

*Original Article***MATERNAL AND ENVIRONMENTAL DETERMINANTS OF STUNTING AMONG CHILDREN AGED 24–59 MONTHS IN JOMBANG, INDONESIA: A CROSS-SECTIONAL STUDY**Arlia Shanti Astuti ^{1*}, Masruroh ¹, Ade Armada Sutedja ¹, Herin Mawarti ¹¹ Master of Public Health, Universitas Pesantren Tinggi Darul ‘Ulum Jombang, East Java Province, Indonesia**Correspondence:** Arlia Shanti Astuti

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ABSTRACT

Background: Stunting remains a major public health problem among children under five years of age, particularly in developing countries. Maternal factors and poor environmental sanitation contribute significantly to impaired child growth and chronic malnutrition.

Purpose: This study aimed to analyze the association between maternal factors and environmental sanitation with stunting among children aged 24-59 months in Jombang Regency, Indonesia.

Methods: This study employed a quantitative analytical observational design with a cross-sectional approach. The study was conducted in 20 stunting locus villages in Jombang from June to July 2025. A total of 166 mother–toddler pairs were selected using proportional random sampling. Data were collected through structured questionnaires, household sanitation observations, and anthropometric measurements. Data analysis included univariate, bivariate using chi-square tests, and multivariate logistic regression analyses with a significance level of $p < 0.05$.

Results: Maternal education was significantly associated with stunting prevalence ($p = 0.000$). Most stunted toddlers were cared for by mothers with basic education levels (50.6%), whereas non-stunted toddlers were mostly cared for by mothers with higher education levels (47.0%). Environmental sanitation and clean water quality were also significantly associated with stunting ($p = 0.000$). Multivariate analysis showed that maternal education (AOR = 16.977; 95%CI = 2.55–113.00; $p = 0.003$), environmental sanitation (AOR = 6.977; 95%CI = 1.08–45.10; $p = 0.003$), and clean water quality (AOR = 4.198; 95%CI = 1.58–11.17; $p = 0.004$) were factors significantly associated with stunting.

Conclusion: Maternal education, environmental sanitation, and clean water quality were significantly associated with stunting among toddlers. Integrated interventions focusing on maternal education, sanitation improvement, and access to safe water are essential to reduce stunting prevalence.

Keywords: Stunting, Maternal Education, Environmental Sanitation, Clean Water Quality, Toddlers.

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INTRODUCTION

Stunting remains one of the most critical public health problems affecting children under five years of age worldwide, particularly in low- and middle-income countries. Stunting is defined as impaired linear growth characterized by a height-for-age z-score below minus two standard deviations according to the World Health Organization (WHO) child growth standards. This condition reflects chronic malnutrition resulting from prolonged inadequate nutrient intake, recurrent infections, and unfavorable environmental conditions during the first 1,000 days of life (World Health Organization [WHO], 2025). Globally, approximately 150.2 million children under five were affected by stunting in 2024, with the highest burden occurring in Asia and Africa. Stunting has serious short- and long-term consequences for children's health and development. Children who experience stunting are more vulnerable to infectious diseases, delayed cognitive and motor development, poor academic achievement, reduced productivity in adulthood, and increased risk of non-communicable diseases later in life. Furthermore, stunting contributes substantially to intergenerational cycles of poverty and poor health outcomes, thereby becoming a major challenge for achieving the Sustainable Development Goals (SDGs), particularly those related to nutrition, health, and child well-being (World Health Organization [WHO], 2025).

Indonesia continues to face a substantial burden of childhood stunting despite ongoing national nutrition interventions. Several studies have identified that the determinants of stunting in Indonesia are multifactorial and involve complex interactions between maternal, child, household, and environmental factors. Environmental sanitation has emerged as one of the most influential determinants contributing to impaired child growth. Poor sanitation conditions, including inadequate access to clean water, unsafe waste disposal, poor hygiene practices, and lack of proper latrine facilities, increase children's exposure to recurrent infections and environmental enteric dysfunction, which subsequently impair nutrient absorption and growth processes (Novianti, Huriyati, & Padmawati, 2023).

Previous evidence demonstrated that children living in households with poor sanitation conditions had a significantly higher risk of becoming stunted compared with those living in healthier environments. A study conducted in rural West Java reported that unsafe drinking water, poor sanitation, and inadequate maternal hygiene practices were strongly associated with stunting among children aged 6–23 months (Novianti et al., 2023). Similarly, research in Kulon Progo, Indonesia, revealed that poor family environmental sanitation status contributed significantly to stunting incidence among toddlers (Hurint et al., 2023). These findings support the ecological perspective that child nutritional status is influenced not only by dietary intake but also by the environmental conditions in which children grow and develop.

Maternal factors also play a central role in the occurrence of stunting. Maternal education, nutritional status during pregnancy, antenatal care utilization, maternal age, feeding practices, and maternal knowledge regarding child nutrition substantially affect children's growth outcomes. Mothers with limited education and inadequate health literacy are less likely to implement optimal child feeding practices, maintain environmental hygiene, and access maternal and child healthcare services (Kiik & Nuwa, 2021). Maternal nutritional deficiencies during pregnancy may also contribute to intrauterine growth restriction, low birth weight, and impaired postnatal growth, all of which increase the risk of stunting in early childhood.

In addition, maternal caregiving practices strongly influence children's nutritional and health status. Appropriate breastfeeding, timely complementary feeding, hygiene practices, and healthcare-seeking behaviors are essential for preventing chronic malnutrition and infection-related growth failure. However, in many developing regions, socioeconomic limitations and poor environmental conditions often hinder mothers from providing optimal childcare and nutrition practices. Consequently, children become more susceptible to repeated infections such as diarrhea and respiratory tract infections, which are recognized as major contributors to stunting (Gusnedi et al., 2023).

Although previous studies have separately examined environmental sanitation and maternal determinants of stunting, evidence integrating both factors simultaneously remain limited, particularly in Indonesian settings with high stunting prevalence. Understanding the interaction between environmental sanitation and maternal factors is important for designing comprehensive and context-specific interventions to reduce childhood stunting. Therefore, this study aimed to analyze the association between environmental sanitation and maternal factors with stunting among toddlers. The findings are expected to contribute to evidence-based

strategies for strengthening nutrition-sensitive and nutrition-specific interventions in Indonesia.

METHODS

Study Design

This study employed a quantitative analytical observational approach using a cross-sectional design to examine the association between environmental sanitation and maternal factors with stunting among children aged 24–59 months. A cross-sectional study is an epidemiological design in which exposure variables and outcome variables are measured simultaneously at a single point in time. This design is widely used in public health and nutritional epidemiology because it allows researchers to identify relationships between risk factors and health outcomes efficiently within a defined population (Arief et al., 2025).

The cross-sectional design was considered appropriate for this study because stunting is a multifactorial condition influenced by environmental, maternal, and socioeconomic determinants that can be assessed concurrently. Previous studies investigating stunting and environmental sanitation in Indonesia and other developing countries have also applied cross-sectional approaches due to their effectiveness in identifying associated factors within community settings (Sarwoko, 2026; Teshome, Tamirat, & Wondimu, 2023).

Setting and Participants

This study was conducted in 20 stunting locus villages in Jombang from June to July 2025. These villages were selected because they were identified as priority areas with a high prevalence of stunting among toddlers by the local government and the Jombang District Health Office. The research activities were carried out in collaboration with community health centers (Puskesmas) and integrated health service posts (Posyandu) located within the study area.

This study employed a quantitative analytical observational study using a cross-sectional design. The target population consisted of all toddlers aged 24–59 months residing in the 20 stunting locus villages in Jombang Regency. Based on data obtained from the Jombang District Health Office, the total population included 824 toddlers.

The sample size was calculated using the Lemeshow formula for analytical observational studies where n is the minimum sample size, N is the target population, Z is the standard normal value corresponding to a 95% confidence level (1.96), p is the expected proportion (0.50), q is

(1-p) (0.50), and d is the desired absolute precision (0.10). These parameters were specified in the original thesis sample-size calculation. The sample of 166 mother–child pairs.

Participants were selected using proportional random sampling to ensure representativeness from each stunting locus village. Eligible respondents included mothers with toddlers aged 24–59 months who had lived in the study area for at least six months and were willing to participate in the study by signing informed consent forms. Toddlers with congenital abnormalities, severe chronic illnesses, or incomplete anthropometric data were excluded from the study.

Data collection was conducted through household visits and community health service sessions at Posyandu. Mothers were interviewed using structured questionnaires to obtain information regarding maternal characteristics, environmental sanitation, and childcare practices. Anthropometric measurements of toddlers were performed following the World Health Organization (WHO) child growth standards procedures to determine stunting status. Additional data related to maternal and child health history were obtained from maternal and child health handbooks (Buku KIA) and Posyandu records.

The study participants represented diverse maternal educational backgrounds, occupations, socioeconomic status, and household environmental sanitation conditions. These variations enabled comprehensive analysis of the association between environmental sanitation and maternal factors with stunting among toddlers. Community health cadres and healthcare workers assisted in participant recruitment and data collection to improve community participation and ensure data accuracy throughout the study process.

Instruments and Data Collection

Data collection in this study was conducted from June to July 2025 in 20 stunting locus villages in Jombang. The study used primary data obtained through structured interviews, direct household observations, and anthropometric measurements of toddlers aged 24–59 months. Data collection procedures were carried out by trained enumerators assisted by community health cadres and healthcare workers from local Puskesmas and Posyandu to ensure data accuracy and consistency.

The primary instrument used in this study was a structured questionnaire developed based on previous literature and national stunting assessment guidelines. The questionnaire consisted of several sections covering respondent characteristics, maternal factors, environmental sanitation conditions, and child health information. Similar structured questionnaires have been

widely used in recent studies investigating environmental and maternal determinants of stunting among children under five years of age (Novianti et al., 2023).

The maternal factors section included maternal age, educational level, occupation, nutritional knowledge, breastfeeding history, complementary feeding practices, antenatal care history, and maternal caregiving behaviors. Environmental sanitation variables included access to safe drinking water, household latrine ownership, wastewater disposal systems, solid waste management, housing conditions, and hygiene practices within the household. Observational checklists were also used to validate sanitation conditions directly at participants' homes.

Anthropometric measurements were conducted to determine the nutritional status of toddlers. Body height or length measurements were obtained using calibrated microtoise or length boards with an accuracy of 0.1 cm according to World Health Organization (WHO) standardized procedures. Height-for-age z-scores (HAZ) were calculated using WHO Child Growth Standards. Toddlers with HAZ scores below -2 standard deviations were categorized as stunted (United Nations Children's Fund (UNICEF), World Health Organization (WHO), & World Bank Group, 2023).

Prior to data collection, the questionnaire underwent content validity testing through expert review involving public health and maternal-child health specialists. A pilot test was conducted among respondents with characteristics similar to the study population to evaluate clarity, comprehensibility, and consistency of the questionnaire items. Reliability testing was performed using Cronbach's alpha coefficient, with values above 0.70 considered acceptable for internal consistency reliability (Taherdoost, 2022).

Data collection began with coordination and permission from the local health authorities, village officials, and healthcare facilities in the study area. Eligible respondents were identified through Posyandu registration records and community health databases. Mothers meeting the inclusion criteria were approached during household visits or Posyandu activities and informed about the study objectives and procedures. Written informed consent was obtained from all participants prior to data collection.

The study used a structured questionnaire, observation checklist, and anthropometric measurement tools to collect data related to maternal factors, environmental sanitation factors, and stunting status among toddlers.

The structured questionnaire was developed based on previous studies and national guidelines for stunting assessment. The questionnaire consisted of sections covering maternal characteristics, particularly maternal education level, which was categorized into basic,

secondary, and higher education. Information regarding respondents' sociodemographic characteristics was obtained through face-to-face interviews with mothers or caregivers.

Environmental sanitation factors were assessed using a household sanitation observation checklist. The observed variables included household sanitation conditions and clean water quality. Environmental sanitation was categorized into poor, moderate, and good based on sanitation facility availability, waste disposal systems, wastewater management, and household hygiene conditions. Clean water quality was classified into no risk, low risk, and moderate risk according to household water source conditions and environmental health indicators.

Anthropometric measurements were performed to determine stunting status among toddlers aged 24–59 months. Height measurements were obtained using a calibrated microtoise with an accuracy of 0.1 cm following World Health Organization (WHO) standardized procedures. Height-for-age z-scores (HAZ) were calculated using WHO Child Growth Standards. Toddlers with HAZ scores below -2 standard deviations were categorized as stunted.

Before data collection, all instruments underwent validity and reliability testing. Enumerators received training regarding interview techniques, sanitation observation procedures, and anthropometric measurements to ensure consistency and accuracy during data collection.

Data Analysis

Data were checked for completeness, coded, and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Anthropometric measurements were interpreted using the World Health Organization (WHO) Child Growth Standards. Toddlers with height-for-age z-scores (HAZ) below -2 standard deviations were categorized as stunted (United Nations Children's Fund (UNICEF) et al., 2023).

Data analysis consisted of univariate, bivariate, and multivariate analyses. Univariate analysis was used to describe respondent characteristics and study variables using frequencies, percentages, means, and standard deviations. Bivariate analysis was performed using the chi-square test to assess the association between environmental sanitation, maternal factors, and stunting among toddlers. Variables with p-values < 0.25 were included in the multivariate analysis.

Binary logistic regression analysis was conducted to identify dominant factors associated with stunting while controlling for potential confounding variables. The results were presented as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Statistical significance

was determined at $p < 0.05$. Logistic regression is commonly used in epidemiological studies examining determinants of stunting because it enables analysis of dichotomous outcome variables and adjustment for confounders (Sari et al., 2024; Teshome et al., 2023).

Ethical Consideration

This study received ethical approval from the Health Research Ethics Committee of STIKES Husada Jombang and was declared ethically appropriate on October 13, 2025, with ethical clearance number No.10627-KEPKSHJ. All research procedures were conducted in accordance with the principles of the Declaration of Helsinki for research involving human participants.

Before participation, all respondents were informed about the study objectives, procedures, benefits, and their rights as participants. Written informed consent was obtained from mothers or caregivers before interviews and anthropometric measurements were conducted. Participants were assured that their participation was voluntary and that they could withdraw from the study at any time without consequences.

To maintain confidentiality and privacy, all collected data were anonymized and used solely for research purposes. Respondents' identities were replaced with unique codes during data processing and analysis. Ethical considerations related to confidentiality, informed consent, and participant protection are essential components of public health and epidemiological studies involving mothers and children (World Medical Association, 2022).

RESULTS

Characteristics of Respondents

Table 1. Distribution of Maternal, Child, Family, and Environmental Factors among Children Aged 24–59 Months (n = 166).

Variables	Category	n	%
Maternal factors			
Maternal education	Basic	53	31.9
	Secondary	72	43.4
	Higher	41	24.7
Maternal CED	Yes	76	45.8
	No	90	54.2
Child factors			

Nutritional status	Normal	86	51.8
	Abnormal	80	48.2
History of infectious disease	Yes	94	56.6
	No	72	43.4
Immunization status	Complete	143	86.1
	Incomplete	23	13.9
Exclusive breastfeeding	Yes	124	74.7
	No	42	25.3
Birth weight	Normal ($\geq 2,500$ g)	138	83.1
	Low birth weight ($< 2,500$ g)	28	16.9
Complementary feeding practices	Appropriate	34	20.5
	Less appropriate	50	30.1
	Inappropriate	82	49.4
Vitamin A supplementation	Yes	141	84.9
	No	25	15.1
Family factors			
Household economic status	Good	95	57.2
	Poor	71	42.8
Health insurance (JKN)	Yes	148	89.2
	No	18	10.8
Environmental factors			
Environmental sanitation	Good (76–100%)	65	39.2
	Moderate (56–75%)	57	34.3
	Poor ($< 56\%$)	44	26.5
Clean water quality	Low/no risk	38	22.9
	Moderate risk	84	50.6
	High risk	4	2.4
	No risk*	40	24.1

Table 1 summarizes the distribution of maternal, child, family, and environmental characteristics among the 166 children aged 24–59 months. Among maternal characteristics,

secondary education was the most common level of maternal education (43.4%), while 45.8% of mothers were identified as having chronic energy deficiency (CED).

For child characteristics, more than half of the children had a history of infectious disease (56.6%), whereas 51.8% had normal nutritional status. Most children had complete immunization (86.1%), received exclusive breastfeeding (74.7%), had a normal birth weight (83.1%), and received vitamin A supplementation (84.9%). However, nearly half of the children (49.4%) had inappropriate complementary feeding practices, indicating an important nutritional concern within the study population.

At the family level, 57.2% of households had good economic status and 89.2% of children were covered by National Health Insurance (JKN). Environmental characteristics showed that 39.2% of households had good sanitation, while 34.3% and 26.5% had moderate and poor sanitation, respectively. In addition, moderate-risk clean water conditions were observed in 50.6% of households. Overall, the study population demonstrated substantial variation across maternal, child, family, and environmental characteristics, with notable concerns regarding maternal CED, infectious disease history, complementary feeding practices, and household environmental conditions.

Maternal Factor

Table 2. Maternal Factors Associated with Stunting among Children Aged 24–59 Months ($n = 166$).

Maternal Education	Stunted n (%)	Non-Stunted n (%)	p -value
Basic education	42 (50.6)	18 (21.7)	0.000
Secondary education	27 (32.5)	26 (31.3)	
Higher education	14 (16.9)	39 (47.0)	

The results showed a significant association between maternal education and stunting incidence ($p = 0.000$). Most stunted toddlers were cared for by mothers with basic education levels, accounting for 42 respondents (50.6%), whereas non-stunted toddlers were mostly cared for by mothers with higher education levels, accounting for 39 respondents (47.0%).

Environmental Sanitation Factors

Environmental sanitation (Table 2.) was significantly associated with stunting incidence ($p = 0.000$). Poor sanitation conditions were more frequently observed among stunted toddlers,

accounting for 29 respondents (34.9%), whereas good sanitation conditions were more common among non-stunted toddlers, accounting for 40 respondents (48.2%).

Clean water quality also showed a significant association with stunting ($p = 0.000$). Most stunted toddlers lived in households with moderate-risk clean water conditions, accounting for 59 respondents (71.1%), while 40 non-stunted toddlers (48.2%) lived in households without clean water risk.

Table 3. Environmental Sanitation Factors Associated with Stunting among Children Aged 24–59 Months ($n = 166$).

Variables	Stunted n (%)	Non-Stunted n (%)	p-value
Environmental Sanitation			0.000
Poor	29 (34.9)	12 (14.5)	
Moderate	33 (39.8)	31 (37.3)	
Good	21 (25.3)	40 (48.2)	
Clean Water Quality			0.000
Moderate risk	59 (71.1)	19 (22.9)	
Low risk	18 (21.7)	24 (28.9)	
No risk	6 (7.2)	40 (48.2)	

Multivariate Analysis

Table 4. Final Multivariable Logistic Regression Model for Stunting.

Variables	B	Adjusted OR	95%CI	p-value
Maternal education	2.832	16.977	2.55-113.0	0.003
Environmental sanitation	1.972	6.977	1.08–45.10	0.003
Clean water quality	1.435	4.198	1.58–11.17	0.004

Note: Variables with $p < 0.05$ were considered statistically significant. Maternal education was identified as the strongest factor associated with stunting among toddlers.

The multivariate logistic regression analysis identified seven significant determinants of stunting among toddlers. Maternal education (AOR = 16.977; $p = 0.003$), environmental sanitation (AOR = 6.977; $p = 0.003$), and clean water quality (AOR = 4.198; $p = 0.004$) were positively associated with stunting incidence.

DISCUSSION

This study aimed to analyse the association between maternal factors and environmental sanitation with stunting among toddlers aged 24–59 months in stunting locus villages in Jombang Regency. The findings demonstrated that maternal education, environmental sanitation, and clean water quality were significantly associated with stunting incidence. Furthermore, multivariate analysis identified maternal education as the strongest determinant of stunting among toddlers. These findings emphasize that stunting is a multifactorial problem influenced by both behavioral and environmental determinants (Arief et al., 2025; Victora et al., 2021).

The present study found a significant association between maternal education and stunting incidence among toddlers. Mothers with lower educational levels were more likely to have stunted children compared with mothers who attained higher education. This finding is consistent with previous studies indicating that maternal education plays an important role in determining child nutritional outcomes. Mothers with adequate educational backgrounds generally possess better health literacy, nutritional knowledge, childcare skills, and healthcare-seeking behaviors, all of which contribute positively to child growth and development (Arief et al., 2025; Gusnedi et al., 2023; Kiik & Nuwa, 2021). Similarly, a systematic review by Gusnedi et al. (2023) identified low maternal education as one of the strongest predictors of childhood stunting in Indonesia.

Higher maternal education may improve mothers' ability to understand nutritional information, implement appropriate feeding practices, maintain household hygiene, and utilize healthcare services effectively. Educated mothers are also more likely to access antenatal care services, monitor child growth regularly, and provide balanced nutrition during the critical first 1,000 days of life (Black et al., 2017; Victora et al., 2021). In contrast, limited maternal education may hinder mothers from recognizing early signs of malnutrition and adopting preventive health behaviors, thereby increasing children's vulnerability to chronic undernutrition and infection-related growth failure (Beal, Tumilowicz, Sutrisna, Izwardy, & Neufeld, 2018).

The findings also demonstrated that environmental sanitation was significantly associated with stunting among toddlers. Children living in households with poor sanitation conditions experienced a higher prevalence of stunting compared with those living in households with good sanitation facilities. This result supports previous evidence showing that inadequate sanitation contributes substantially to impaired child growth through increased exposure to

infectious diseases and environmental enteric dysfunction (Hurint et al., 2023; Novianti et al., 2023; Teshome et al., 2023). Poor sanitation conditions, including improper waste disposal, inadequate latrine facilities, and poor household hygiene, facilitate the transmission of pathogenic microorganisms that may cause recurrent diarrhea, intestinal infections, and chronic inflammation affecting nutrient absorption (Torlesse, Cronin, Sebayang, & Nandy, 2016).

Environmental enteric dysfunction is recognized as one of the major biological pathways linking poor sanitation with stunting. Continuous exposure to fecal pathogens can damage intestinal integrity and impair nutrient absorption despite adequate dietary intake (Humphrey et al., 2019; Prendergast & Humphrey, 2021). Repeated infections may also increase metabolic demands while reducing appetite and nutrient utilization among children. Consequently, prolonged exposure to unhealthy environmental conditions may contribute to chronic growth retardation among toddlers (Walson & Berkley, 2018).

This study further identified clean water quality as a significant determinant of stunting. Toddlers living in households with moderate-risk water quality had a significantly higher likelihood of experiencing stunting compared with those living in households without clean water risk. This finding aligns with studies conducted in Indonesia and other developing countries demonstrating that access to safe drinking water is essential for preventing childhood malnutrition and infection-related morbidity (Cumming & Cairncross, 2022; Sari et al., 2024; Teshome et al., 2023). Unsafe water sources may expose children to waterborne pathogens, increasing the incidence of diarrhea and other infectious diseases that contribute to nutrient loss and impaired growth (Headey et al., 2022).

The significant relationship between water quality and stunting may also reflect broader socioeconomic and environmental inequalities. Households lacking access to safe water often experience additional challenges such as poverty, overcrowding, food insecurity, and limited healthcare access, which collectively increase the risk of chronic malnutrition (de Onis, Branca, & Victora, 2016; United Nations Children's Fund (UNICEF) et al., 2023). Therefore, improving water quality should become an essential component of integrated stunting prevention programs.

Multivariate analysis in this study revealed that maternal education was the strongest factor associated with stunting among toddlers. This result suggests that maternal education may influence multiple dimensions of child health simultaneously, including feeding behavior, hygiene practices, healthcare utilization, and household environmental management. Similar findings have been reported in previous studies where maternal education consistently emerged

as a dominant determinant of child nutritional status across diverse settings (Arief et al., 2025; Beal et al., 2018; Prendergast & Humphrey, 2021).

The findings of this study provide important implications for nursing practice and public health interventions. Community health nurses play a strategic role in preventing stunting through health education, growth monitoring, nutrition counseling, sanitation promotion, and maternal empowerment programs. Strengthening maternal education regarding child nutrition, breastfeeding practices, complementary feeding, and household hygiene may contribute significantly to reducing stunting prevalence. In addition, nurses can collaborate with local governments, community leaders, and environmental health officers to improve sanitation infrastructure and promote healthy living behaviors within communities.

From a policy perspective, the study highlights the importance of integrating nutrition-specific and nutrition-sensitive interventions in stunting reduction programs. Nutrition-specific interventions alone may not adequately address environmental determinants contributing to chronic malnutrition. Therefore, multisectoral approaches involving healthcare, sanitation, education, and community development sectors are required to achieve sustainable reductions in stunting prevalence (United Nations Children's Fund (UNICEF) et al., 2023; Victora et al., 2021). Programs aimed at improving household sanitation, expanding access to clean water, and enhancing maternal literacy should be prioritized, particularly in high-risk rural communities.

This study contributes to the growing body of evidence regarding the interaction between maternal and environmental determinants of stunting in Indonesia. Unlike previous studies focusing only on nutritional or environmental aspects separately, the present study simultaneously analysed maternal education, sanitation conditions, and water quality within the same analytical framework. The findings strengthen the ecological perspective that child growth outcomes are shaped by interconnected biological, behavioral, and environmental factors (Arief et al., 2025; Danaei et al., 2023).

Several limitations should be acknowledged in this study. First, the cross-sectional design limits the ability to establish causal relationships between the identified factors and stunting incidence. Second, some maternal and household information was self-reported, potentially introducing recall bias and reporting inaccuracies. Third, the study was conducted only in stunting locus villages within Jombang Regency, which may limit generalizability to other regions with different sociodemographic characteristics. Despite these limitations, the study

provides valuable insights into modifiable determinants of stunting and offers evidence for designing comprehensive community-based interventions (Taherdoost, 2022).

IMPLICATION AND LIMITATIONS

The findings of this study have important implications for nursing practice, public health programs, education, and policy development related to stunting prevention among toddlers. The significant association between maternal education, environmental sanitation, and clean water quality with stunting indicates that interventions should not focus solely on nutritional supplementation but also address broader social and environmental determinants of child health.

For nursing practice, community health nurses play a crucial role in early detection and prevention of stunting through health promotion, nutritional counseling, growth monitoring, and family-centered education programs. Nurses can strengthen maternal knowledge regarding exclusive breastfeeding, complementary feeding practices, child hygiene, and environmental sanitation management. In addition, home visits and community-based interventions through Posyandu activities may improve mothers' awareness and encourage healthy childcare behaviors within households at risk of stunting.

The study also highlights the importance of strengthening multisectoral collaboration in stunting prevention programs. Healthcare providers, environmental health officers, educational institutions, and local governments should work collaboratively to improve access to safe drinking water, sanitation facilities, and maternal health education. Policies focusing on sanitation infrastructure development and clean water accessibility in rural and high-risk communities may contribute significantly to reducing stunting prevalence. Furthermore, integrating maternal education and environmental health promotion into primary healthcare services may support more sustainable stunting reduction efforts.

From an educational perspective, the findings may serve as evidence for developing nursing and public health curricula emphasizing the relationship between environmental health, maternal factors, and child nutritional outcomes. Increased competency among healthcare workers regarding nutrition-sensitive interventions is essential to support effective community-based stunting prevention strategies.

Despite its contributions, this study has several limitations. First, the cross-sectional design limits the ability to determine causal relationships between maternal factors, environmental sanitation, and stunting incidence. The study only identifies associations at a

single point in time; therefore, longitudinal studies are needed to evaluate causal pathways more comprehensively. Second, some information regarding maternal behaviors and household conditions was obtained through self-reported interviews, which may introduce recall bias and social desirability bias. Third, the study was conducted only in 20 stunting locus villages in Jombang Regency, which may limit the generalizability of the findings to other regions with different demographic, socioeconomic, and cultural characteristics.

Additionally, this study focused primarily on maternal education and environmental sanitation variables, while other important determinants of stunting such as household income, dietary intake, birth weight, infectious disease history, paternal factors, and food security were not analysed comprehensively. Future studies are recommended to include broader biological, socioeconomic, and behavioral variables using longitudinal or mixed-method approaches to provide a more holistic understanding of stunting determinants among children under five years of age.

CONCLUSION

This study concluded that maternal education, environmental sanitation, and clean water quality were significantly associated with stunting among toddlers aged 24–59 months in stunting locus villages in Jombang Regency. Mothers with lower educational levels were more likely to have stunted children, while poor household sanitation and unsafe clean water conditions also increased the risk of stunting. Among all variables analyzed, maternal education was identified as the strongest determinant associated with stunting incidence.

The findings emphasize that stunting is a multidimensional public health problem influenced not only by nutritional factors but also by maternal and environmental conditions. Poor sanitation and inadequate access to safe water may increase children's exposure to recurrent infections and impair nutrient absorption, whereas limited maternal education may affect childcare practices, nutritional knowledge, and healthcare utilization. Therefore, comprehensive and integrated interventions are essential to reduce the burden of stunting effectively.

The study highlights the importance of strengthening nutrition-sensitive and nutrition-specific interventions through multisectoral collaboration involving healthcare services, environmental health programs, educational sectors, and local governments. Community-based health promotion focusing on maternal education, sanitation improvement, hygiene practices, and clean water accessibility should be prioritized, particularly in high-risk rural communities.

Future research is recommended to explore additional determinants of stunting, including socioeconomic status, dietary intake, infectious diseases, household food security, and paternal factors using longitudinal or mixed-method approaches. Such studies may provide a more comprehensive understanding of the complex mechanisms contributing to childhood stunting and support the development of more effective prevention strategies.

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AI ASSISTANCE STATEMENT

The research presented in this article was conducted in accordance with established scientific standards and principles. AI tools were not used in the design, conduct, analysis, or interpretation of the research. The author team used AI solely for language editing and grammatical refinement to improve the clarity and readability of the manuscript while maintaining the originality and scientific integrity of its content.

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