ORIGINAL ARTICLE

Maternal and Toddler Characteristics, Environmental Factors, and Health Services as a Risk for Stunting in Rural Karanganyar, Indonesia

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Abstract

Background: Stunting remains a significant public health concern in Indonesia, particularly in rural areas. Although the national stunting prevalence declined to 19.8%, disparities persist. Despite interventions, there is limited evidence on the combined effects of maternal, environmental, and health service-related factors that contribute to stunting in this region. This study aimed to analyze the risk factors for stunting.

Methods: A case-control design was used, involving 85 stunted and 85 non-stunted toddlers in Jumapolo, Karanganyar, Central Java. Data were analyzed through univariate and bivariate analyses using the Chi-square test, followed by multivariate analysis with logistic regression.

Results: Six variables met criteria for inclusion in the final model: mother education (OR=2.042, 95% CI [1.059, 3.937], P=0.048), family income (OR=4.358, 95% CI [0.894, 21.256], P=0.102), birth weight (OR=5.203, 95% CI [1.659, 16.318], P=0.005), birth height (OR=3.128, 95% CI [1.441, 6.786], P=0.006), integrated-services-post *(Posyandu)* visit (OR=3.257, 95% CI [1.338, 7.929], P=0.013), and hand hygiene behavior by toddler (OR=3.087, 95% CI [1.391, 6.851], P=0.008). The most dominant factor was irregular *Posyandu* visits. Toddlers were 3.286 times more likely to be stunted (CI 95% 1.271-8.493, value 0.014). Additionally, toddlers with poor hand hygiene had 2.964 times higher odds of stunting (CI 95% 1.251-7.023, P=0.014). The findings suggest that limited access to routine health services and inadequate hygiene practices significantly contribute to stunting.

Conclusion: Intervention should prioritize promoting regular attendance of health services and improving hand hygiene practices among toddlers.

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Introduction

Stunting is defined as the condition in which children under five are shorter than children their own age in both height and body length (more than two standard deviations below the median standard of child growth and development), according to the World Health Organization (2019).[1] Globally, stunting remains a major public health challenge, affecting approximately 148 million children under the age five in 2023, with

the highest burden concentrated in South Asia and Sub-Saharan Africa.[2] Stunting has long-term effects on people and society, such as impaired physical and cognitive development, lower productivity, and a higher chance of developing degenerative diseases.[3] Male gender, child age,[4] maternal height and education, premature birth and birth length, exclusive breastfeeding for 6 months, household socio-economic status,[5] history of low birth-weight, pregnancy distance, knowledge about complementary feeding, hand washing habits,[6] household sanitary facility, household water treatment, and untreated drinking water[4] are some of the risk factors that contribute to stunting in Indonesia. There is limited evidence on how socio-cultural, educational, agricultural, and environmental factors contribute to childhood stunting; thus, operational research is needed to integrate water, sanitation, and hygiene into multisectoral strategies and strengthen targeted health promotion to reduce under-five stunting in Indonesia.[4-7]

The World Health Organization (WHO) targets every country in the world to reduce the prevalence of stunting by 20%. Indonesia is ranked fourth as a country with a high prevalence of stunting (30.8%) based on the Global Nutrition Report (2020) after Timor Leste (51.7%), Laos (33.1%), and Cambodia (32.4%). The prevalence of stunting in Indonesia has decreased from 27.7% in 2019 to 21.6% in 2022. However, this prevalence still needs to meet the WHO target. Apart from that, stunting occurs evenly in almost all regions of Indonesia. The highest prevalence of stunting occurred in West Sulawesi (35%) and the lowest in Bali (8%) in 2022, while the prevalence of stunting in Central Java was 20.8%.[8] This data shows quite significant disparities between regions in Indonesia. This condition indicates variations in community exposure to the determinants of stunting in children.

Based on previous research results, several groups of risk factors contribute to stunting, including internal maternal factors and external factors. Internal maternal factors that have been proven to influence the incidence of stunting include education, age, history of anemia, BMI, and smoking behavior. Meanwhile, external factors include family, healthcare workers, healthcare services, and environmental sanitation. The results of an earlier study indicated that stunting in Indonesian children under two years old was related to the mother's educational level. The mother's level of education influences the incidence of stunting. The risk is 1.587 times, 1.430 times, and 1.230 times higher for mothers with elementary, middle, and high school educations, respectively, than for mothers with a college degree.[9] A history of low-birth-weight babies has also been proven to be a risk factor for stunting in children aged 6-24 months, even as a dominant factor.[6] Mothers giving birth to low-birth-weight babies are a result of the mother's condition during pregnancy, such as anemia and low BMI. Previous research shows that mothers of at-risk age (<20 or >35 years) have a 16.2 times greater risk of giving birth to low-birth-weight babies compared to mothers who are not at risk. Likewise, mothers who are anemic are also 6.3 times more likely to give birth to low-birth-weight babies compared to those who are not anemic.[10]

Economically disadvantaged households also have a higher risk of experiencing stunting in children aged 12 and 24 months compared to economically privileged households. Poverty plays a role in influencing malnutrition in children. The nutritional status of these children is also predicted to get worse if they are in households with environmental hazards.[11] Several environmental hygiene conditions, such as foodborne disease transmission, poor waste management, unstandardized floors, unhygienic living conditions, and low-quality cooking fuels are associated with a higher risk of stunting in children. Access to clean water sources has been the subject of several studies, but more definitive conclusions are needed due to inconsistent findings. Because currently there is a need to carry out more research on arsenic, mercury, and ecologically friendly tobacco, it is unclear how these substances affect growth.[12] Although many studies have examined the risk factors for stunting in Indonesia, ranging from biological factors (e.g., low birth weight, anemia, maternal age) to environmental and socioeconomic factors, few have adopted an integrative approach that combines these elements, particularly in the Karanganyar region. Furthermore, there is no comprehensive local data that integrates maternal, household, health system, and environmental dimensions in assessing the determinants of stunting. Most existing studies emphasize isolated variables, thus limiting the effectiveness of interventions.

The prevalence of stunting occurs throughout Central Java Province. Karanganyar Regency is one of the districts where the prevalence of stunting has increased significantly, from 16.2% in 2021 to 22.3% in 2022.[8, 13] Jumapolo District has a stunting prevalence of 6.8% (130 cases), ranked the second highest after Karanganyar District in 2022. The coverage of toddlers weighing in Jumapolo still needs to be increased (81.7%) even though the number of toddlers experiencing nutritional problems(356 toddlers) is relatively high in 2021.[14] Previous research has yet to comprehensively examine the risk factors for stunting in the Karanganyar region, Indonesia. A better understanding of the double burden of malnutrition in the region, particularly in early childhood, will help decision-makers develop potential strategies to address the problem. Thus, this study aimed to analyze the risk factors for stunting in

Jumapolo District, Karanganyar, Indonesia, through an integrative approach that includes maternal characteristics, household conditions, access to health services, and environmental factors. This research is projected to contribute to improvement in understanding the multidimensional determinants of stunted growth in specific local contexts and offer scientific evidence to inform targeted and context-specific policy interventions.

Methods

Study Design and Data Source

From June to August 2023, this study was carried out in the Jumapolo Health Center's working area in the Karanganyar Regency of the Province of Central Java. The aim of this case-control study was to identify the main risk factors for stunting in children between the ages of 24 and 59 months. All the children who were living in the study area and were between the ages of 24 and 59 months made up the population. Based on measurements from the Jumapolo Health Center, children classified as not stunted make up the control group, and those classified as stunted make up the case group. The number of children under five who were recorded as stunted was 130. To estimate the minimum required sample size, prior research findings were used to determine the proportion of exposure among the control group (P_2=0.35) and the anticipated odds ratio (OR=3.1).[15] These values were put in the Lemeshow formula for sample size calculation in case-control studies, using $Z_{1-\alpha/2}$=1.96 for a 95% confidence level and $Z_{1-\beta}$=0,84 for an 80% statistical power, resulting in estimated sample size of 51 participants per group. To account for potential sample dropout or non-response, the final sample size was increased to 75 individuals in both the case and control groups. Mothers of toddlers made up the research respondents in this study.

Outcome Variable

The categorization of stunting and non-stunting toddler data is based on community health center data. The basis for calculating the height-for-age index is based on the WHO-MGRS 2006 Child Growth Standards.[16]

Exposure Variables

Maternal characteristics

Maternal age is categorized into two parts: pregnant women at risk aged ≤20 years and ≥35 years, and pregnant women not at risk aged between 21-34 years.[17] Maternal work status is categorized into mothers who work full time (employees, civil servants, factory workers) and those who do not (homemakers, farmers, self-employed). It is assumed that mothers do not have time to make antenatal-care visits during primary healthcare working hours. Maternal education was categorized based on the last formal education completed by the respondent. The category comprises low-education students who have completed elementary or middle school or no school, and higher-education students who have completed high school or university. Maternal height is categorized into two: short if she is <150cm tall, and standard if she is >150cm tall.[5]

Toddlers' Characteristics

Children were grouped by gender (male and female). Birth weight was categorized into low (<2500 g) and normal (≥2500 g),[18] while birth height was classified as normal (46-55 cm) and low (<46 cm).[19] Infectious disease history was recorded as 'yes' (if the toddler had experienced illnesses such as diarrhea, ARI, etc.) or 'no'. Immunization history was categorized as complete or incomplete based on the toddler's immunization status.

External Factor Characteristics

Family income in Indonesia is categorized into low and high incomes, with 142 USD being the regional minimum wage (Karanganyar, Central Java). Antenatal care visits are based on the Republic of Indonesia Minister of Health Regulation No. 21 of 2021, measured based on quantity and quality. ANC visits fall into two categories: 1) standardized visits, which occur six times during pregnancy and involve one visit in the first trimester, two in the second trimester, and three in the third trimester, followed by visits to an obstetrician or physician for monitoring in the first and third trimesters; 2) non-standardized visits, which occur in violation of the Minister of Health regulations. Only after the respondent completes the number and quality of the visit are ANC visits classified by standards.[20] Integrated service post visits are categorized as either routine, occurring regularly every month, or non-routine. Hand hygiene behavior of toddlers and mothers is categorized into good if toddlers consistently wash their hands during predetermined activities and bad if they do not. Household cooking fuels are categorized as recommended if they do not produce smoke or other pollutants, and not recommended if they do. Drinking water sources, based on Minister of Health Regulation No. 32 of 2017, are classified as standard if they meet the specified criteria, and non-standard if they do not.[21]

Data Collection Methods

Primary data were collected through structured interviews with mothers using a validated questionnaire. The questionnaire included sections on maternal characteristics, child characteristics, environmental factors, and utilization of health services. The questionnaire was tested for validity by three public health experts and piloted on 30

respondents outside the study area, with a Cronbach's Alpha value for internal consistency of ≥0.7 for all sections. All interviews were conducted face-to-face by trained enumerators under the supervision of public health researchers. Anthropometric and health service data were verified against medical records.

Data Analysis

The data processing software utilized was SPSS version 24. Descriptive analysis was conducted initially to summarize the maternal and toddler characteristics. Subsequently, the Chi-square test was used to examine the association and strength of the relationship between independent and dependent variables. Furthermore, multivariate analysis employing the Logistic Regression Test at a 95% confidence level (α=0.05) revealed dominating components.

Ethical Approval

The Health Research Ethics Committee of Rumah Sakit TK. II 04.05.01 dr. Soedjono approved this study, recommending ethical permission number 210/EC/VI/2023. All research participant gave their informed consent, data confidentiality was upheld, and privacy was ensured.

Results

Univariate analysis showed that most stunted toddlers were aged 36–47 months (42.7%), and their mothers were predominantly aged 21–30 years (45.3%), with the average age of stunted toddlers and their mothers being comparable to those in the normal group (Table 1). Bivariate analysis was conducted to identify the factors associated with stunting. Among maternal factors, only maternal education showed a statistically significant association with stunting (Table 2). Regarding toddler characteristics, low birth weight and low birth height were significantly associated with a higher incidence of stunting (Table 3). In addition, two external factors, irregular visits to the health center and poor hand hygiene behavior, were significantly associated with the incidence of stunting (Table 4).

Table 1: Maternal and Toddler Characteristics

Variables	Stunting n (%)	Normal n (%)
Toddler Age (Months)		
24-35	29 (38.7)	33 (44)
36-47	32 (42.7)	27 (36)
48-59	14 (18.7)	15 (20)
Mean±SD	37.99±9.195	37.91±9.322
Min-Max	24-56	24-56
Maternal Age (Years)		
21-30	34 (45.3)	25 (33.3)
31-40	27 (36)	39 (52)
41-50	14 (18.7)	9 (12)
>50	0	2 (2,7)
Mean±SD	33.07±7.056	33.59±6.716
Min-Max	22-50	23-53

SD: Standard deviation; min: Minimal; max: Maximal

Table 2: Bivariate Analysis Maternal Factors and Stunting

Variables	Stunting (N=75) (%)	Normal (N=75) (%)	OR	95% CI	P value
Maternal Age					
High-risk age	22 (29.3)	27 (36)	0.738	0.372-1.464	0.486
Low-risk age	53 (70.7)	48 (64)			
Maternal work status					
Employment	7 (9.3)	8 (10.7)	0.862	0.296-2.511	1.000
Unemployment	68 (90.7)	67 (89.3)			
Maternal Education					
Low	49 (65.3)	36 (48)	2.042	1.059-3.937	0.048
High	26 (34.7)	39 (52)			
Maternal height					
Short	27 (36)	20 (26.7)	1.547	0.771-3.102	0.291
Normal	48 (64)	55 (73.3)			
Family income					
Low	73 (97.3)	67 (89.3)	4.358	0.894-21.256	0.102
High	2 (2.7)	8 (10.7)			

OR: Odd ratio; CI: Confidence interval

Table 3: Bivariate Analysis Toddlers Factors and Stunting

Variables	Stunting (N=75) (%)	Normal (N=75) (%)	OR	95% CI	P value
Gender toddlers					
Male	40 (53.3)	40 (53.3)	1.000	0.526-1.899	1.000
Female	35 (46.7)	35 (46.7)			
Birth weight toddlers					
Low birth weight	17 (22.7)	4 (5.3)	5.203	1.659-16.318	0.005
Normal birth weight	58 (77.3)	71 (94.7			
Birth height toddlers					
Low birth height	28 (37.3)	12 (16)	3.128	1.441-6.786	0.006
Normal birth height	47 (62.7)	63 (84)			
History of infectious disease of toddlers					
Yes	13 (17.3)	9 (12)	1.538	0.614-3.850	0.489
No	62 (82.7)	66 (88)			
Immunization history toddlers					
Incomplete	6 (8)	4 (5.3))	1.543	0.417-5.708	0.743
Complete	69 (92)	71 (94.7)			

OR: Odd ratio; CI: Confidence interval

Table 4: Bivariate Analysis of Health Services, Environmental Factors, and Stunting

Variables	Stunting (N=75) (%)	Normal (N=75) (%)	OR	95% CI	P value
Antenatal-care visits					
Not standard	19 (25.3)	14 (18.7)	1.478	0.678-3.224	0.430
Standard	56 (74.7)	61 (81.3)			
Integrated-service-post visit					
Unroutine	21 (28)	8 (10.7)	3.257	1.338-7.929	0.013
Routine	54 (72)	67 (89.3)			
Health service access					
Difficult	21 (28)	24 (32)	0.826	0.411-1.663	0.722
Easy	54 (72)	51 (68)			
Hand hygiene behavior by toddlers					
Bad	64 (85.3)	49 (65.3)	3.087	1.391-6.851	0.008
Good	11 (14.7)	26 (34.7)			
Hand hygiene behavior by mothers					
Bad	4 (5.3)	0 (0)	0.486	0.412-0.575	0.120
Good	71 (94.7)	75 (100)			
Household cooking fuel					
Not recommended	17 (22.7)	13 (17.3)	1.398	0.624-3.130	0.540
Recommended	58 (77.3)	62 (82.7)			
Source of drinking water					
Not standard	18 (24)	19 (25.3)	0.931	0.443-1.956	1.000
Standard	57 (76)	56 (74.7)			

OR: Odd ratio; CI: Confidence interval

Variables found to be significant in the bivariate analysis (Tables 2-4), including maternal education, family income, birth weight, health post visits, and toddlers' hand hygiene, were included in a multivariate logistic regression model (Table 5). The analysis identified irregular visits to the health post (AOR=3.286; 95% CI: 1.271–8.493; P=0.014) and poor hand hygiene (AOR=2.964; 95% CI: 1.251–7.023; P=0.014) as the most influential factors associated with stunting in rural Karanganyar district. Children with un-routine access to the integrated-service-post visit were more 3.286 likely to be stunted than those with routine access to the integrated-service-post visit (CI 95% 1.271-8.493, P=0.014). In addition, children with bad hand hygiene behavior were 2.964 times more likely to suffer stunting than those with good hand hygiene behavior (CI 95% 1.251-7.023, P=0.014).

Discussion

This study indicated that low maternal education, low birth weight and height, irregular visits to the integrated health center, and poor hygiene in toddlers contributed to stunting in rural Karanganyar, Indonesia. It was found that mothers with low education levels (below junior high school) were significantly more likely to have stunted children compared to those with higher education. Education has an important role in shaping maternal knowledge and practices, particularly regarding child nutrition and health.

Table 5: Multivariate analysis

Risk Factors	First model				Last model				Rank
	OR	95% CI		P value	OR	95% CI		P value	
		Lower	Upper			Lower	Upper		
Mother with low education	1.553	0.739	3.265	0.245	-	-	-	-	-
Low family income	2.788	0.546	14.231	0.218	-	-	-	-	-
Low birth weight	3.214	0.852	12.127	0.085	3.327	0.915	12.102	0.068	-
Low birth height	2.141	0.833	5.501	0.114	2.359	0.949	5.863	0.065	-
Unroutine integrated-service-post visit	3.304	1.241	8.796	0.017	3.286	1.271	8.493	0.014	I
Bad hand hygiene behavior by toddlers	2.715	1.137	6.480	0.024	2.964	1.251	7.023	0.014	II
Constant	0.067	-	-	0.002	0.230	-	-	<0.001	-

OR: Odd ratio; CI: Confidence interval

Previous research showed that mothers with elementary, middle, and high school education risked to have stunting children.[9] Educated mothers had the proper understanding that nutritionwas related to stunting or other undernutrition-prevention behavior in toddlers.[22, 23] Moreover, maternal education also influences decisions in accessing health services related to child care, including the use of iodized salt, immunization, and vitamin A supplementation.[9, 24] In addition, the use of innovative health applications to monitor maternal and child health during and after pregnancy has also been shown to reduce the risk of stunted growth by supporting the availability of timely information and services.[25]

Compared to toddlers with normal birth weight, those who were born with low birth weight were 5.302 times more likely to experience stunting. As in the control group, there were also a significant number of toddlers in the case group with a history of LBW. According to an earlier study, stunted children were more likely to be low birth weight [aOR=1.68, 95% CI=1.58–1.78].[18] LBW babies have experienced growth retardation since the intrauterine period. Lack of nutrition in these babies affects birth weight and length.[26] The systematic review results showed that 80% of the studies reviewed revealed that birth weight was the most important determinant of children's nutritional status. Children born with a normal birth weight were less likely to experience malnutrition than those with a low birth weight.[23] In addition, longitudinal research has proven that LBW babies are susceptible to infectious diseases such as diarrhea and fever. This contagious disease also has the potential to inhibit nutritional absorption in babies.[27]

Toddlers born with low birth height were at risk of stunting 3,128 times compared to toddlers with normal birth height. The results of a study in North Pontianak, Indonesia, showed that 25.6% of toddlers with low birth length experienced stunting.[28] Babies who have low birth length are born when the pregnant mother is in an unhealthy condition as a result of poor economic conditions, disease, and poor nutrition in the mother. This condition results in the baby's brain development not being optimal, and they tend to have small body proportions at birth. Evidence of a significant relationship between birth height and stunting also occurs in 46.4% of toddlers in Jombang, Indonesia.[29] According to the results of a study conducted by Islam et al. (2018), mothers who give birth to children with a birth weight of less than 50 cm increase the risk of stunting at the age of 12-24 months.[11]

Toddlers on irregular integrated-service-post visits have a risk of stunting that is 3.257 times higher than those who regularly visit these centers. Each village sub-region organizes integrated service posts, known as *Posyandu*, in Indonesia. The number of *Posyandu* depends on the area of the village. In most villages, there are four to five *Posyandu,* which is a health service that monitors the growth and development of newborns and toddlers. *Posyandu* services are offered by health cadres once a month for toddlers, which include weighing, measuring height, nutritional advice, providing supplemental food, and dispensing vitamins under the supervision of a midwife. However, the survey results reveal that the use of *Posyandu* services still has to be enhanced. Past studies have demonstrated a connection between the prevalence of stunting and mothers' desire to bring their toddlers to *Posyandu*,[30] as well as its role in preventing anemia during pregnancy.[31] According to Mutalazimah and Rahayu (2019), there is still a need to implement community nutrition policies to provide mothers with additional information on how to reduce their risk of stunting.[32]

Toddlers who practice poor hand hygiene were 3.087 times more likely to have stunting than those who practice good hand hygiene. According to several earlier studies, the frequency of stunting was correlated with mothers' practice of washing their hands with soap after having direct contact with children.[33, 34] Hand washing behavior in this study focused on hand washing habits carried out by children. Children who did not wash their hands before eating were associated with stunting because they had drunk contaminated water or food.[35] One of the efforts made to get children interested in implementing hand-washing behavior

is by providing education. Providing education to children using A Germ's Journey has been proven to increase children's knowledge and encourage them to practice hand-washing behavior. It is designed in books, websites, songs, online games, and glo-glue activities, both at school and in public places.[36]

Attendance in integrated service is the dominant variable that influences stunting. Integrated healthcare, particularly exemplified through initiatives such as *Posyandu*, plays a pivotal role in addressing stunting by enhancing community education and frontline interventions. The training cadres in stunting, anthropometry, and nutrition enhance their ability to assess children's growth accurately and provide relevant guidance to parents.[37, 38] Furthermore, the implementation of Interprofessional Collaboration programs has proven to be efficacious in altering maternal perceptions regarding stunting, thereby further bolstering prevention endeavours.[39] By means of integrated nutrition interventions and comprehensive assessments, healthcare centers can pinpoint risk factors, optimize treatments, and take targeted measures to enhance nutrition, hygiene, and health practices, ultimately resulting in a decrease in stunting prevalence within communities.[40] Noteworthy increases in knowledge levels among cadres have been observed through counseling sessions, empowering them to conduct growth monitoring and providing crucial support to families facing the risk of stunting.[41]

This study used an accurate sample calculation based on the Lemeshow formula. Data collection with the validated instruments with ethical approval, which strengthens its reliability. The use of multivariate logistic regression also provided valuable insights into independent predictors of stunting. However, potential bias may exist due to self-reported data, especially for variables such as maternal and child characteristics. This study was conducted in a single rural area, limiting the generalizability of the findings to other areas, especially urban areas. Several factors may also influence stunting but were not included in this study, such as dietary diversity and breastfeeding practices.[42, 43] Irregular integrated-service-post *(Posyandu)* visits and poor hand hygiene among toddlers were identified by this study as significant risk factors for stunting in rural Karanganyar. All these risk factors can be reduced by increasing mother-child visits to *Posyandu*. However, the current use of Posyandu remains suboptimal, likely due to a lack of maternal awareness. Therefore, efforts from both the government and community leaders are needed to promote regular monthly visits to Posyandu for mothers and their children.

Authors' Contribution

Kusuma Estu Werdani: conceptualization, study design, and initial draft preparation; Syifa Kurnia: methodology development, instrument preparation, and supervision of data collection; Anggia Rahma: data collection, data management, and verification; Bintang Agustina Pratiwi: literature review and contribution to the introduction and discussion sections; Purwo Setiyo Nugroho: data analysis and interpretation of results; Anggi Putri Aria Gita: critical revision and substantial editing of the manuscript; Anisa Catur Wijayanti: final editing, reference alignment, and manuscript finalization

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Artificial Intellegence Usage Statement

The authors confirm that generative artificial intelligence tools were used to assist in language editing and academic phrasing during manuscript preparation. All content was reviewed and verified by the authors to ensure accuracy and integrity.

Conflict of Interest

The authors declare no competing interests.

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