

Risk factors of stunting incidence among children aged 6-23 months in fishing families in Brebes Regency, Central Java

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ORIGINAL ARTICLES

Submitted: 18 October 2025

Accepted: 21 November 2025

Keywords:

Case control, Children aged 6-23 months, Risk factor, Stunting, Fishing families

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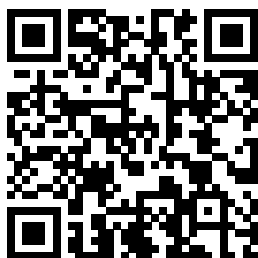
ABSTRACT

Stunting remains a major public health problem, particularly in coastal communities where poverty and limited dietary diversity are prevalent. Children in fishing families are vulnerable due to low household income, inadequate food intake, and exposure to infections. This study aimed to identify and analyze the risk factors associated with stunting among children aged 6–23 months in fishing families in Brebes Regency, Central Java. A matched case-control study was conducted from April to May 2025 in three coastal villages (Kluwut, Grinting, and Pulogading), Bulakamba Subdistrict, Brebes. A total of 132 subjects were enrolled, consisting of 44 stunting cases and 88 controls matched by age. Data were collected on child, maternal, and household characteristics, dietary intake, and health status. Statistical analyses included Chi-square test and Binary Logistic Regression to determine significant risk factors ($p < 0.05$). The results showed that children with a history of pulmonary TB had an 9.622 times higher risk of being stunted (OR = 8.120; 95% CI: 1.009–91.735; $p = 0.049$). Inadequate energy intake ($\leq 89\%$ RDA) had an 8.12 times higher risk of stunting (OR = 8.120; 95% CI: 2.552–25.839; $p = 0.001$). Birth length < 48 cm increased the risk of stunting by 4.105 times ((OR = 4.105; 95% CI: 1.593–10.575; $p = 0.003$). Meanwhile, age 6-11 months showed a protective effect (OR=0.343; 95% CI: 0.135-0.869; $p=0.024$).

Key Messages:

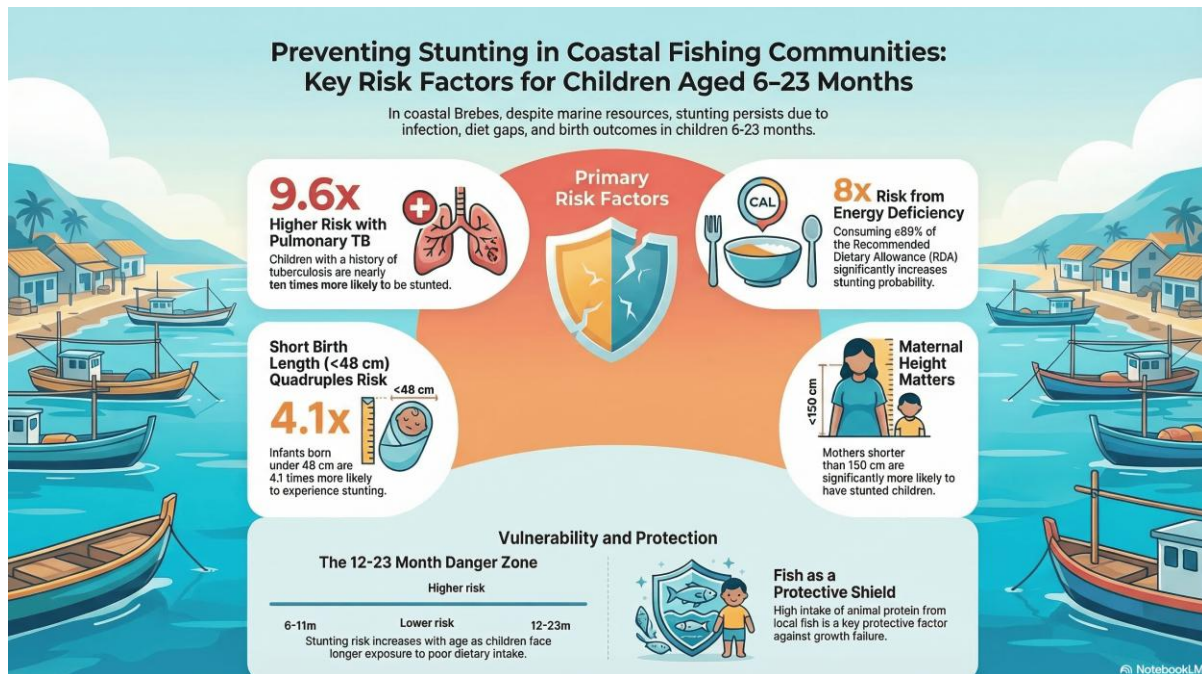
- Infection history, low energy intake and poor birth outcomes are major causes of stunting among children aged 6–23 months in fishing families.
- Improving maternal and child nutrition during the first 1000 days of life is crucial to prevent stunting in coastal communities.

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GRAPHICAL ABSTRACT



INTRODUCTION

Coastal areas possess strong economic potential due to their abundance of marine and biological resources. However, the diversity of natural wealth in these regions is not accompanied by adequate community welfare, as most coastal populations still live with low economic status (1). Fishermen typically lack a stable monthly income because their earnings fluctuate based on the volume of their catch. Uncertain fish catches, influenced by climate change and seasonal variations, threaten their livelihoods (2). Low household income among fishing families limits their ability to allocate expenditures for diverse and nutritious foods, thereby affecting family nutritional adequacy, particularly for children (3).

Previous studies have reported that the prevalence of stunting in coastal areas of East Java is considerably higher than in agricultural, urban, or mining regions (4). A study in West Sumatra also found that coastal fishing communities have a 3.279 times higher risk of malnutrition compared to agricultural, plantation, and urban populations (5). Although access to animal protein sources such as fish is relatively easy in coastal regions, protein consumption remains lower than that of mountain communities (6). Stunting in coastal areas has been linked to low household food security, poor socio-economic conditions, and inadequate intake of macro- and micronutrients (7). Poor sanitation facilities, limited access to clean water, and inadequate waste management make these regions highly polluted (8). Children living in such environments are more vulnerable to gastrointestinal infections and diseases (9).

Stunting is diagnosed when a child's height-for-age value is below the standard reference, defined as a height-for-age Z-score (HAZ) less than -2 standard deviations (SD) according to sex-specific growth charts (10). Stunting is a complex nutritional problem influenced by factors beginning during pregnancy and continuing after birth (11). Several studies have shown that children who receive exclusive breastfeeding are less likely to experience stunting than those who do not (12). Breast milk provides essential antibodies that protect against infections and serves as an optimal nutrient source for infant growth (13). Infectious diseases are closely related to nutritional intake; children suffering from infections tend to have poorer nutritional status, whereas adequate nutrition strengthens immunity and prevents illness (14). Indirect causes of stunting often begin during pregnancy, when maternal undernutrition can increase the risk of low birth weight (LBW). Infants with LBW are more vulnerable to infections and degenerative diseases, which may impair growth and development (15). More complex community-level determinants include health service accessibility, maternal education and knowledge, household economic status, and sociocultural conditions (12). A study in Maros District found that low- to middle-income

families have a higher risk of stunting (16). Stunting remains a major nutritional problem in developing countries, including Indonesia, where its prevalence reached 21.5% in 2023. According to the Strategic Plan of Central Java Province (2018–2023), 11 priority districts and cities were designated for stunting reduction, particularly 14 regions with a prevalence above 20% based on the SSGI 2022, including Brebes, Temanggung, Magelang, Purbalingga, Blora, Rembang, Sragen, Batang, Pekalongan, Kota Pekalongan, Pati, Karanganyar, Kebumen, and Purworejo (17). Brebes Regency remains one of the areas with a high prevalence of stunting, reported at 21.6% in 2023 (18). This rate is still above the national target of 14% and the WHO standard of below 20% (10). Brebes is located along the northern coast of Central Java and has extensive coastal zones supporting marine and inland fisheries (19).

The stunting problem among fishing families demands urgent governmental attention due to its long-term impact on human resource quality. Stunting is associated with an increased the risk of disease, impaired cognitive development, and a reduced quality of human resources (20). Based on this background, the purpose of this study is to identify and analyze what risk factors can affect the incidence of stunting in children aged 6-23 months in fishing families in Brebes Regency, Central Java.

METHODS

This research utilized a matched case-control design to identify and analyze the risk factors associated with stunting among children aged 6–23 months in fishing families residing in Brebes Regency, Central Java, Indonesia. The study was conducted from April to May 2025 in three coastal villages—Kluwut, Grinting, and Pulogading—located in Bulakamba Subdistrict, which represent typical fishing communities in the region. The population of this study was all fishing families with children aged 6-23 months in Brebes District. The minimum sample size was determined using the Charan and Biswas formula (21), establishing a 1:2 case-to-control ratio to enhance statistical power. The final sample comprised 132 children: 44 stunting cases (height-for-age Z-score < -2 SD) and 88 controls (height-for-age Z-score \geq -2 SD), matched by age. A consecutive sampling technique was applied to select participants who met the inclusion criteria. Inclusion criteria were families whose primary livelihood was fishing, who had children aged 6–23 months, had lived in the study area for at least 6 months, and possessed a Child and Maternal Health (Kesehatan Ibu dan Anak, KIA) book. Exclusion criteria included children with physical or mental disabilities and whose caregiver declined participation. Children with physical or mental disabilities were excluded because these conditions may independently influence growth and nutritional status, potentially confounding the analyses and reducing the accuracy of the associations being examined.

Data were collected through structured interviews and direct measurements. Before completing the questionnaire, respondents must sign an informed consent form for the study. The information gathered included child characteristics (age, sex, birth weight, birth length, infection history), dietary intake (energy and macronutrient adequacy), maternal characteristics (age at pregnancy, height, pre-pregnancy nutritional status, and gestational weight gain), and household socio-economic factors (parental education, income, and food expenditure). Anthropometric data, specifically body length of children aged 6-23 months were measured without shoes using an infantometer, and the length was recorded to the nearest 0.1 cm. The maternal pregnancy history data, including age, height, pre-pregnancy nutritional status, gestational weight gain, birth weight, and length, were obtained through KIA book sheets and direct interviews. Infection history and household socio-economic data were also obtained through interviews with questionnaires. Dietary intake was assessed using a 2×24-hour food recall conducted on both a weekday and a weekend day, and the data were analyzed using Nutrisurvey software. Anthropometric data were processed using WHO AnthroPlus. Data were analyzed using IBM SPSS Statistics version 25.0. Descriptive statistics were used to summarize participant characteristics. The bivariate analysis used nonparametric statistical testing with Chi-square ($p < 0.05$). If more than 20% of the expected cell counts were less than 5, Fisher's exact test was used to assess associations between independent variables and stunting. Variables with $p < 0.25$ were included in the multivariate analysis using binary logistic regression to determine the most significant risk factors for stunting. Odds ratio at 95% CI were used to measure the strength of association between outcome and predictor variables.

CODE OF HEALTH ETHICS

Ethical approval for this study was obtained from the Research Ethics Committee of Universitas Muhammadiyah Surakarta (No. 5655/B.1/KEPK-FKUMS/III/2025).

RESULTS

Table 1 presents the characteristics of the children according to their nutritional status. No statistically significant differences were observed for age, sex, or the majority of infection histories between stunted and normal children ($p > 0.05$). The proportion of stunted children aged 12–23 months was higher than that of normal children. The prevalence of stunting was relatively similar between male and female children. Children with birth weight below 2500 g had a higher prevalence of stunting compared to those with normal birth weight, the association did not reach statistical significance ($p = 0.063$). Birth length, however, demonstrated a significant relationship with stunting ($p = 0.003$), half of the stunted children were born with a length less than 48 cm, while in the normal group, while only 23.9% of the normal children had short birth length. Among the infection-related variables, only pulmonary tuberculosis showed a statistically significant association with stunting ($p = 0.006$). The prevalence of pulmonary TB was higher among stunted children compared to normal children.

Table 1. Subject's characteristics

Characteristics	Stunting (n=44)		Normal (n=88)		p-value
	n	%	n	%	
Age					
6-11 months	13	29.5	37	42	0.163
12-23 months	31	70.5	51	58	
Sex					
Male	21	47.7	43	48.9	0.902
Female	23	52.3	45	51.1	
Birth weight					
<2500 g	6	13.6	4	4.5	0.063
≥2500 g	38	86.4	84	95.5	
Birth length					
<48 cm	22	50	21	23.9	0.003*
≥48 cm	22	50	67	76.1	
History of infection					
ARI	19	43.2	24	27.3	0.066
Diarrhea	19	43.2	30	34.1	0.308
Pneumonia	0	0	4	4.5	0.301
Pulmonary TB	6	13.6	1	1.1	0.006*
Measles	1	2.3	3	3.4	1.000
Helminthiasis	2	4.5	0	0	0.109

Table 2 presents the distribution of macronutrient adequacy among children aged 6–23 months based on their nutritional status. Energy intake was significantly associated with stunting, with a higher proportion of stunted children experiencing energy deficiency (81.8%) compared to normal children (54.5%) ($p = 0.009$). Protein intake also showed a significant association; adequate and excessive protein intake were more common among normal children than stunted children ($p = 0.015$). In contrast, carbohydrate and fat adequacy did not differ significantly between the two groups ($p > 0.05$). The majority of carbohydrate intake and fat intake was categorized as deficiency and the results were not much different in both the stunted children and normal children.

Table 2. Macronutrient adequacy

Variables	Stunting (n=44)		Normal (n=88)		p-value
	n	%	n	%	
Energy					
Deficiency ($\leq 89\%$ RDA)	36	81.8	48	54.5	0.009*
Adequate (90-119% RDA)	7	15.9	35	39.8	
Excess ($\geq 120\%$ RDA)	1	2.3	5	5.7	
Carbohydrate					
Deficiency ($\leq 89\%$ RDA)	41	93.2	76	86.4	0.207
Adequate (90-119% RDA)	3	6.8	6	6.8	
Excess ($\geq 120\%$ RDA)	0	0	6	6.8	
Protein					
Deficiency ($\leq 89\%$ RDA)	8	18.2	17	19.3	0.015*
Adequate (90-119% RDA)	18	40.9	16	18.2	
Excess ($\geq 120\%$ RDA)	18	40.9	55	62.5	
Fat					
Deficiency ($\leq 89\%$ RDA)	37	84.1	64	72.7	0.348
Adequate (90-119% RDA)	5	11.4	17	19.3	
Excess ($\geq 120\%$ RDA)	2	4.5	7	8	

Table 3 presents the distribution of maternal characteristics in relation to the nutritional status of children. The majority of both stunted and normal children were born to mothers aged 20–35 years, with no significant difference between groups ($p = 0.199$). Maternal height showed a significant association with stunting ($p = 0.043$), as a higher proportion of mothers of stunted children were <150 cm compared to mothers of normal children. Maternal nutritional status before pregnancy and gestational weight gain did not differ significantly between groups ($p > 0.05$).

Table 3. Mother's characteristics

Characteristics	Stunting (n=44)		Normal (n=88)		p-value
	n	%	n	%	
Mother's age at pregnancy					
<20 or >35	6	13.6	6	6.8	0.199
20-35	38	86.4	82	93.2	
Mother's height					
<150 cm	18	40.9	21	23.9	0.043*
≥ 150 cm	26	59.1	67	76.1	
Mother's nutrition status before pregnancy (BMI)					
Underweight (<18.5)	6	13.6	4	4.5	0.256
Normal (18.5-22.9)	17	38.6	37	42	
Overweight (23-24.9)	6	13.6	13	14.8	
Obese I (25-29.9)	13	29.5	23	26.1	
Obese II (≥ 30)	2	4.5	11	12.5	
Weight gain during pregnancy					
Low	23	52.3	38	43.2	0.613
Normal	12	27.3	29	33	
High	9	20.5	21	23.9	

Table 4 presents the family socio-economic characteristics by child nutritional status. No significant differences were observed between stunted and normal children across all variables ($p > 0.05$). Most fathers and mothers had an elementary or junior high school education. The majority of households in both groups had more than four members. Most families in both categories had incomes above the Brebes Regency Minimum Wage (\geq Rp 2,239,801 per month) (22), and the majority of households allocated $\geq 60\%$ of their total expenditure to food indicates vulnerability to food insecurity (23).

Table 4. Family socio-economic characteristics

Characteristics	Stunting (n=44)		Normal (n=88)		p-value
	n	%	n	%	
Father's education					
Elementary/Junior high school	42	95.5	85	96.6	0.747
Senior high school	2	4.5	3	3.4	
Mother's education					
Elementary/Junior high school	43	97.7	83	94.3	0.375
Senior high school	1	2.3	5	5.7	
Number of family members					
≤ 4 people	25	56.8	39	44.3	0.176
> 4 people	19	43.2	49	55.7	
Family income					
< Rp2,239,801	14	31.8	26	29.5	0.789
≥ Rp2,239,801	30	68.2	62	70.5	
Food expenditure					
< 60% total expenditure	12	27.3	18	20.5	0.378
≥ 60% total expenditure	32	72.7	70	79.5	

Variables with $p < 0.25$ from the bivariate analysis were included in the model in this study. The variables of protein intake adequacy and history of helminthiasis could not be included in the model because the bivariate analysis using binary logistic regression showed p-values exceeded 0.25. Based on Table 5, the variables entered into the model were age, birth weight, birth length, energy adequacy, ARI and pulmonary TB history, mother's age at pregnancy, mother's height, and number of family members. These variables were then removed one by one according to the highest p-value. Only four of the nine variables remained significantly associated with stunting ($p < 0.05$) and were included in the final multivariate binary logistic regression model.

Table 5. Multivariate analysis results of logistic regression on factors influencing stunting

Variables	Category	OR	95% CI	p-value
Age	6-11 months	0.339	0.126-0.915	0.033*
	12-23 months (ref)	1.000	-	-
Birth weight	<2500 g	3.293	0.572-18.973	0.182
	≥2500 g (ref)	1.000	-	-
Birth length	<48 cm	4.145	1.547-11.107	0.005*
	≥48 cm (ref)	1.000	-	-
Energy adequacy	≤89% RDA	7.462	2.258-24.665	0.001*
	>90% RDA (ref)	1.000	-	-
ARI history	Yes	1.779	0.691-4.581	0.233
	No (ref)	1.000	-	-
Pulmonary TB history	Yes	11.280	1.176-108.192	0.036*
	No (ref)	1.000	-	-
Mother's age at pregnancy	<20 or >35	2.386	0.542-10.497	0.250
	20-35 (ref)	1.000	-	-
Mother's height	<150 cm	1.996	0.777-5.129	0.151
	≥150 cm (ref)	1.000	-	-
Number of family members	>4 people	1.163	0.444-3.043	0.758
	≤4 people (ref)	1.000	-	-

Table 6 presents the analysis of risk factors associated with stunting in children aged 6–23 months. Children with a history of pulmonary TB had an 9.622 times higher risk of being stunted (OR = 9.622; 95% CI: 1.009–91.735; $p = 0.049$). Children with energy intake deficiency (≤89% of the Recommended Dietary Allowance, RDA) had an 8.12 times higher risk of being stunted (OR = 8.120; 95% CI: 2.552–25.839; $p = 0.001$) compared to those with adequate or excess energy intake (>90% RDA). Children with a birth length below 48 cm were 4.105 times more likely to experience stunting (OR = 4.105; 95% CI: 1.593-10.575; $p = 0.003$) compared to those with normal birth length (≥48 cm). Children aged 6–11 months had a lower risk of stunting (OR = 0.343; 95% CI: 0.135-0.869; $p=0.024$) compared to those aged 12–23 months.

Table 6. Risk factors of stunting in children aged 6-23 months

Risk Factors	Category	OR	95% CI	p-value
Pulmonary TB history	Yes	9.622	1.009-91.735	0.049*
	No (ref)	1.000	-	-
Energy adequacy	≤89% RDA	8.120	2.552-25.839	0.001*
	>90% RDA (ref)	1.000	-	-
Birth length	<48 cm	4.105	1.593-10.575	0.003*
	≥48 cm (ref)	1.000	-	-
Age	6-11 months	0.343	0.135-0.869	0.024*
	12-23 months (ref)	1.000	-	-

DISCUSSION

The subjects of this study were children aged 6–23 months in Bulakamba Subdistrict, Brebes Regency. The results showed no significant difference between children's age and the occurrence of stunting ($p=0.163$; $p>0.05$). As shown in Table 1, the proportion of stunted children aged 6–11 months (29.5%) was lower than that of normal children (42%), conversely, the proportion of stunted children aged 12–23 months (70.5%) was higher than that of normal children (58%). Gender was also not significantly related to stunting ($p=0.902$; $p>0.05$), although female children experienced stunting slightly more often than males (52.3% vs 47.7%). This finding supports Ibrahim (2023), who found higher stunting rates among females in Nabire's coastal area (24). In many Indonesian regions, girls often receive lower priority in food distribution due to cultural factors (25). Women and girls often eat after men and boys as part of traditional customs, which can result in them receiving less or leftover food. These cultural norms give women and girls lower priority in household food allocation and less power to negotiate for better portions (26).

Infectious diseases are direct factors affecting children's nutritional status. A study in Enrekang Regency reported a significant relationship between infection and stunting ($p=0.012$; $p<0.05$) (27). In this study, acute respiratory infection (ARI) showed no significant relationship with stunting ($p=0.066$; $p>0.05$), though a study in Southern Ethiopia found that children who had ARI in the past two weeks were three times more likely to be stunted (OR=3.04; 95% CI=1.04–13.35) (28). Malnourished children often have weaker immune systems, making them more prone to infections. This may explain why ARI occurs 24% more frequently among stunted children (29). Diarrheal infection also showed no significant association with stunting ($p=0.308$; $p>0.05$). Diarrhea can worsen environmental enteric dysfunction (EED), which reduces nutrient absorption. A cohort study in Pakistan found that frequent diarrhea and ARI contribute to poor linear growth (30). Similarly, pneumonia was not significantly associated with stunting ($p=0.301$; $p>0.05$). Stunted children may have impaired lung development, increasing pneumonia risk, while pneumonia can further worsen stunting (28). The relationship between malnutrition, infection, and growth is cyclical—malnutrition increases infection risk, and repeated infections hinder growth (31).

In contrast, there was a significant association between pulmonary tuberculosis (TB) and stunting ($p=0.006$; $p<0.05$). A study in Bandung involving 169 stunted and severely stunted children found that 59.76% had pulmonary TB. Low BCG vaccination coverage and low body weight were also associated with TB risk, suggesting a strong link between TB and stunting (32). Measles infection was not significantly related to stunting ($p=1.000$; $p>0.05$), although measles may increase stunting risk through recurrent infections and nutrient loss. Complete immunization can help prevent these effects (33;34). Helminth infection was not significantly related to stunting ($p=0.109$; $p<0.05$). Data from the Tanzania Demographic and Health Survey (2015–2016) involving 7,962 children aged 12–59 months showed that children who did not receive deworming treatment had a higher prevalence of stunting (61%). While the association was not statistically strong, deworming was linked to lower anemia rates and better overall health. Deworming is most effective when combined with child nutrition and health programs (35;36).

Table 2 shows that energy intake was significantly associated with stunting ($p=0.009$; $p<0.05$), consistent with the study by Punuh et al. ($p=0.008$) (37). Adequate energy intake supports growth, immune function, and cognitive development (38). Protein intake was also significantly associated with stunting ($p=0.015$; $p<0.05$). Protein intake also showed a significant association; adequate and excessive protein

intake were more common among normal children than stunted children. Studies in several regions of Maros Regency showed that the high intake of animal protein is largely due to the widespread availability of fish, making it easily accessible. Food availability is closely linked to physical access to food facilities, such as markets, and the distance to these markets influences food accessibility and daily dietary intake (39). In this study, Bulakamba Subdistrict has its own fish auction market, making fish readily accessible to the community. This aligns with Ramadhani et al. and Stuijvenberg et al., who found that higher protein, calcium, and iron intake lowers stunting risk (40;41). Sholikhah and Dewi also identified animal protein as a key protective factor ($p=0.000$) (42), as it provides complete amino acids and essential micronutrients such as iron, vitamin B12, and zinc (43). Similarly, Kaimila et al. found that each 1-gram increase in animal protein intake improved height-for-age Z-score (HAZ) by 0.02 per month (44). Table 2 shows that carbohydrate ($p=0.207$; $p>0.05$) and fat ($p=0.348$; $p>0.05$) intake had no significant association with stunting. This finding is consistent with results from the Cimarga Health Center, which also found no significant association between carbohydrate ($p=0.439$) and fat ($p=0.607$) intake and stunting (45). However, Widyawardani et al. reported a significant relationship between fat ($p<0.001$) and carbohydrate ($p=0.001$) intake and stunting (46). Carbohydrates are the main energy source, and inadequate intake can force the body to use fat and protein for energy, disrupting growth. Similarly, low fat intake can cause energy deficits that affect metabolism and activity (47).

Table 3 shows no significant relationship between maternal age during pregnancy and stunting ($p=0.199$; $p>0.05$). Most mothers were aged 20–35 years (86.4% for stunted and 93.2% for normal children), an ideal reproductive range that supports healthy pregnancy, while ages below 20 or above 35 increase fetal growth risk (48). Maternal height was significantly related to stunting ($p=0.043$; $p<0.05$); mothers under 150 cm were more common among stunted children (40.9%) than normal children (23.9%), consistent with findings from Lombok, which also found significant association between maternal height and stunting ($p=0.044$; $OR=2.3$) (49). The relationship between maternal height and children's linear growth is influenced by a combination of genetic and maternal environmental factors. Mothers with shorter stature tend to have lower protein and energy reserves, smaller reproductive organs, and a more limited space for fetal development. These factors affect fetal growth through the placenta and infant growth through the quantity and quality of breast milk. Such conditions may lead to intrauterine growth restriction, which is also associated with shorter stature in children (50;15). Pre-pregnancy nutritional status showed no significant relationship ($p=0.207$; $p>0.05$), similar to the study by Qurani et al. reported no significant relationship between mother's pre-pregnancy nutritional status and stunting ($p=0.256$) (49), but different from a research conducted by Pusparini et al., who found that $BMI < 18.5$ increased stunting risk by 2.3 times (51). Maternal weight gain during pregnancy was also not significantly different ($p=0.613$; $p>0.05$), though inadequate gain was more frequent among mothers of stunted children (52.3%) compared to normal children (43.2%). Dewi et al. stated that insufficient weight gain raises stunting risk sevenfold due to poor nutrition or suboptimal pregnancy conditions (52).

Table 4 shows no significant relationship between parents' education and stunting ($p=0.747$; $p=0.375$), with most parents having low education (elementary–junior high). This supports studies from the Banda and Kei Islands, which showed that most fishermen have low education levels (53), as well as research in Kediri that also found no significant relationship between maternal education ($p=0.53$) and stunting incidence (54). Family size was also not related to stunting ($p=0.176$; $p>0.05$), although larger families in developing countries face higher stunting risk due to limited economic and food resources (55). Monthly family income showed no significant relationship with stunting ($p=0.789$; $p>0.05$), with most families earning above the Brebes regional minimum wage. This result is consistent with research conducted at the Sukajaya Health Center in Sabang City, which also found no significant relationship between family income ($p=0.789$) and stunting (56). Food expenditure exceeding 60% of total spending indicates vulnerability to food insecurity (57). In this study, that proportion was similar among stunted (72.7%) and normal (79.5%) children ($p=0.378$). This supports the study by Veronika et al., who reported that 62% of fishermen's income is spent on food, reflecting low household welfare in coastal areas (58). The nutritional condition of a community is largely determined by a family's sociodemographic characteristics and food security. Poor community nutrition can result from low food security, which

ultimately deteriorates overall health. A family's ability to obtain and prepare food according to nutritional needs is also influenced by sociodemographic factors (59). In this study, the sociodemographic characteristics were similar because all subjects came from fishing families in coastal areas.

Based on Table 5, the present study examined multiple biological, nutritional, and environmental factors associated with stunting among children aged 6–23 months. The findings highlight the complex nature of stunting, which results from interactions between inadequate nutrient intake, early-life growth deficits, and infectious diseases. Several variables remained significantly associated with stunting in the multivariate model, including child's age, birth length, energy adequacy, and a history of pulmonary tuberculosis (TB). Although birth weight, ARI history, maternal age at pregnancy, maternal height, and family size did not show significant associations in the adjusted model, their direction of effect aligns with previous research. For example, maternal height <150 cm is widely recognized as a risk factor for stunting due to intergenerational influences on child growth (50). Likewise, larger household size may dilute family resources, potentially affecting dietary adequacy and caregiving practices (55). The lack of statistical significance in this study may be attributed to sample size or contextual differences within the study population.

Based on Table 6, there are four risk factors for stunting were identified in children aged 6-23 months in fishing families in Brebes Regency, namely pulmonary TB history, energy adequacy, birth length, and age. This study also found a significant association between pulmonary TB history and stunting ($p=0.003$). Children with a history of pulmonary TB history were 8.662 times higher risk of being stunted ($OR = 9.622$; 95% CI: 1.009–91.735; $p = 0.049$). This finding is supported by a study showed a significant association between tuberculosis history and stunting. Their study reported that stunted children were 2.96 times more likely to contract tuberculosis, while severely stunted children had an 8.18-fold higher risk. Stunted children generally have weakened immune systems, making them more susceptible to *Mycobacterium tuberculosis* infection, the bacterium responsible for pulmonary tuberculosis in children. Moreover, untreated tuberculosis can further impair a child's growth (60). The finding of this study is consistent with research by Ikhtiarti et al. conducted in the coastal area of Brebes among children aged 1–3 years, showed a significant relationship between infectious diseases and stunting ($p=0.001$; $OR=17.875$), indicating that children suffering from infectious diseases were 17 times more likely to experience stunting. This is likely due to the environmental conditions in fishing communities, which are often characterized by poor sanitation (61). Previous studies have shown that bacterial contamination resulting from poor sanitation is a common cause of nutritional problems among young children (62). Bacterial infections can disrupt the digestive system and lead to various illnesses that negatively affect child growth, including tuberculosis infection. A study in Padang City found that tuberculosis cases were more prevalent in coastal areas compared to mountainous regions. The clustering of TB cases is influenced by social and economic factors such as poverty, population density, and limited access to healthcare. This situation is worsened by social stigma surrounding TB, which often leads to treatment delays and increases the risk of transmission. Moreover, environmental conditions such as poor ventilation, overcrowded housing, and humid environments further contribute to the spread of tuberculosis (63). These findings are also supported by Ikhtiarti et al. who noted that coastal areas of Brebes Regency have relatively poor environmental sanitation (61). The present study was conducted in Bulakamba sub-district, one of the most densely populated sub-districts in Brebes Regency (19).

The results of this study indicate that children with inadequate energy intake ($\leq 89\%$ RDA) were 8.12 times more likely to experience stunting compared to those with sufficient or excessive intake ($>90\%$ RDA) ($OR = 8.120$; 95% CI: 2.552–25.839; $p = 0.001$). This finding is consistent with the study by Ramadhani et al., which reported a significant association between energy intake and stunting ($OR=16.71$) (40), indicating that children with low energy intake were 16.71 times more likely to be stunted compared to those with adequate intake. Energy intake plays a crucial role in supporting children's growth, immune function, intellectual development, and emotional formation. Therefore, ensuring adequate and high-quality nutrient intake during early childhood is essential to meet the body's energy and nutrient requirements (38). This finding is supported by Satriani et al. who reported that low energy intake was a significant risk factor for stunting among coastal children in Sinjai, South Sulawesi ($p=0.039$; $OR=2.99$; 95%

CI: 1.13–7.87) (6). Similarly, Yuliantini et al. found a significant association between energy intake and stunting among children in fishing families in Bengkulu City ($p=0.006$), with children having low energy adequacy levels being 9.5 times more likely to experience stunting. The low energy intake among coastal children is influenced by multiple factors, including low family income, inadequate feeding practices, frequent infections, limited utilization of local food resources, and poor maternal knowledge regarding child nutrition (64;65).

This study also found a significant association between birth length and stunting ($p=0.003$). The proportion of children with birth length <48 cm was higher in the stunted group (50%) compared to the normal group (23.9%). Children with shorter birth length (<48 cm) were 4.105 times more likely to experience stunting compared to those with normal birth length (≥ 48 cm) (OR = 4.105; 95% CI: 1.593–10.575). This result is supported by data from Indonesia Basic Health Research (2018) showing that a birth length <48 cm is a risk factor for stunting (OR=1.50; 95% CI: 1.35–1.66) (66). Similarly, a study conducted in Lempake, Samarinda, also revealed a significant association between short birth length (<48 cm) and stunting ($p=0.004$; OR=2.34; 95% CI: 1.331–4.114) (67). A normal birth length typically ranges between 48–52 cm (68). Birth length is influenced by maternal nutritional status during pregnancy, as inadequate maternal nutrition can cause intrauterine malnutrition that restricts fetal growth, resulting in shorter birth length (69). Birth length thus serves as an important indicator of maternal health and nutritional status during pregnancy. Furthermore, nutritional status before conception, during adolescence, and throughout pregnancy plays an essential role in determining birth outcomes, including infant birth length (70). In addition, the study found that children aged 6–11 months had a 0.343 times lower risk of stunting compared to those aged 12–23 months (OR=0.343; 95% CI: 0.135–0.869; $p=0.024$). This finding suggests that the risk of stunting increases with age due to longer exposure to poor dietary intake and infectious diseases, particularly when children do not receive adequate nutritional interventions (71).

The limitation of this study is that stunting results from chronic nutritional deficiency, whereas the 2×24-hour recall method cannot fully capture usual or long-term dietary intake and is subject to high intra-individual variability. In addition, recall bias may occur because caregivers may not accurately remember or estimate portion sizes. This method also may not reflect seasonal variations in food availability and consumption patterns, which are particularly relevant in coastal communities. These limitations may have contributed to the exceptionally high odds ratio (8.120) observed for energy adequacy.

CONCLUSION

This study shows that stunting in children aged 6-23 months in fishing families in Brebes Regency is still a serious nutritional problem. The results showed that there were four factors significantly associated with the incidence of stunting in children aged 6-23 months in fishing families in Brebes Regency, Central Java namely pulmonary TB history, energy adequacy, birth length, and child age. Children with pulmonary TB history, low energy intake, and birth length <48 cm have a higher risk of stunting. In contrast, younger children (6-11 months) had a lower risk than older children. This suggests that nutrition and growth conditions from pregnancy to the first two years of life play an important role in stunting prevention.

FUNDING

This research received no external funding.

ACKNOWLEDGMENTS

The author expresses gratitude to head of the Brebes Regency health office and all the heads, staff, nutritionist and midwife of Bulakamba and Kluwut public health center, who have given permission and support to conduct this study. The author would also like to thank all the cadres and enumerators contributed to this research.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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