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Maternal Knowledge as an Independent Determinant of Stunting in a Suburban Setting: A Case-Control Study in South Tangerang City, Indonesia

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ABSTRACT

Background: In Indonesia, malnutrition during the first 1,000 days of life is the primary cause of stunting, a serious public health issue. Between 2019 and 2021, the prevalence of stunting in South Tangerang City increased from 15.4% to 19.4%. However, specific data on stunting risk factors in suburban settings like South Tangerang City remain limited, as most existing studies were conducted in rural areas. This study aimed to identify independent risk factors for stunting among children under five in South Tangerang City using a case-control design.
Subjects and Method: There were 53 cases and 53 controls in a 1:1 case-control design using consecutive sampling technique. A structured questionnaire was used for in-person interviews, and an infantometer or microtoise was used for direct anthropometric measurements. Independent variables were exclusive breastfeeding history, early initiation of breastfeeding history, complementary feeding history, low birth weight history, diarrhea history, maternal age, maternal occupation, maternal height, maternal education level, maternal knowledge level, and family income level. The analysis applied multiple logistic regression.
Results: Low maternal knowledge level was an independent determinant of stunting (aOR 3.19; 95% CI: 1.37 to 7.45; p=0,007). Recurrent diarrhea history (aOR 2.72; 95% CI: 0.97 to 7.65; p=0,057) and low family income (aOR 2.34; 95% CI: 0.97 to 5.62; p=0,058) were associated with increased odds of stunting, although statistical significance was not achieved.
Conclusion: Low maternal knowledge level was an independent determinant of stunting in children under five. Nutrition education interventions targeting mothers, particularly in low-income suburban households, are recommended as a priority strategy for stunting prevention.

Keywords: Stunting, maternal knowledge, case-control study

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BACKGROUND

The second Sustainable Development Goal (SDG), which aims to eradicate all types of malnutrition in children worldwide by 2030, includes stunting as a persistent global health issue. Stunting is a condition of impaired growth and development in children caused by various factors including chronic inadequate nutrition, low socioeconomic position, and recurrent illnesses,

particularly within the first 1,000 days of life, which results in small stature (World Health Organization, 2018). Children with stunting generally have weak immune systems, making them more prone to illness, as well as lower intelligence and productivity (Lestari et al., 2024).

In 2022, there were 22.3% of children under five worldwide who were stunted. Stunting affects more than half of all young children in Asia (UNICEF/WHO/The World Bank, 2025). According to the Indonesian Health Survey from 2023, 21.5% of people in the country are stunted (Ministry of Health of the Republic of Indonesia, 2023). The prevalence of stunting in South Tangerang City increased by 4 percentage points over two years, from 15.39% in 2019 to 19.4% in 2021 (Ministry of Health of the Republic of Indonesia, 2022). This figure approaches the WHO threshold for stunting prevalence of 20%, indicating that stunting remains an ongoing public health concern in South Tangerang City that requires targeted intervention (De Onis et al., 2019; UNICEF/ WHO/The World Bank, 2025). The high prevalence of stunting is not only a chronic nutritional issue but also has broad implications for children's development, health, and future productivity.

Stunting can have negative effects in both the short and long term. It causes higher rates of illness and death, and delays cognitive, motor, and verbal development in children (Latief et al., 2024; Maulina et al., 2023). Without early intervention, stunting can lead to an unhealthy body shape in adulthood, a higher risk of obesity, poor academic performance, and reduced work productivity. Stunting can slow economic growth, increase poverty, and widen social inequality on a larger scale (Suryana & Azis, 2023).

Previous studies show that stunting is closely linked to insufficient nutritional intake (Masitoh et al., 2023; Yusigania et al., 2024) and disease episodes, especially infections during the first 1,000 days of life (Ministry of Health of the Republic of Indonesia, 2025). Growth and development delays in children might result from inadequate nutrition (Wulandari et al., 2022). Stunting risk is also influenced by the mother's health during pregnancy and the baby's birth weight (Ayu et al., 2024). Direct causes of growth delays in children include low protein intake, not receiving exclusive breastfeeding, a history of respiratory infections, and diarrhea.

Many studies on stunting risk factors have been conducted in Indonesia, however the majority of them use data from national surveys like the SSGI or IFLS, which make it impossible to identify risk variables at the primary health center (PHC) level (Masitoh et al., 2023; Utami et al., 2023). Existing community-based studies were mostly conducted in rural or semi-rural areas such as East Java and Sulawesi (Sunarto et al., 2025; Yusigania et al., 2024), which differ in socioeconomic characteristics and health service access from suburban areas like South Tangerang City. In rural areas, stunting is predominantly driven by limited physical availability of nutritious food, constrained by geographic remoteness and underdeveloped food distribution infrastructure (Dewi et al., 2025; Yusigania et al., 2024). By contrast, suburban areas such as South Tangerang City are characterized by adequate physical food availability, where the primary barriers shift from food availability to food affordability and caregivers' capacity to make appropriate nutritional choices, dimensions more closely linked to household income and maternal knowledge than to geographic food access (Hariawan et al., 2024).

Moreover, suburban populations tend to exhibit high socioeconomic hetero-

geneity, with low-income informal workers residing alongside middle-income households within the same administrative area, creating a more complex and layered risk profile for stunting compared to the relatively homogeneous socioeconomic composition of rural communities. Access to healthcare services, while structurally available in suburban settings, is more likely mediated by maternal knowledge and health-seeking behavior rather than physical distance, a pattern distinct from rural barriers to care (Dewi et al., 2025; Juniarti et al., 2025). These contextual differences suggest that risk factors identified in rural populations may not adequately capture the role of knowledge-based and socioeconomic determinants in suburban settings, underscoring the need for context-specific evidence to inform effective local stunting prevention strategies. The aim of this research was to identify the risk factors for stunting in children under five at three PHC of South Tangerang with the highest prevalence of stunting.

SUBJECTS AND METHOD

1. Study Design

The design of this study is a case-control design. The study was conducted in July–August 2023 at three PHC (PHC Pondok Benda, PHC Pondok Ranji, and PHC Sawah Baru) in South Tangerang, Banten Province, Indonesia. These three PHC were selected based on an internal rapid survey report from the field trip program conducted by the Faculty of Health Sciences, Syarif Hidayatullah State Islamic University (UIN) in 2022, which assessed stunting prevalence across all 14 PHC in South Tangerang City using a sample of 77 children for each PHC. From the five PHC with the highest stunting prevalence, three were selected to ensure geographic representation across South Tangerang City, each located in a different subdistrict: PHC Pondok Ranji (Ciputat Timur; prevalence 70.1%), PHC Pondok Benda (Pamulang; 61.0%), and PHC Sawah Baru (Ciputat; 42.9%), each based on a sample of 77 children.

2. Population and Sample

The study population consisted of all children aged 12 to 59 months who attended community-integrated health posts in the catchment areas of the three selected PHC during the study period. The total number of the target population was not recorded at the time of the study, as there was no centralized registry of children aged 12 to 59 months across the three selected PHC catchment areas during the study period. Community-integrated health posts attendance records, which served as the primary source of participant identification, captured only children who actively visited health posts and did not reflect the complete population of eligible children residing in the study area. Consequently, a formal sampling frame could not be established prior to data collection.

Participants were recruited using a consecutive sampling technique. Both cases and controls were enrolled sequentially from children attending community-integrated health posts sessions at the three selected PHC during the study period who met the inclusion criteria, until the required sample size was achieved. To minimize selection bias and ensure more complete case ascertainment, an active case-finding strategy was employed in parallel, whereby stunting cases who did not attend community-integrated health posts during the study period were identified through community health workers and visited at home together with PHC's professional health care providers. Controls were recruited from children attending the same community-integrated health posts sessions as the identified cases, which indirectly

controlled geographic location and healthcare accessibility between groups.

This study adopted an unmatched case-control design. Cases and controls were recruited across all three PHC simultaneously without site-specific quotas or individual matching procedures. The unequal distribution of participants across study sites reflects the natural availability of eligible children at each community-integrated health posts session during the data collection period. Although PHC location was not formally entered as a covariate in the analysis, recruiting both groups from the same three catchment areas indirectly controlled for geographic location, healthcare accessibility, and community-level contextual factors. Potential confounding was addressed through multivariate logistic regression at the analysis stage.

The inclusion criteria were: (1) children aged 12–59 months at the time of data collection; (2) residing with their biological mother; and (3) attending integrated community health post (*Posyandu*) during the study period. Children diagnosed with mental disorders or physical disabilities by professional health care providers were excluded. The required sample size was estimated using a two-proportion hypothesis test at a 95% confidence interval, 80% statistical power, and a 1:1 case-to-control ratio based on an estimated stunting proportion of 74% in the case group and 46% in the control group (Rizky and Sutjiati, 2021). Adding 10% to account for potential dropouts, the final sample consisted of 106 participants (53 cases and 53 controls).

3. Study Variables

The dependent variable was stunting status in children aged 12–59 months, defined as a height-for-age z-score (HAZ) of −3 SD to <−2 SD based on the Indonesian Child Anthropometric Standards (Ministry of Health of the Republic of Indonesia, 2020). The independent variables were exclusive breastfeeding history, early initiation of breastfeeding history, complementary feeding history, low birth weight (LBW) history, diarrhea history, maternal age, maternal occupation, maternal occupation, maternal height, maternal education level, maternal knowledge level, and family income level.

4. Operational Definition of Variables

Stunting was classified as a HAZ between −3 SD and <−2 SD based on direct anthropometric measurement, using Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2020 on Child Anthropometric Standards as the reference standard (Ministry of Health of the Republic of Indonesia, 2020). Children with HAZ between −2 SD and +3 SD were classified as not stunting and assigned to the control group.

Exclusive breastfeeding history was defined as the child receiving only breast milk for the first six months of life without any other food or liquid, coded as 1 (non-exclusive) or 0 (exclusive).

Early initiation of breastfeeding history was defined as breastfeeding initiated within one hour of birth, coded as 1 (>1 hour) or 0 (≤1 hour).

Complementary feeding history was defined as the introduction of solid or semi-solid foods at 6 months of age, coded as 1 (not at 6 months) or 0 (at 6 months).

Low birth weight (LBW) was defined as birth weight <2500 grams, coded as 1 (LBW) or 0 (normal).

Diarrhea history was defined as the occurrence of two or more diarrhea episodes in the six months preceding data collection, categorized as at risk (≥2 episodes) (1) or not at risk (<2 episodes) (0).

Maternal age was the mother's age at the time of data collection, categorized as ≥35 years (1) or 21–34 years (0).

Maternal occupation was categorized as employed (1) or housewife (0).
Maternal height was measured at the time of interview and categorized as <150 cm (1) or ≥150 cm (0).
Maternal education level was categorized as low (below senior high school) (1) or high (senior high school or above) (0).
Maternal knowledge level was assessed using a structured questionnaire of 15 items covering the definition of stunting, nutrients required for stunting prevention, risk factors, and prevention strategies. Total scores were categorized as low knowledge (≤75% of correct answers) (1) or high knowledge (76–100% of correct answers) (0).
Family income level was categorized based on the 2023 South Tangerang City Regional Minimum Wage *(UMK Kota Tangerang Selatan Tahun 2023)* as low (monthly household income <Rp4,551,451) (1) or high (≥Rp4,551,451) (0).

5. Study Instruments

Data was collected by face-to-face interview of mothers through structured questionnaires and direct anthropometric measurement. The questionnaire covered child characteristics (LBW history, diarrhea history), infant feeding practices (exclusive breastfeeding, early initiation of breastfeeding, complementary feeding), maternal characteristics (age, occupation, height, education level, knowledge level), and family income level.

The questionnaire items were adapted from a previously published instrument (Hulu, 2020) through addition, removal, and rewording of items to ensure contextual relevance for the study population. Content validation was conducted by the research supervisors and nine health professionals across the three selected PHC (a head of PHC and two professional health care providers per site), who assessed the relevance, clarity, and appropriateness of each item. The adapted instrument was then pilot tested with 30 respondents at PHC Pondok Ranji, who were not included in the main study sample. Construct validity was assessed using item-total correlation ($r > 0.361$) and internal consistency was evaluated using Cronbach's alpha (0.698), both conducted on the pilot test sample.

Anthropometric measurements were performed using a standardized kit. For children 12-23 months of age, body length was measured in the supine position with an infantometer or a length board. Height was measured by stadiometer in children aged 24-59 months in standing position, after removal of shoes, socks, hats and hair accessories. All measurements were conducted by trained community health workers under the direct supervision of PHC's professional health care providers and recorded in each child's Maternal and Child Health Record Book (KIA Book). Children's ages were verified through the KIA Book to ensure accuracy of HAZ calculation and reduce the risk of stunting misclassification.

6. Data Analysis

Data analysis was performed using IBM SPSS Statistics version 25. The descriptive analysis was displayed as percentages (%) and frequencies (n). To evaluate the relationship between each independent variable and stunting status, bivariate analysis was performed using the chi-square test and crude odds ratios (cOR) with 95% confidence intervals. In the bivariate analysis, variables having a p-value less than 0.25 were kept as potential risk factors for the multivariate model (Bursac et al., 2008). Multivariate analysis was performed using multiple logistic regression to identify independent risk factors for stunting after adjusting for all candidate variables simultaneously. Adjusted odds ratios (aOR) with 95% confidence intervals were reported.

7. Research Ethic

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Health Sciences, Syarif Hidayatullah State Islamic University Jakarta (letter number Un.01/-F.10/KP.01.1/KE.SP/08.08.007/2023). All participating mothers provided written informed consent prior to data collection. Confidentiality of participant data was maintained throughout the study process.

RESULTS

1. Sample Characteristics

A total of 106 children aged 12 to 59 months participated in this study, comprising 53 cases (stunting) and 53 controls (not stunting). In the stunting group, the majority of children were female (52.8%), and most mothers were housewives (92.5%) and aged 21–34 years (77.4%). In the not stunting group, children were predominantly male (50.9%), and mothers were more evenly distributed by age, with a higher proportion aged ≥35 years (34.0%) compared to the stunting group (22.6%). Regarding maternal height, a higher proportion of mothers in the stunting group had a height of less than 150 cm (20.8%) compared to the non-stunting group (9.4%). Mothers with low educational attainment were more common in the stunting group (43.4%) than in the not stunting group (26.4%), and the same pattern was observed for maternal knowledge, where 54.7% of mothers in the stunting group had low knowledge levels compared to 26.4% in the not stunting group (see Table 1).

Table 1. Sample characteristics of study

Characteristics	Stunting (n=53)		Not Stunting (n=53)	
	n	%	n	%
Study Area				
PHC Pondok Ranji	20	37.7	21	39.6
PHC Pondok Benda	23	43.4	15	28.3
PHC Sawah Baru	10	18.9	17	32.1
Child Characteristics				
Child Age (months)				
12–23	15	28.3	14	26.4
24–35	13	24.5	12	22.6
36–47	10	18.9	13	24.5
48–59	15	28.3	14	26.4
Sex				
Male	25	47.2	27	50.9
Female	28	52.8	26	49.1
Maternal Characteristics				
Maternal Age (years old)				
≥35	12	22.6	18	34.0
21–34	41	77.4	35	66.0
Maternal Occupation				
Employed	4	7.5	11	20.8
Housewife	49	92.5	42	79.2
Maternal Height				
<150 cm	11	20.8	5	9.4
≥150 cm	42	79.2	48	90.6
Maternal Education Level				
Low	23	43.4	14	26.4

Characteristics	Stunting (n=53)		Not Stunting (n=53)	
	n	%	n	%
High	30	56.6	39	73.6
Maternal Knowledge Level				
Low	29	54.7	14	26.4
High	24	45.3	39	73.6

2. Bivariate analysis

The bivariate analysis results (Table 2) showed that statistically significant risk factors for stunting included non-exclusive breastfeeding history (cOR 2.63; 95% CI: 1.18 to 5.88; p=0.017), inappropriate complementary feeding history (cOR 2.52; 95% CI: 1.15 to 5.52; p=0.020), low birth weight history (cOR 5.22; 95% CI: 1.07 to 25.43; p=0.026), recurrent diarrhea history ≥2 episodes (cOR 3.10; 95% CI: 1.16 to 8.29; p=0.020), low family income level (cOR 2.55; 95% CI: 1.03 to 6.37; p=0.025), and low maternal knowledge level (cOR 3.37; 95% CI: 1.39 to 8.30; p=0.003)

Table 2. Bivariate analysis of risk factors for stunting

Variables	Stunting		Not Stunting		cOR	95% CI	p
	n	%	n	%			
Exclusive Breastfeeding History							
Non-exclusive	27	50.9	15	28.3	2.63	1.18–5.88	0.017
Exclusive	26	49.1	38	71.7	Ref.		
Early Initiation of Breastfeeding History							
>1 hour after birth	19	35.8	23	43.4	0.73	0.33–1.59	0.427
≤1 hour after birth	34	64.2	30	56.6	Ref.		
Complementary Feeding History							
Not at 6 months	31	58.5	19	35.8	2.52	1.15–5.52	0.020
At 6 months	22	41.5	34	64.2	Ref.		
Low Birth Weight							
<2500 g	9	17	2	3.8	5.22	1.07–25.43	0.026
≥2500 g	44	83	51	96.2	Ref.		
Diarrhea History							
≥2 times	17	32.1	7	13.2	3.10	1.16–8.29	0.020
<2 times	36	67.9	46	86.8	Ref.		
Maternal Age							
≥35 years old	12	22.6	18	34.0	0.57	0.24–1.34	0.196
21–34 years old	41	77.4	35	66.0	Ref.		
Maternal Occupation							
Employed	4	7.5	11	20.8	0.31	0.09–1.05	0.051
Housewife	49	92.5	42	79.2	Ref.		
Maternal Height							
<150	11	20.8	5	9.4	2.51	0.81–7.83	0.104
≥150	42	79.2	48	90.6	Ref.		
Maternal Education							
Low	23	43.4	14	26.4	2.14	0.94–4.84	0.067
High	30	56.6	39	73.6	Ref.		
Maternal Knowledge							
Low	29	54.7	14	26.4	3.37	1.39–8.30	0.003

Variables	Stunting		Not Stunting		cOR	95% CI	p
	n	%	n	%			
High	24	45.3	39	73.6	Ref.		
Family Income Level							
Low	40	75.5	29	54.7	2.55	1.03–6.37	0.025
High	13	24.5	24	45.3	Ref.		

Maternal education level (cOR 2.14; 95% CI: 0.94 to 4.84; p=0.067), maternal height <150 cm (cOR 2.51; 95% CI: 0.81 to 7.83; p=0.104), maternal occupation (cOR 0.31; 95% CI: 0.09 to 1.05; p=0.051), and maternal age ≥35 years (cOR 0.57; 95% CI: 0.24 to 1.34; p=0.196) did not reach statistical significance at the 0.05 level but had p-values below 0.25 and were therefore retained as candidate risk factors for the multivariate model. Early initiation of breastfeeding (cOR 0.73; 95% CI: 0.33 to 1.59; p=0.427) was not significant and was excluded from further analysis.

3. The result of multivariate analysis

The results of the multiple logistic regression model are presented in Table 3. After adjusting for all variables in the model, low maternal knowledge independent risk factor for stunting (aOR 3.19; 95% CI: 1.37 to 7.45; p=0.007). Recurrent diarrhea history (aOR 2.72; 95% CI: 0.97 to 7.65; p=0.057) and low family income (aOR 2.34; 95% CI: 0.97 to 5.62; p=0.058) were identified as borderline independent risk factors.

Table 3. Multivariate analysis of risk factors for stunting

Independent Variables	aOR	95% CI		p
		Lower limit	Upper limit	
Maternal knowledge level	3.19	1.37	7.45	0.007
Diarrhea History	2.72	0.97	7.65	0.057
Family income level	2.34	0.97	5.62	0.058
N observation = 106				
-2 log likelihood = 129.75				
Nagelkerke R2 = 20%				

DISCUSSION

1. Maternal knowledge as a risk factor for stunting

This study identified low maternal knowledge level as an independent determinant of stunting in South Tangerang City. Children whose mothers had low knowledge had 3.19-fold higher odds of being stunted than in children of mothers with high knowledge, even after controlling for other factors. This finding is consistent with prior studies in Indonesia demonstrating that poor maternal nutritional knowledge is a significant risk factor for stunting (Fradila & Prabawati, 2023; Wulandari et al., 2022).

Maternal knowledge is a key determinant of child nutritional status (Sunarto et al., 2025). Mothers' caregiving practices, including exclusive breastfeeding for at least six months (Kapti et al., 2023), timely introduction of complementary foods (Piniliw et al., 2021), and provision of a balanced diet (Qomariyah & Dinasty Putri, 2020), are shaped by their understanding of child health and nutrition. Mothers with high knowledge are better equipped to recognize early signs of malnutrition, seek timely healthcare, and maintain appropriate feeding practices (Juniarti et al., 2025; Picauly, 2024).

In this study, the dominance of maternal knowledge as the only variable reaching conventional significance in the multivariate model suggests that in a suburban setting like South Tangerang, where physical access to food is less constrained than in rural areas, the capacity to translate knowledge into appropriate child feeding behaviour may suggest that maternal knowledge plays a relatively proximal role in growth outcomes.

2. Recurrent diarrhea history as a risk factor for stunting

The identification of recurrent diarrhea as a borderline independent risk factor for stunting is consistent with the well-established biological pathway linking repeated enteric infections to linear growth faltering. Diarrheal episodes cause nutrient malabsorption, increased energy expenditure, and appetite suppression, all of which cumulatively impair growth during critical developmental periods (WHO, 2024). The history of recurrent diarrhea may result in rapid depletion of fluids and electrolytes, disruption of nutrient absorption secondary to intestinal epithelial injury, and elevated energy expenditure associated with the host immune response to infection (Bhatnagar et al., 2019; Ningsih et al., 2020).

In this study, 32.1% of children in the stunting group had a history of two or more diarrhea episodes, compared to 13.2% in the non-stunting group. The failure to reach conventional significance in the adjusted model, alongside the wide confidence interval that included the null value (95% CI: 0.97 to 7.65), indicates that this association should be interpreted with caution. Future studies with larger samples are needed to provide more precise estimates and confirm whether diarrhea history is an independent risk factor for stunting in suburban Indonesian settings.

3. Low Family Income as Risk Factor of Stunting

Family income has a direct impact on a household's capacity to provide for fundamental needs such as adequate and nutritious food (Lapodi et al., 2021; Rizky and Sutjiati, 2021). Limited purchasing power among low-income families directly restricts access to nutritious food, particularly animal-source proteins and iron-rich foods that are essential for children's linear growth (Hariawan et al., 2024; Siregar & Siagian, 2021). This is further compounded by inadequate sanitation and limited access to clean water, which increase children's exposure to pathogens, elevate infection frequency, impair nutrient absorption, and reduce the family's capacity to seek timely healthcare (Khairani & Effendi, 2019). The simultaneous occurrence of these conditions creates a cumulative environment that is fundamentally unsupportive of optimal child growth.

In this study, 75.5% of children in the stunting group came from low-income families, compared to 54.7% in the not stunting group. Low-income families tend to limit the variety and quantity of nutritious food consumed (Siregar & Siagian, 2021), which over time leads to chronic undernutrition and impairs children's growth. Beyond food security, economic status also shapes access to health services, sanitation, and a supportive environment for child development.

The borderline significance of family income in the adjusted model ($p = 0.058$) warrants cautious interpretation. While this finding may partly reflect limited statistical power given the sample size, alternative explanations cannot be excluded, including the possibility that the true independent effect of income on stunting is attenuated when other correlated variables are simultaneously controlled, or that the binary

income categorization based on the regional minimum wage may not have fully captured the spectrum of economic deprivation relevant to child nutritional outcomes.

4. Exclusive breastfeeding and complementary feeding history on the occurrence of stunting

Exclusive breastfeeding and appropriate complementary feeding may function as intermediary pathways in the causal pathway between maternal knowledge and child nutritional status (Shrestha et al., 2020; Sudarianti et al., 2022). When maternal knowledge was included in the multivariate model, the effects of breastfeeding and complementary feeding observed in the bivariate analysis were likely absorbed by the maternal knowledge variable.

This is because mothers with higher knowledge tend to practice exclusive breastfeeding and introduce complementary feeding more consistently and on time. This finding suggests that maternal knowledge may play a more direct role in determining child nutritional status compared to feeding practices themselves in this population.

5. Low birth weight on the occurrence of stunting

Low birth weight showed a notably large bivariate risk estimate, with 17% of stunted children having a history of LBW compared to only 3.8% of non-stunted children. Although LBW met the $p < 0.25$ threshold in the bivariate analysis and was initially included as a candidate variable, it was subsequently excluded from the final multivariate model due to sparse data. With only 9 exposed cases and 2 exposed controls, the cell counts were insufficient to produce stable estimates in logistic regression, resulting in an extremely wide confidence interval. The exclusion of LBW from the final model should therefore not be interpreted as evidence that LBW is not a biological risk factor for stunting, but rather reflects the statistical limitations imposed by the small number of exposed participants in this sample.

6. Maternal education level on the occurrence of stunting

Higher maternal education theoretically increases mothers' nutritional knowledge, which in turn influences their feeding practices (Prasetyo et al., 2023; Rakotomanana et al., 2023). Maternal education level lost its significance when maternal knowledge was taken into account in the model. This suggests that maternal knowledge may partially explain the relationship between maternal education level and child stunting, though formal mediation analysis would be required to confirm this pathway. The UNICEF perspective on the causes of child malnutrition, which views maternal education as an indirect factor that affects a child's nutritional status through intermediary pathways, is in line with this conclusion (Dewi et al., 2025).

This study contributes to the understanding of risk factors for stunting in young children. The case-control design allowed for efficient and effective identification of risk factors. Anthropometric data was collected through direct measurements by trained community health workers under the supervision of PHC's health care providers, providing accurate and objective data for determining stunting status. Additionally, children's age was not only based on mothers' self-report but was also confirmed through the KIA Book brought by mothers during integrated community health post (posyandu) visits. This approach improves the accuracy of age data used in interpreting HAZ, reducing the risk of misclassifying stunting status due to errors in recording birth dates.

This study has several limitations. The use of consecutive sampling without formal matching may have introduced selection

bias, since the study only included children who actively visited integrated community health post (posyandu). Children with the poorest nutritional status who were not reached by integrated community health post (posyandu) services were not represented in this study, meaning that the OR estimates may be underestimated. Additionally, generalizability to larger groups may be limited by the sample size. History of exclusive breastfeeding and complementary feeding were collected retrospectively through interviews. For children aged 48–59 months, mothers were asked to recall feeding practices from 4–5 years ago. This recall bias may reduce the observed difference in exposure between the case and control groups (non-differential misclassification), which statistically tends to move the OR toward the null hypothesis. Future studies should expand the sample size and study sites to improve representativeness and generalizability. Longitudinal study design could provide a deeper understanding of the causal relationships between risk factors and stunting.

This study identified low maternal knowledge level as an independent determinant of stunting among children aged 12–59 months in South Tangerang City, with children of mothers with low knowledge being 3.19 times more likely to experience stunting compared to children of mothers with high knowledge. This study contributes evidence on stunting determinants in a suburban Indonesian setting, where most existing literature has focused on rural populations. The findings suggest that strengthening maternal knowledge through targeted nutrition education should be prioritized as a key strategy for stunting prevention in South Tangerang City.

AUTHOR CONTRIBUTION

SH has cotributed in conceptualization and study design, data collection, data analysis, manuscript writing & revision, and supervision. JAS has contributed in conceptualization and study design, data analysis. All authors have read and approved the final version of the manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest.

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Nil or none.

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