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Animal-source food consumption and stunting among children aged 6–23 months in coastal Kotawaringin Barat, Indonesia

Konsumsi pangan hewani dan stunting pada anak usia 6–23 bulan di wilayah pesisir Kabupaten Kotawaringin Barat, Indonesia

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Abstract

Stunting remains prevalent in Indonesian coastal communities despite the abundance of fish. This study examined animal-source food consumption and factors associated with stunting in children aged 6–23 months in coastal Kotawaringin Barat, Indonesia. A mixed-methods sequential explanatory study was conducted from March to May 2025, involving 55 mother–child dyads. Nutritional status was assessed using anthropometry, and dietary intake was evaluated using a semi-quantitative food frequency questionnaire. Quantitative data were analyzed using the Mann–Whitney U test, Fisher's Exact Test, and binary logistic regression, while qualitative data were analyzed thematically. The prevalence of stunting was 20.0%, although 98.2% of the children met the Estimated Average Requirement (EAR) for protein. The median protein intake was lower among stunted than non-stunted children (22.60 vs. 29.35 g/day; $p < 0.001$). Higher protein intake was associated with lower odds of stunting (OR = 0.268; 95% CI: 0.095–0.754). Fish, eggs, and milk were the main animal-source foods consumed, whereas iron-rich foods were rarely consumed. Low maternal nutritional literacy, ultra-processed food consumption, unstable fishing income, and poor sanitation emerged as major barriers. In conclusion, protein adequacy alone may not ensure optimal linear growth among children in coastal communities. Improving dietary quality, caregiver nutritional literacy, and sanitation conditions may be important components of stunting reduction strategies in these settings.

Keywords: Animal source foods, coastal communities, protein intake, stunting

Abstrak

Stunting masih ditemukan pada masyarakat pesisir Indonesia meskipun ketersediaan ikan dan pangan hewani relatif melimpah. Penelitian ini menganalisis konsumsi pangan hewani dan faktor yang berhubungan dengan stunting pada anak usia 6–23 bulan di pesisir Kabupaten Kotawaringin Barat. Penelitian *mixed methods* dengan desain *sequential explanatory* dilakukan pada Maret–Mei 2025 terhadap 55 pasangan ibu-anak. Status gizi diukur melalui antropometri, dan konsumsi pangan dinilai menggunakan *Semi-Quantitative Food Frequency Questionnaire* (SQ-FFQ). Analisis kuantitatif menggunakan uji *Mann–Whitney, Fisher's Exact Test,* dan regresi logistik biner, sedangkan data kualitatif dianalisis secara tematik. Hasil, prevalensi stunting sebesar 20,0%, meskipun 98,2% anak telah memenuhi Estimated Average Requirement (EAR) protein. Median asupan protein lebih rendah pada anak stunting dibandingkan non-stunting (22,60 vs. 29,35 g/hari; $p < 0,001$). Asupan protein yang lebih tinggi berhubungan dengan peluang stunting yang lebih rendah (OR = 0,268; IK95%: 0,095–0,754). Ikan, telur, dan susu merupakan pangan hewani yang paling sering dikonsumsi, sedangkan sumber zat besi heme

jarang diberikan. Hambatan utama meliputi rendahnya literasi gizi ibu, konsumsi pangan ultra-proses, ketidakstabilan pendapatan nelayan, dan sanitasi yang kurang memadai. Kesimpulan, kecukupan protein saja belum menjamin pertumbuhan linear optimal pada anak di wilayah pesisir. Peningkatan kualitas pola makan, literasi gizi pengasuh, dan kondisi sanitasi perlu dipertimbangkan sebagai bagian dari strategi penurunan stunting di wilayah tersebut.

Kata Kunci: Pangan hewani, masyarakat pesisir, asupan protein, stunting

Introduction

Stunting, defined as impaired linear growth resulting from chronic undernutrition and recurrent infection, remains a major global public health challenge. In 2022, an estimated 148 million children under the age of five were stunted, with the greatest burden concentrated in South Asia and sub-Saharan Africa (UNICEF et al., 2023). In Indonesia, the national prevalence of stunting declined from 30.8% in 2018 to 21.5% in 2023; however, this figure still exceeds the WHO threshold of 20%, which denotes a high burden (Ministry of Health of the Republic of Indonesia, 2023). Central Kalimantan Province reported a prevalence of 23.5%, whereas the Kotawaringin Barat District recorded 17.9%. Both areas require sustained attention within the national acceleration strategy, which targets a 14% prevalence by 2024 (Ministry of Health of the Republic of Indonesia, 2023).

The 6–23 months period, within the first 1,000 days of life, constitutes a critical window for nutritional intervention. During this phase, the requirements for animal-source protein to support linear growth, neurocognitive development, and immune function are at their highest (Parikh et al., 2022). Animal-source foods are nutrient-dense foods that provide complete proteins containing all essential amino acids and critical micronutrients, including heme iron, zinc, and vitamin B12. These nutrients are generally more bioavailable and may be challenging to obtain in sufficient amounts from plant-based foods alone, particularly during periods of rapid growth in early childhood (Sheffield et al., 2024).

Coastal areas would theoretically benefit from an abundance of fish protein. Kotawaringin Barat is one of Central Kalimantan's productive capture fisheries centers, with an output of 28,000 tonnes in 2022 and per-capita fish consumption rising from 56.28 to 64.10 kg/year (DKPP, 2023). Fish are rich in protein, omega-3 fatty acids (DHA, EPA), iron, zinc, and vitamin D, which are essential for child growth (Rifat et al., 2023). However, a striking paradox emerges: despite 85.01% of children aged 6–23 months in Kotawaringin Barat reportedly consuming animal-source protein (SIGIZI Terpadu, 2023), the prevalence of stunting remains a persistent public health concern. Similar patterns have been documented in several fishing and coastal communities, where abundant access to fish and other aquatic foods does not necessarily translate into improved child nutritional outcomes. For example, Gibson *et al*. (2020) reported that households in fishing communities in eastern Indonesia consume fish regularly; however, dietary diversity among mothers and children remains limited. Likewise, Cartmill *et al*. (2022) found that in coastal Kenya, fish availability alone was insufficient to ensure optimal complementary feeding practices because of household, cultural, and caregiving constraints. These findings suggest that the availability of nutrient-rich foods may not automatically result in adequate dietary utilization at the household level, a phenomenon increasingly described as the "coastal nutrition paradox" (Hicks et al., 2019).

Previous research on children's animal-source protein consumption has predominantly focused on urban or highland settings, with limited attention paid to coastal contexts (Afifah, 2025). Existing studies have tended to employ quantitative designs without exploring the sociocultural dimensions of intra-household food distribution (Zakariah-Akoto et al., 2024).

Evidence on complementary feeding practices, intra-household food allocation, and cultural factors influencing children's protein intake in Indonesian coastal communities remains scarce. Nevertheless, existing evidence from Indonesian fishing communities suggests that food availability may coexist with inadequate dietary diversity and suboptimal feeding practices among young children (Gibson et al., 2020). This indicates that factors beyond

food supply, including caregiver knowledge, household decision-making, and socioeconomic vulnerability may influence the nutritional benefits derived from locally available animal-source foods. Potential contributors to this paradox include inequitable intra-household food distribution, suboptimal complementary feeding practices, reliance on ultra-processed foods, low exclusive breastfeeding coverage, food taboos, and income instability associated with seasonal fishing (Gibson et al., 2020; Ramenzoni, 2023).

This study aimed to (1) analyze patterns of animal-source food consumption (frequency, types, and quantities) among children aged 6–23 months in coastal Kotawaringin Barat, (2) assess child nutritional status using height-for-age z-scores (HAZ), and (3) identify facilitators and barriers to animal-source protein consumption through in-depth qualitative exploration. By integrating quantitative and qualitative data, this research contributes to understanding the availability–utilization gap in coastal settings and offers implications for designing contextually appropriate nutritional interventions.

Methods

Study Design and Setting

This study employed a mixed-methods sequential explanatory design in which quantitative data collection and analysis preceded a qualitative phase intended to explain and contextualize the quantitative findings (Creswell & Poth, 2016). We selected this approach because the research questions required both a statistical description of dietary patterns and an in-depth exploration of the socio-structural mechanisms behind them, dimensions that a single method could not adequately address. Data integration was performed at the interpretation stage.

The research was conducted in two coastal villages in Kumai subdistrict, Kotawaringin Barat district, Central Kalimantan: Sungai Bakau village (mainland coast) and Sungai Cabang village (a small offshore island reachable by 3–5 hours of sea travel). Villages were purposively chosen because they recorded the highest stunting prevalence within the Teluk Bogam community health center catchment area in 2023, 13.68% and 23.53%, respectively, and together represent diverse coastal geographic characteristics. Data collection will be conducted from March to May 2025. This study was reviewed and approved by the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas Brawijaya, under document number 12865/UN10.F17.10.4/TU/2024.

Population and Sampling

The study was conducted in four phases. Phase one involved nutritional screening of all children aged 6–23 months in both villages using total sampling (n = 67) to classify nutritional status based on height-for-age z-scores (HAZ) according to the WHO Child Growth Standards: stunted (HAZ < −2 SD) and non-stunted (HAZ ≥ −2 SD). Phase two comprised a quantitative survey of 55 mother–child dyads meeting the following inclusion criteria: child aged 6–23 months, residency in the village for at least six months, no congenital disease, and maternal consent to participate. Total sampling was applied to all eligible dyads in both the villages.

Phase three consisted of in-depth interviews with 22 purposively selected mothers to achieve balanced representation between the stunted (n = 11) and normal (n = 11) groups, enabling the exploration of contrasting complementary feeding experiences. Phase four was a focus group discussion (FGD) with 21 key informants, including village heads, Family Empowerment and Welfare Team (Indonesian call *Tim Penggerak Pemberdayaan dan Kesejahteraan Keluarga* [TP PKK]) leaders, midwives, community health center nutrition staff, *Posyandu* cadres, and family support officers from both the villages.

Because the study was conducted in two relatively small coastal villages, all eligible mother–child dyads were included using a total sampling approach to maximize the population coverage. Although the final quantitative sample (n = 55) and number of stunting cases (n = 11) were relatively small, this study aimed to provide exploratory evidence from an under-researched coastal population. To reduce the risk of model overfitting, the logistic regression analysis was restricted to a limited number of theoretically relevant variables, and the findings were interpreted cautiously.

Instruments and Measurements

Child recumbent length was measured using a standardized infantometer/length board with

0.1 cm precision (Kenko length board) by trained enumerators who had completed anthropometric measurement training. The measurement procedures followed the standardized techniques recommended by the WHO Child Growth Standards, which have been adopted as the national reference in Indonesia (World Health Organization, 2023).

Animal-source food consumption was assessed using a semi-quantitative food frequency questionnaire (SQ-FFQ) covering 20 animal-source food items, recording both consumption frequency (times/week) and estimated quantity (g/day) over the preceding month. The questionnaire was administered through face-to-face interviews with mothers or primary caregivers to minimize recall bias and improve the completeness of the data (Ansari et al., 2016). The SQ-FFQ was adapted from dietary assessment instruments previously used and validated for evaluating dietary intake in Indonesian populations, including studies assessing PUFA intake among children aged 6–23 months and animal protein intake among toddlers. Prior to data collection, the adapted questionnaire underwent expert review and field pre-testing to assess content relevance, clarity, feasibility, and cultural appropriateness within the study setting. Because the instrument was adapted from previously validated dietary assessment tools and was used primarily to estimate food intake rather than to measure latent constructs, no additional formal psychometric validation or reliability coefficients were calculated in this study. Protein adequacy was evaluated against the WHO/FAO Estimated Average Requirement (FAO & WHO, 2013).

Sociodemographic and contextual data were collected using a structured questionnaire. Qualitative data were gathered using pilot-tested semi-structured interview guides for in-depth interviews and focus group discussions (FGDs). All sessions were audio-recorded using a Sony ICD-PX470 digital recorder and transcribed verbatim.

Data Analysis

Quantitative data were analyzed using IBM SPSS version 26 and Nutrisurv. The Shapiro–Wilk test was used to assess normality before inferential analyses. Descriptive statistics (means, standard deviations, medians, interquartile ranges, and frequency distributions) were calculated for the key variables. Between-group comparisons (stunted versus normal children) used the Mann–Whitney U test for non-normally distributed continuous variables and Fisher's Exact Test for categorical variables with expected cell counts <5.

Binary logistic regression was performed to explore the association between protein intake, exclusive breastfeeding, and stunting status. Because only 11 stunting cases were identified, the inclusion of multiple covariates was not considered statistically appropriate due to the risk of model overfitting and unstable parameter estimates. Therefore, the regression model was intentionally restricted to the primary exposure variables. Potential confounding factors, including child age, sex, maternal education, household income, sanitation conditions, and recent infection history, were collected descriptively and considered during the interpretation of the findings but were not included in the multivariable model. Statistical significance was set at $p < 0.05$.

Qualitative data were analyzed using inductive thematic analysis (Braun & Clarke, 2006) through familiarization, initial coding, theme generation, review, and theme naming. Trustworthiness was addressed using three strategies: (1) triangulation of sources (mothers, cadres, health workers), methods (in-depth interviews and FGDs), and data types (quantitative and qualitative); (2) member checking by presenting summaries of key findings to a representative subsample of informants to verify interpretive accuracy; and (3) an audit trail documenting analytic decisions in researchers' reflexivity notes. The integration of quantitative and qualitative findings occurred during interpretation to produce a more comprehensive understanding.

Result and Discussion

Sociodemographic Characteristics

A total of 55 mother–child dyads participated in the quantitative survey for this study. Children aged 12–23 months accounted for 56.4% of the sample, and 54.5% were female. The prevalence of stunting was 21.8% (n = 12/55). More than half of the mothers had completed only primary education (54.5%), and the most common paternal occupations were fishermen (30.9%) and company employees/civil servants (30.9%). Most participants resided in Sungai Bakau village (65.5%), and the remainder lived in Sungai Cabang village (34.5%).

Table 1. Characteristics of the quantitative study participants (n = 55)

Characteristic	n	%
Child age		
6–11 months	24	43.6
12–23 months	31	56.4
Child sex		
Male	25	45.5
Female	30	54.5
Nutritional status		
Non-stunted	43	78.2
Stunted	12	21.8
Maternal education		
Primary school	30	54.5
Junior high school	17	30.9
Senior high school or higher	8	14.5
Paternal occupation		
Fisherman	17	30.9
Company employee/civil servant	17	30.9
Labourer/driver/mechanic/ construction worker	12	21.8
Trader	1	1.8
Farmer	8	14.5
Study area		
Sungai Bakau	36	65.5
Sungai Cabang	19	34.5

Animal-Source Protein Intake, Exclusive Breastfeeding, and Stunting

The mean daily protein intake among children was 28.26 ± 3.21 g/day, with an average Estimated Average Requirement (EAR) adequacy of 132.68 ± 7.01%. Overall, 98.2% of the children met the EAR threshold. However, children with stunting exhibited lower protein intake and EAR adequacy than non-stunted children did. As protein intake and EAR adequacy were not normally distributed according to the Shapiro–Wilk test, non-parametric analyses were applied. Significant differences in protein intake and EAR adequacy were observed between the nutritional status groups, whereas exclusive breastfeeding was not significantly associated with stunting. Nevertheless, qualitative interviews revealed several instances of early formula introduction before six months of age, suggesting that infant feeding practices may still influence dietary trajectories beyond the period captured by quantitative analysis. To identify factors independently associated with stunting, binary logistic regression analysis was performed. The results of the bivariate and multivariate analyses are presented in Table 2.

Table 2. Association of animal-source protein intake and exclusive breastfeeding with stunting among children aged 6–23 months (n = 55)

Panel A. Bivariate analysis by nutritional status				
Variable	Stunting (n=11) Median (IQR) / n (%)	Non-stunting (n=44) Median (IQR) / n (%)	p-value	Statistical test
Protein intake (g/day)	22.60 (20.95–24.90)	29.35 (28.48–30.47)	<0.001*	Mann–Whitney U = 32; Z = −4.419
Mean ± SD (g/day)	23.20 ± 3.32	29.53 ± 1.48	–	–
Range (g/day)	18.7–26.7	26.5–33.0	–	–
EAR adequacy (%)	121.0 (118.85–124.75)	134.75 (132.78–137.98)	<0.001*	Mann–Whitney U = 25.5; Z = −4.556
Mean ± SD (%)	121.91 ± 6.72	135.38 ± 3.75	–	–
EAR met, n (%)	11 (100.0)	43 (97.7)	–	–
Exclusive breastfeeding, n (%)	4 (36.4)	31 (70.5)	0.076*	Fisher's Exact Test

Panel B. Multivariable logistic regression for the stunting status					
Variable	β	SE	OR	95% CI	p-value
Protein intake (g/day)	−1.318	0.528	0.268	0.095–0.754	0.013*
Exclusive breastfeeding	−1.736	1.549	0.176	0.008–3.671	0.263
Constant	35.761	15.076	–	–	0.018

Statistically significant at $p < 0.05$. †Not statistically significant at $\alpha = 0.05$. Mann–Whitney U test was applied because Protein_g_day ($W = 0.864$; $p < 0.001$) and EAR_percent ($W = 0.913$; $p < 0.001$) were not normally distributed according to the Shapiro–Wilk test. Fisher's Exact Test was used because one expected cell count was <5 (minimum expected count = 4.00). Logistic regression model fit: −2 Log Likelihood = 16.016; Cox & Snell $R^2 = 0.508$; Nagelkerke $R^2 = 0.779$; $\chi^2(2) = 39.028$; $p < 0.001$. OR, Odds Ratio; CI = Confidence Interval; SE = Standard Error. Dependent variable: Stunting status (1 = stunted, 0 = non-stunted).

Animal-Source Food Consumption Patterns

The most commonly consumed animal-source foods were milk (formula/UHT), eggs, and fresh fish, with mean intakes of 74.55 g/day, 48.38 g/day, and 36.15 g/day, respectively. Fresh fish was consumed most frequently, averaging 7.4 times per week, indicating near-daily consumption and reflecting the high availability of marine food in this coastal setting. Eggs and milk were regularly consumed, with average frequencies of 6.6 and 5.2 times per week, respectively.

In contrast, the consumption of iron-rich animal-source foods was substantially lower. The mean intakes of red meat and shrimp were 5.76 g/day and 5.36 g/day, respectively, and both were consumed less than twice per week. Chicken and beef liver, one of the richest dietary sources of bioavailable heme iron, had a mean intake of only 2.07 g/day and was consumed an average of 0.4 times per week. Other animal-source foods, including shellfish, squid, processed fish products (abon), and salted fish, contributed minimally to children's diets, with mean intakes below 2 g/day and consumption frequencies of less than once per week. Ultra-processed meatball products were consumed in moderate amounts (7.95 g/day; 3.2 times/week), particularly by older children. The detailed consumption patterns are presented in Table 3.

Table 3. Animal-source food consumption patterns among children aged 6–23 months in coastal areas (n = 55)

Food item	Mean intake (g/day)	Frequency (times/week)	Interpretation
Milk (formula/UHT)	74.55	5.2	Frequently consumed
Egg	48.38	6.6	Regularly consumed
Fish (fresh fish)	36.15	7.4	Consumed almost daily
Meatball (ultra-processed)	7.95	3.2	Moderate consumption
Red meat	5.76	1.3	Infrequently consumed
Shrimp	5.36	1.2	Infrequently consumed
Chicken/beef liver	2.07	0.4	Rarely consumed
Shellfish	1.27	0.3	Rarely consumed
Squid	0.38	0.2	Rarely consumed
Processed fish products (abon)	0.29	0.1	Rarely consumed
Salted fish	0.07	0.1	Rarely consumed

Qualitative Findings: Facilitators and Barriers

The qualitative subsample consisted of 22 purposively selected mothers, including 11 mothers of stunted children and 11 mothers of non-stunted children, to ensure the representation of contrasting child feeding experiences. Inductive thematic analysis of 22 in-depth interviews and FGDs with 21 participants yielded four overarching themes describing the facilitators and barriers to optimal animal-source protein consumption. We triangulated sources (mothers, cadres, health workers), methods (in-depth interviews and FGDs), and data types (quantitative and qualitative) to enhance the credibility of our findings. The qualitative findings, representative quotations, and their analytical relevance to the quantitative data are presented in Table 4.

Table 4. Qualitative findings: facilitators and barriers to animal-source protein consumption in coastal communities (in-depth interviews n = 22; FGD n = 21)

Theme/sub-theme	Representative quotation (informant code)	Analytical interpretation and relevance to quantitative findings
Facilitating Factors		
Abundance of local fish	*"Fish, gembung, belanak, kakap, is available every day here*." (S1-SB)	Consistent with the high fish consumption frequency (7.4×/week) in the quantitative data, availability alone does not guarantee micronutrient adequacy.
Cultural fish-eating tradition	*"We have always eaten fish, it is our custom here."*	Cultural capital reinforces consistent fish consumption and represents a potential leverage

	(FGD3-SB)	point for locally adapted nutrition interventions.
Local food processing innovation	*"I make homemade fish nuggets for my child."* (NS10-SC)	This was observed exclusively in the non-stunting group, suggesting that maternal food preparation capacity may moderate the food availability–child intake relationship.
Posyandu cadre support	*"Bu Hasanah always explains why the weight is not increasing."* (S3-SB)	Cadres function as community nutrition education agents, partially compensating for limited formal maternal nutrition knowledge.
Barriers		
Low maternal nutrition literacy	*"I do not know what protein is."* (S5-SB)	Several informants from households with stunted children demonstrated a limited understanding of animal-source protein and child nutrition, suggesting that maternal nutrition literacy may influence complementary feeding practices.
Ultra-processed food displacement	*"My child prefers snack crackers and refuses fish."* (S6-SB)	Meatball consumption 3.2×/week in quantitative data; displacement of nutrient-dense foods, particularly evident after 12 months of age.
Early formula introduction and suboptimal breastfeeding practices	*"Formula milk was given from 2 months of age." (S4-SB)*	Qualitative findings revealed frequent early Several mothers reported introducing formula milk before six months of age. These practices may affect infant feeding patterns during the complementary feeding period and reflect the challenges in maintaining recommended breastfeeding practices.
Seasonal fishing instability	*"When the waves are big, fishermen cannot go out and fish is scarce*." (FGD5-SC)	This may partially explain the higher stunting prevalence in the more geographically isolated Sungai Cabang (23.53%) compared to Sungai Bakau (13.68%).
Inadequate water and sanitation	*"Sometimes river water, sometimes rainwater."* (S9-SC)	This suggests the potential for environmental enteric dysfunction, which may impair nutrient utilization despite a quantitatively adequate intake.
Household tobacco expenditure	*"If it is about cigarettes, I give up arguing."* (FGD6-SB)	Tobacco spending may compete with food budgets and is more prevalent in fishermen households (45.5% of the stunting group).

Informant codes: S = stunted, NS = normal, SB = Sungai Bakau, SC = Sungai Cabang, FGD = focus group discussion.

Protein Intake Gradient and Linear Growth: Beyond EAR Adequacy

The principal finding of this study was a significant gradient in protein intake between stunted and non-stunted children (median 22.60 vs. 29.35 g/day; $p < 0.001$), despite 98.2% of the sample meeting the Estimated Average Requirement (EAR). In the logistic regression model, higher protein intake was associated with lower odds of stunting (OR = 0.268; $p = 0.013$). Given the relatively small sample size, limited number of stunting cases, and cross-sectional design, this finding should be interpreted cautiously and viewed as exploratory rather than causal in nature. Nevertheless, the observed association suggests that differences in protein intake may be relevant to variations in linear growth status among children whose overall protein intake generally met the recommended requirements. Other biological, environmental, and socioeconomic factors that were not measured in this study may also contribute to the observed growth differences.

A between-group difference of approximately 7 g/day, modest in absolute terms, may nonetheless have biologically meaningful consequences. Animal-source foods provide high-quality proteins containing essential amino acids required for tissue synthesis and growth regulation in humans. Previous studies have demonstrated positive associations between essential amino acid status and child growth indicators, suggesting that differences in protein quality may contribute to variations in linear growth, even when total

protein intake appears adequate. The biological importance of these amino acids is supported by evidence from Malawi, where serum concentrations of lysine, leucine, and methionine in infants aged 6–12 months were positively correlated with weight-for-height, and higher levels of multiple essential amino acids were observed in children with above-average linear growth velocity (Ordiz et al., 2019). Cumulative differences in essential amino acid intake during the complementary feeding period may contribute to variations in growth trajectories despite the apparent adequacy of total protein intake. This pattern is consistent with the findings of Kaimila et al. (2019), who reported that animal protein consumption was associated with improved height-for-age z-scores among rural Malawian children aged 12–36 months (*p* = 0.047). It is important to emphasize that the cross-sectional design precludes causal inference, and longitudinal studies are required to confirm these relationships.

Emerging evidence suggests that children living in environments characterized by recurrent infections and inflammation may require higher-quality dietary proteins to support optimal growth and tissue recovery. Tessema et al. (2018) found that in rural Ethiopian children aged 6–35 months, controlling for inflammation and intestinal parasites, daily protein intake (b = 0.01, p = 0.01) and serum IGF-1 levels (b = 0.01, p = 0.003) were positively associated with linear growth, suggesting that low-quality protein intake and inadequate energy intake may contribute to impaired linear growth among children exposed to inflammatory and infectious conditions. Similarly, a 2024 review by Shivakumar & Kelly (2024) emphasized that children living in regions with a high prevalence of environmental enteropathy require higher-quality protein intake to overcome compromised nutrient availability, highlighting that increased protein requirements in the presence of environmental enteropathy may contribute to protein depletion and impaired growth when dietary intake is inadequate. This interpretation is consistent with our findings. However, the present study did not directly assess the inflammatory status, infection burden, or protein metabolism. Therefore, these mechanisms should be considered as possible explanations rather than conclusions derived from the current data analysis.

Diet Quality Gap: Limited Diversity of Heme-Iron Sources and Micronutrients

The near-exclusive reliance on fish, eggs, and milk, while reflecting local food ecology, indicates limited diversity among animal-source foods. The minimal consumption of organ meats and other high-heme-iron foods may indicate potential vulnerability to micronutrient inadequacy, particularly iron and zinc deficiency, although a biochemical assessment was not conducted in this study. Previous evidence indicates that heme iron from animal-source foods has substantially greater bioavailability than non-heme iron from plant-based sources, and organ meats such as liver contain higher iron concentrations than many commonly consumed fish products (Ems et al., 2017).

The qualitative data reinforce this interpretation. Low maternal nutrition literacy, reported by 15 of the 22 informants and more prevalent among mothers of stunted children, was linked to limited awareness of micronutrient-rich food choices. This finding aligns with that of Gracela et al. (2024), who reported that 39.4% of mothers had low nutritional knowledge, which was significantly associated with limited diversity of animal protein intake among toddlers (p = 0.027). These findings highlight that dietary composition, not merely protein quantity, is a critical target for interventions.

Exclusive Breastfeeding: Interpreting a Non-Significant Result

The Fisher's Exact Test for the association between exclusive breastfeeding and stunting yielded p = 0.076, failing to reach conventional statistical significance at α = 0.05. Consequently, this study did not identify a statistically significant association between exclusive breastfeeding and stunting in the present sample.

Nevertheless, the descriptive disparity (36.4% exclusive breastfeeding in the stunted group versus 70.5% in the normal group) warrants attention. The relatively small number of stunted children and unequal group distribution may have limited our statistical power to detect significant differences. A similar non-significant pattern was observed in the regression analysis. This pattern is consistent with the findings of other studies in Indonesia, where exclusive breastfeeding showed a protective effect against stunting with an odds ratio of 0.55 (95% CI: 0.24–1.23) that did not

reach statistical significance, which the authors attributed to insufficient statistical power (Anindya et al., 2023).

Early cessation of exclusive breastfeeding may increase susceptibility to infection and compromise nutrient utilization during the complementary-feeding period. Previous studies from low- and middle-income countries have suggested that children who are not exclusively breastfed may face a greater risk of growth faltering because of reduced immune protection and increased exposure to infectious diseases (Picauly, 2023). However, larger studies are needed to evaluate this relationship conclusively.

Dietary Displacement by Ultra-Processed Foods

The mean consumption of meatball-type ultra-processed products (3.2 times/week), particularly among children older than 12 months, illustrates the dietary displacement described by Monteiro et al. (2021), wherein ultra-processed foods progressively supplant nutrient-dense options. Ultra-processed foods are generally characterized by lower nutrient density and higher levels of added salt, sugar, and unhealthy fats than minimally processed foods (Monteiro et al., 2021). Meta-analyses have shown dose-response associations between ultra-processed food consumption and adverse health outcomes, with children and adolescents being particularly vulnerable to high UPF intake (Monteiro et al., 2021; Neri et al., 2021).

Although fish and eggs are considered high-quality protein sources, excessive industrial processing and repeated heating may reduce the nutrient quality and amino acid availability of processed meat products (Bailey et al., 2020). Qualitative findings indicating children's preference for snacks and processed foods over fish are consistent with broader Indonesian dietary patterns. A nationwide study conducted across 15 provinces documented high adolescent consumption of ready-to-eat snacks and processed foods, with notable variations between the Java and Bali and non-Java–Bali regions (Briawan et al., 2024).

The increasing presence of ultra-processed foods in children's diets may reflect broader dietary transitions occurring in coastal communities. Such shifts may reduce dietary diversity and displace more nutrient-dense food options, particularly when household resources are limited. Economic vulnerability and changing food environments may contribute to dietary transitions characterized by an increased reliance on lower-quality processed foods among coastal households (Popkin & Ng, 2022).

Structural Determinants: Geography, Sanitation, and Nutrient Utilization

The higher stunting prevalence in Sungai Cabang (23.53%) than in Sungai Bakau (13.68%) likely reflects greater geographic isolation, 3–5 hours by sea, and consequent instability in the food supply during adverse weather. This aligns with evidence from small-island communities in eastern Indonesia, where remoteness and limited physical access to other areas make households vulnerable to food insecurity, as underdeveloped infrastructure and sensitivity to variable weather conditions constrain both food availability and accessibility (Nasrudin et al., 2020). Seasonal variability in catches, reported in FGDs, can cause fluctuations in the availability and access to animal-source foods that monthly average intake data may not capture. Household tobacco expenditures, which were more common among fishing households and present in 45.5% of stunted households, may further exacerbate these constraints by reducing the allocation of limited financial resources to diverse and nutrient-dense foods for children.

Qualitative findings indicated that some households relied on untreated river or rainwater and experienced limitations in sanitation infrastructure. Previous studies have shown that poor water, sanitation, and hygiene (WASH) conditions are associated with a higher risk of childhood infections and growth faltering in low- and middle-income countries (Tickell et al., 2019). Although environmental enteric dysfunction (EED) has been proposed as a potential pathway linking poor sanitation to impaired growth, the present study did not include biological measurements of EED, intestinal inflammation, or nutrient absorption. Consequently, any discussion of these mechanisms remains speculative and should be interpreted with caution. Nevertheless, the findings support the broader importance of integrating nutrition-sensitive interventions, including improvements in WASH conditions, into stunting reduction efforts in vulnerable coastal communities.

Mixed-Methods Integration: from Availability to Utilization

The mixed-methods design strengthened the interpretation of the findings by integrating quantitative dietary patterns with qualitative contextual insights. Quantitative analyses revealed a clear protein intake gradient and identified exclusive breastfeeding as a descriptive differentiator. Qualitative findings helped explain how caregiving practices, maternal nutrition literacy, food preferences, and environmental constraints influenced the dietary patterns. Low maternal nutritional literacy, which is more common among caregivers of stunted children, helps explain why abundant local fish resources do not always translate into optimal child intake.

The observation that homemade fish-processing practices (e.g., fish nuggets) occurred only among caregivers of non-stunted children suggests that maternal food-processing skills can moderate the relationship between availability and child consumption. This aligns with Khonje & Qaim's (2024) framework, which posits that household-level food availability alone does not guarantee optimal child intake because intra-household allocation is mediated by caregiving capacity, nutritional knowledge, and structural pressures such as income instability. Community-based learning through *Posyandu cadres has* emerged as a locally feasible strategy and is supported by meta-analytic evidence of the effectiveness of peer-facilitated interventions in low-literacy settings (Janmohamed et al., 2020).

Study Limitations

This study had several limitations that should be considered when interpreting the findings. First, the cross-sectional design limited the ability to establish causal relationships between dietary intake patterns and stunting outcomes. Second, dietary intake assessment relied partly on caregiver recall, which may have introduced recall bias and measurement inaccuracies. Third, this study did not directly assess biomarkers of micronutrient status, intestinal inflammation, or environmental enteric dysfunction (EED), therefore, the proposed biological mechanisms linking WASH conditions and impaired nutrient utilization remain hypothetical and should be interpreted cautiously.

In addition, protein quality and nutrient bioavailability were inferred from food sources rather than laboratory-based nutrient analyses. Despite these limitations, the mixed-method approach provided important contextual insights into how caregiving behaviors, food preferences, and environmental conditions may interact with dietary intake to influence child growth in coastal communities.

Conclusion

This study found that adequate household availability of animal-source foods and overall protein adequacy did not necessarily correspond with optimal linear growth among children in coastal Kotawaringin Barat, Indonesia. While higher protein intake was associated with lower odds of stunting, qualitative findings suggested that caregiving practices, dietary quality, food preferences, sanitation conditions, and socioeconomic constraints may influence how available nutrients are translated into child growth outcomes.

These findings support the need for integrated nutrition-sensitive interventions that combine caregiver education, dietary improvement strategies and WASH interventions. Future longitudinal studies incorporating dietary quality assessments and biological measurements are needed to clarify the mechanisms underlying these relationships.

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