previous studies reporting differences in protein intake patterns between stunted and non-stunted children. Assuming a confidence level of 95%, statistical power of 80%, and an expected proportion difference of at least 25% between groups, the minimum required sample was 96 children. Therefore, the final sample of 109 participants met the statistical adequacy for the intended analyses, including logistic regression and ROC curve assessment. Inclusion criteria were: (1) children aged 6–59 months, (2) complete anthropometric data (weight and length/height), and (3) parental consent to participate. Exclusion criteria included children with congenital disorders or chronic infectious diseases that could affect growth..

Research instruments included;

1. 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).
2. SPMB adapted from the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) developed by

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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).

3. 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 (Kemenkes, 2020a). (4) Data collection was carried out by trained enumerators, including equipment calibration prior to use, to ensure consistency and reliability of measurements (Citerawati, 2022). Structured interview guidelines were also applied to maintain consistency in parental responses.

Types and methods of data collection/research steps

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 (*WHO Anthro Survey Analyser and Other Tools*, n.d.).

Data analysis

Data were processed and analyzed

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using IBM SPSS Statistics version 16. Univariate analysis was conducted to describe respondent characteristics and the distribution of SPMB scores. Bivariate analysis employed chi-square tests to examine the association between SPMB and stunting status. Multivariate logistic regression was performed to control for potential confounding factors and to determine whether SPMB was an independent determinant of stunting risk. The discriminant validity of the SPMB was further assessed using Receiver Operating Characteristic (ROC) curve analysis to determine the sensitivity, specificity, and optimal cut-off value.

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.

RESULTS AND DISCUSSION

This study involved 109 children aged 6–59 months who were recruited using a consecutive sampling method, consisting of 49 stunted children (44.9%) and 60 non-stunted children (55.1%). These proportions represent the distribution within the study sample and are not intended to reflect the prevalence of stunting at the population level. Most respondents were in the 24–59 months age group, with an almost equal distribution of boys and girls. The majority of mothers had a secondary level of education, while more than half of the families were categorized as middle to lower socioeconomic status (Table 1).

Table 1. Characteristics of Respondents (n = 109)

Characteristics	n	%
Stunted	49	44.9
Non-stunted	60	55.1
Male	56	51.4
Female	53	48.6
Age 6–23 months	38	34.9
Age 24–59 months	71	65.1
Mother's low education	28	25.7
Middle education	63	57.8
Higher education	18	16.5

Table 1 presents the detailed characteristics of the respondents. A higher proportion of stunted children was found among families with lower maternal education and lower socioeconomic status, although further analysis is needed to confirm the statistical significance of these differences.

The distribution of SPMB showed that most children were in the moderate category (43.1%), followed by poor (31.2%)

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and good (25.7%). Bivariate analysis indicated that children with low SPMB (≤3) were more likely to be stunted compared to those with good scores. The chi-square test revealed a significant association between SPMB and stunting status ($p < 0.001$). Furthermore, logistic regression analysis 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 (Table 2).

Table 2. Association of SPMB With Stunting Among Children

SPMB	Stunted n (%)	Non-stunted n (%)	p-value
Good (5–6)	5 (10.2)	23 (38.3ss)	<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 Çorbacıoğlu & Aksel (2023), an AUC between 0.70–0.80 is categorized as fair discrimination, while 0.80–0.90 is considered good. Thus, the AUC value of 0.79 in this study indicates that the SPMB is reasonably appropriate for use as a screening tool. The optimal cut-off point was ≤3, providing a balance between sensitivity and specificity (Figure 1).

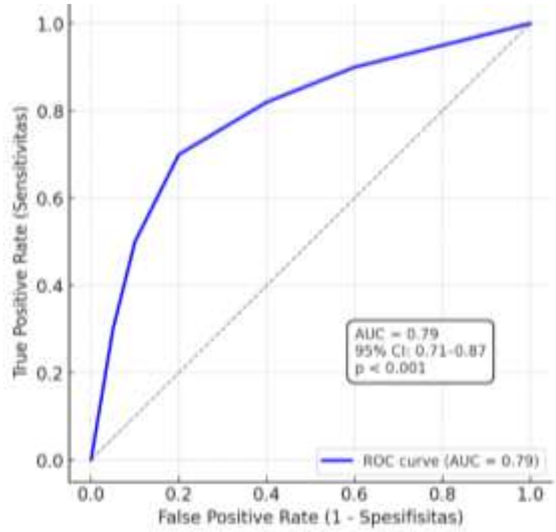

Figure 1. ROC Curve of SPMB for Stunting Prediction

These findings emphasize the importance of both the quantity and quality of protein, particularly animal-based protein, in supporting linear growth (Rahmawati, 2024). Children whose diets contain a higher proportion of animal protein tend to achieve better growth outcomes. This result is consistent with studies in Indonesia showing that regular consumption of animal protein, especially eggs and meat, reduces the risk of stunting (Iswara & Syafiq, 2024; Latief et al., 2024; Meilasari & Adisasmito, 2024). Studies from other countries have also reported that animal protein intake is associated with improved linear growth in

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young children (Haile & Headey, 2023; Khonje & Qaim, 2024; Xiong et al., 2023).

Several methods have been applied to assess protein intake in child nutrition research, yet each has its limitations. The Protein Adequacy Ratio only evaluates total protein relative to daily requirements, without distinguishing the quality of protein from different sources (Heerschop et al., n.d.). The Animal-to-Plant Protein Ratio emphasizes the balance between animal and plant protein (Drewnowski & Hooker, 2025), but overlooks overall adequacy and frequency of consumption, which reflect daily dietary exposure. Both methods may be less sensitive in capturing local dietary patterns that are dominated by cereals and tubers (Kementan, 2024).

In contrast, the SPMB integrates three key dimensions: adequacy of total protein, the proportion of animal protein in total intake, and the weighted quality of specific protein sources based on frequency of consumption. This multidimensional approach makes SPMB more comprehensive, context-specific, and practical, thereby providing a more accurate picture of stunting risk at the community level. Thus, SPMB complements and surpasses the limitations of previous methods.

From an implementation perspective, SPMB has the potential to be applied in primary health services, such as posyandu, for rapid screening. In addition, SPMB can be integrated into nutrition monitoring programs, evaluation of animal-protein–based interventions, and community-based intervention studies. A simple smartphone-based digital application could also enable community health workers to calculate the score automatically and generate follow-up recommendations, thereby improving accuracy and efficiency.

Nevertheless, this study has limitations. First, protein intake was assessed using an SQ-FFQ, which may introduce recall bias (Ardiyanti & Diana, 2025). Second, the scoring weights for local protein sources were partly assumption-based and require further validation using amino acid composition data and protein status biomarkers. Third, the cross-sectional design limits the ability to establish causality (Maier et al., 2023). Therefore, future studies are recommended to adopt a longitudinal design (Elliott et al., 2022), involve larger and more diverse populations, and validate the score against laboratory-based reference methods.

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In conclusion, this study reinforces the evidence that protein quality—particularly the contribution of animal-source protein—is a critical determinant of linear growth in young children. The SPMB demonstrated strong potential as a practical and context-specific screening tool for identifying children at increased risk of stunting. However, several limitations should be acknowledged. The use of an SQ-FFQ may introduce recall bias and limit the precision of intake estimates, and the scoring weights assigned to protein sources are based on theoretical assumptions that require further empirical validation. Additionally, the cross-sectional design restricts causal interpretation.

Future research should therefore include biochemical validation of protein status (e.g., serum amino acid profiles, nitrogen balance markers), longitudinal follow-up to assess predictive accuracy over time, and refinement of scoring categories using data-driven approaches. External validation in diverse regions with different dietary patterns, as well as digital integration of the SPMB into community-based nutrition monitoring systems, is also recommended to enhance its accuracy, applicability, and scalability.

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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