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ORIGINAL ARTICLE

Environmental factors related to children diagnosed with stunting 3 years ago in Salatiga City, Central Java, Indonesia

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Summary
Background. — Stunting is a health problem that has a long-term impact on children's future. It is necessary to intervene in stunting infants up to 2 years old to catch up with the next period of child development. Sensitive nutrition intervention is an act to reduce indirect nutritional problems, such as environmental factors. This study aimed to determine environmental factors that may affect infants diagnosed with stunting 3 years ago.
Method. — The study was carried out from June to October 2021 in Salatiga City, Central Java, Indonesia, by using an observational cross-sectional research design. Of 251 stunted toddlers from six public health centers (confirmed data in 2018), 25 toddlers were randomly selected from each public center for stunting re-assessment in 2021. Subject recruitment follows inclusion criteria (e.g., toddlers should be under five years old, and mother and her baby/toddler occupy the same house in a permanent address, particularly from birth to five years old) and exclusion criteria (e.g., toddlers over five years old, the mother lives separately from her baby/toddler, the mother and her baby/toddlers do not have a permanent address, or the mother is passed away). Furthermore, the medical history of toddlers, maternal interview, household environment conditions, and coliform detection in drinking water were conducted and recorded. Logistic regression was performed to analyze the relationship between stunting conditions and environmental variables.

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Result. — The evaluation of the stunting status of children under five years old in 2021 was dominated by stunted conditions (22%) with a z score of —3 to < —2 standard deviations (SD), followed by severely stunted conditions (8%) with a z score of < —3 SD. The study demonstrated that environmental factors did not contribute to the stunting condition. However, boiled water was considered a risk factor for stunting conditions. Furthermore, our analysis showed that exclusive breastfeeding correlated with stunting condition and it offered a protection factor for stunting in toddlers.

Introduction

Stunting is a manifestation of chronic malnutrition and is a public health problem that needs global attention as it harms the quality of life of the next generation. Approximately 250 million children under five come from low- and middle-income countries at risk of not achieving proper human development due to stunting and poverty. Globally, the prevalence of stunting between 2000 and 2020 decreased from 33.1% to 22%, and 149.2 million toddlers were stunted in 2020. In 2020, the high prevalence areas of stunting included Africa and South Asia, whereas the low stunting prevalence was found in Europe, Central Asia, and North America [1]. Indonesia is the third country with a high prevalence of stunting in children under 5 years of age in the Southeast Asia region in 2005—2017 at 36.4% and in 2019 at 27.7%. The prevalence of stunting in children under five can be a public health problem if the prevalence is up to 20% [2,3].

The Sustainable Development Goal of Indonesia by 2025 is to reduce the stunting rate by more than 40%. So, further research is required to analyze the nutritional intake of children under five. The early development of infants until toddlers is a crucial period for the growth and development of children. Stunting conditions will disrupt the physical and cognitive development of the child [4,5]. Stunting can be presented with a z score by comparing height to toddler age. Z score is an index of body length according to age or size. This index can identify children stunted or severely stunted, caused by prolonged malnutrition or frequent illness. A toddler with a z-score below —2 is defined as stunting [6]. Stunting is divided into two criteria: severely stunted and stunted. Severely stunted has a z-score of < —3 standard deviation (SD), whereas stunted has the z-score between —3 to < —2 SD. Typical toddlers have a z score of —2 to 2 SD, and more than 2 SD is considered high [7].

According to the World Health Organization (WHO), stunting is defined as disabilities in growth and development experienced by children due to poor nutrition, repeated infections, and inadequate psychosocial stimulation. However, this definition does not include genetic variation [8]. Stunting is a form of chronic malnutrition mainly caused by poor nutrition before birth. Babies with stunting at birth are two to four times more likely to be stunted at 3 months to 2 years [9,10]. The impact of stunting has short- and long-term adverse effects that are not only limited to the lives of children but also extend to the next generation. It leads to physical disability, health problems, and economic losses. Stunting is correlated with high mortality and morbidity rates in children, including increased susceptibility to infection and impaired cognitive and physical development. Nutrition is needed for brain development, especially from birth to 6 months [11,12].

Stunted children often face infections and have a greater risk of illness and death [13]. Stunting is a complex condition reflecting several causes, such as poor and unbalanced nutritional intake, inadequate intake of vitamins and micronutrients, and suboptimal breastfeeding in the first month of life. Indirect factors, such as access to health services, parental education, economic status or wealth, political stability, and social support, can also affect the condition of stunting [12]. The cause of stunting is not solely the result of food shortage but also hampered by improper feeding and care practices and poor health and sanitation services [14]. The interaction of environmental factors and nutritional status plays a significant role in stunting in children. For example, iron (Fe) deficiency in pregnant women and parasitic infections in children can be associated with stunting. Environmental risk factors include poor sanitation, poor waste disposal, lack of clean water, soil floors in the home environment, mycotoxins contained in food, and indoor fuel use shown to correlate with child stunting cases worldwide. Approximately 7.2 million cases of stunting worldwide are caused by poor sanitation [15,16]. Salatiga City is one of the highland areas in Central Java Province, Indonesia. Stunting cases in this area are still relatively high, with 250 babies born in 2018 declared stunted. However, the development of those babies after 3 years has never been studied. Therefore, this study examined environmental factors and the status of a 3-years-old toddler diagnosed with stunting at birth in Salatiga City, Semarang, Indonesia. These findings will be beneficial as an evaluation material and future strategic actions in alleviating the stunting problem.

Methods

An observational study with a cross-sectional design was conducted from June to October 2021. This research has received ethical approval from the Research Ethics Commission of the Faculty of Public Health, Diponegoro University (No. 120/EA/KEPK-FKM/2021). The health protocols under COVID-19 measures were applied during the research. This study used the stunting babies' data in six public health centers in Salatiga City. Of all born registered in the facilities, 251 (9.89%) babies were declared stunted. Subject recruitment follows inclusion criteria (e.g., toddlers should be under five years old, and mother and her baby/toddler occupy the same house in a permanent address, mainly since birth to five years old) and exclusion criteria (e.g., toddlers over five years old, the mother lives separately from her baby/toddler, the mother and her baby/toddlers do not have a permanent address, or the mother is passed away).

Sample determination was performed in two stages. First, 25 data were collected proportionally from each public health center. Second, random sampling was conducted in six public health centers in Salatiga City. The data were obtained by measuring the stunting status of children under five selected as samples. Next, interviews and observations were conducted to gather essential information such as the history of childhood illness, health services, waste management, types of household wastewater disposal systems, latrines, types of water sources, and coliform detection in drinking water. Trained enumerators collected the data. The presence of coliform in drinking water from houshold of stunted children was examined in the Water Quality Laboratory of Salatiga Public Health Center.

Assessment of stunting status

The stunting condition of toddlers was calculated by the z score from the toddler's height index according to age (TB/U). The toddler's height was measured using a microtoise device. The results were interpreted based on WHO: severely stunted: z < −3 SD, stunted: −3 to < −2 SD, normal: −2 to 2 SD, and high: > 2 SD.

Water quality assessment

This study only collected water samples from households of confirmed stunted children. Therefore, the sample was the water used for their daily needs. The bacteriological examination used the most probable number (MPN) parameters to determine coliform bacteria contamination. Samples (100 mL) were collected into sterile bottles, closed with aluminum foil, and sent to the laboratory.

Statistical analysis

Statistical analysis of data was performed using the Chi^2 test. Prevalence ratio (PR) and 95% confidence interval (CI) were used to determine the risk factors for stunting in children under five. The relationship between the current stunting status of toddlers and other categorical variables was analyzed through logistic regression performed by the SPSS program to determine the statistical significance value ($P < 0.05$).

Table 1 Assessment of stunting status in toddlers diagnosed 3 years ago in Salatiga City.

	Total $n = 150$
Female, *n* (%)	69 (46)
Male, *n* (%)	81 (54)
Age, mean (range, months)	41 (33—48)
Height, mean (range, cm)	93 (74—107)
Weight, mean (SD, kg)	13 (11—16)
Stunting status 3 years ago	
Severely stunted, *n* (%)	48 (32)
Stunted, *n* (%)	102 (68)
Current stunting status (study results)	
Normal, *n* (%)	104 (69)
Stunted, *n* (%)	33 (22)
Severely stunted, *n* (%)	13 (8)
Household expense, mean (SD)	2,387,248 (1,109,680)

Results

Determination of stunting status

In total, 150 samples of children under five have been measured for stunting status by calculating the z score (Table 1). Their average age was 41 (33—48) months, with a weight of 13 (11—16) kg and a height of 93 (74—107) cm. Stunted cases were more experienced by males (54%) than females (46%). In 2018, 102 (68%) babies were born with stunted conditions, and 48 (68%) babies with severely stunted conditions. However, this study found that in 2021, 46 (30%) toddlers still suffer from stunting conditions, in which 33 (22%) were stunted with a z score of −3 to < −2 SD, and the other 13 (8%) were severely stunted with a z score of < −3 SD. Their household expenses were approximately Rp. 2,387,248 ± 1,109,680.

The environmental conditions in observed households include drinking water sources, types of latrines, ownership of wastewater treatment and infiltration wells, presence of temporary disposal sites at home and garbage caps, waste management, and water cooking. Table 2 shows that 30% of respondents use clean water sources for their daily needs. Most households already have latrines, but some do not meet the requirements (26%). The houses of stunting toddlers were often found without or clogged wastewater treatment plans (25%), no garbage disposal (32%) but provided with an open garbage dump inside the house, and poor waste management (40%), such as being dumped in the garden, burned, and littering in the river. Based on the results, there was no relationship between types of water sources ($P = 1.00$; PR = 1.00; 95% CI = 0.60—1.66), types of latrines ($P = 0.63$; PR = 0.81; 95% CI = 0.45—1.48), ownership of wastewater treatment ($P = 0.74$; PR = 0.79; 95% CI = 0.35—1.76), ownership of infiltration wells ($P = 0.63$; PR = 1.17; 95% CI = 0.72—1.92), presence of dustbin in the house ($P = 1.00$; PR = 1.06; 95% CI = 0.58—1.93), capped dustbin ($P = 0.13$; PR = 1.59; 95% CI = 0.90—2.81), waste management ($P = 0.38$; PR = 1.38; 95% CI = 0.79—2.41), and cooked or uncooked drinking water ($P = 0.31$; PR = 1.46; 95%

Table 2 Observation results of house environment for toddlers diagnosed with stunting 3 years ago in Salatiga City.

	Current stunting status		*P*-value
	Stunting*n* (%)	Normal*n* (%)	
Types of water source			1.00
Clean water	16 (30)	36 (69)	
Drinking water	30 (30)	68 (69)	
Types of latrines			0.63
Unsuitable	10 (26)	28 (73)	
Suitable	36 (32)	76 (67)	
Ownership of wastewater treatment			0.74
No	5 (25)	15 (75)	
Yes	41 (31)	89 (68)	
Ownership of infiltration wells			0.63
No	27 (32)	55 (67)	
Yes	19 (27)	49 (72)	
Presence of dustbin in the house			1.00
No	9 (32)	19 (67)	
Yes	37 (30)	85 (69)	
Capped dustbin			0.13
No	34 (35)	62 (64)	
Yes	12 (22)	42 (77)	
Waste management			0.38
Unsuitable	10 (40)	15 (60)	
Suitable	36 (28)	89 (71)	
Cooked drinking water			0.31
No	0 (0)	4 (100)	
Yes	46 (31)	100 (68)	

CI = 1.30—1.63) with the current stunting status of children under five. Boiling drinking water consumed by children under five was a risk factor with a PR of 1.46 and a CI of 1.30—1.63.

Water quality inspection based on bacteriology

The existence of *Escherichia coli* bacteria within the water samples of stunted toddlers' households was confirmed with MPN parameters. The results showed that out of 46 samples, 26 (56%) contained *E. coli* (coliform) bacteria, and 12 (46%) exceeded the bacteriological quality requirements of clean water (Table 3).

Interviews with respondents were conducted to determine the access to health services related to children under five's health during the last 3 years. They mentioned that the stunted toddlers experienced illness (32%), incomplete immunization (22%), were not taking vitamin A (33%), the mothers did not take Fe tablets during pregnancy (25%), the mothers did not attend antenatal care visits (28%), and the stunted toddlers did not receive exclusive breastfeeding (14%). There was a significant correlation between exclusive breastfeeding and the current stunting status of toddlers ($P = 0.03$; PR = 0.41; 95% CI = 0.17—0.97). However, no significant relationship was found between the medical history of stunted toddlers ($P = 0.53$; PR = 1.40; 95% CI = 0.62—3.17), immunization ($P = 0.72$; PR = 0.71; 95% CI = 0.20—2.47), vitamin A ($P = 1.00$; PR = 1.08; 95% CI = 0.21—5.49), Fe ($P = 100$; PR = 0.80; 95% CI = 0.23—2.74), and antenatal care ($P = 1.00$; PR = 0.92; 95% CI = 0.38—2.19) with the current stunting status (Table 4).

Based on logistic regression modeling, exclusive breastfeeding ($P = 0.02$; PR = 0.31; 95% CI = 0.11—0.87) becomes a protective factor for the current stunting status of toddlers by 0.3 times compared to those without exclusive breastfed (Table 5).

Discussion

Stunting at birth is a form of chronic malnutrition mainly caused by poor nutrition and is influenced by several factors. This study shows that 30% of children under five with stunting status were categorized as stunted (22%) and severely stunted (8%) in Salatiga City. It is in line with research conducted in Ethiopia that shows up to 30% of newborns was stunted at birth and male infants were at risk of stunting. Stunted infants are two to four times more likely to be stunted at 3 months—2 years [10].

This study found that exclusive breastfeeding was a significant variable and acted as protection for toddlers with stunting. Breast milk contains high-quality protein crucial in the growth process as it has a balance of whey protein and casein compared to cow's milk. Whey protein is easier for babies to digest as it is more refined than protein in cow's milk. Exclusive breastfeeding for 6 months will protect babies from infectious diseases and maintain optimal growth [17]. Research in Mexico shows that breastfeeding protects against stunting compared to those who have never

Table 3 Results of water quality inspection.

MPN results	*n* = 46	%
Does not contain coliform bacteria	20	43
Contained coliform bacteria	26	56
Under the clean water quality requirements	14	53
Exceeding the clean water quality requirements	12	46

MPN: most probable number.

Table 4 Health services.

	Current status stunting		*P*-value	PR (95% CI)
	Stunting *n* (%)	Normal *n* (%)		
Medical history			0.53	1.40 (0.62—3.17)
Been sick	41 (32)	87 (68)		
Never been sick	5 (22)	17 (77)		
Immunization			0.72	0.71 (0.20—2.47)
Never	2 (22)	7 (77)		
Complete	44 (31)	97 (68)		
Vitamin A consumption			1.00	1.08 (0.21—5.49)
No	1 (33)	2 (66)		
Yes	45 (30)	102 (69)		
Exclusive breastfeeding			0.03	0.41 (0.17—0.97)
No	5 (14)	29 (85)		
Yes	41 (35)	75 (64)		
Fe consumption			1.00	0.80 (0.23—2.74)
No	2 (25)	6 (75)		
Yes	44 (31)	98 (69)		
Antenatal care			1.00	0.92 (0.38—2.19)
No	4 (28)	10 (71)		
Yes	42 (30)	94 (69)		

PR: prevalence ratio; 95% CI: 95% confidence interval.

Table 5 Logistic regression model.

Variable	B	S.E	*P*-value	PR (95% CI)
Exclusive breastfeeding	−1.15	0.52	0.03	0.31 (0.11—0.87)
Constant	1.75	0.48	0.00	5.80

PR: prevalence ratio; 95% CI: 95% confidence interval.

been breastfed. The use of breast milk helps strengthen children's immune systems, reduces exposure to infections from liquids or food, and decreases diarrheal diseases and gastrointestinal infections that have been identified as significant risk factors for stunting in toddlers [18]. A previous study also proves a relationship between breastfeeding for children of 0—5 months and stunted reduction [19]. A well-developed immune system can support optimal growth and development of children and reduce the risk of disease [20].

Other factors that were not related to the current stunting status based on this study were the medical history of the toddlers, immunizations, vitamin A and Fe tablets consumption, and antenatal care. Some research studies suggest no significant relationship between multiple micronutrient supplements compared to Fe and folic acid supplementation for postnatal growth [21] and stunting in children [22]. However, a previous study contradicts these findings by stating that children with vitamin A deficiency have a 43% higher chance of stunted growth than children with complete vitamin A [23]. Vitamin A intake is essential in increasing humoral immunity, reducing the risk of anemia due to infectious diseases, and optimizing linear and hematological growth status. Children with vitamin A deficiency will have a higher risk of developing anemia and stunting at

the same time. Lack of consumption of meat and legumes and low frequency of eating may lead to higher rates of anemia and stunting [24]. Immunization in toddlers is not significantly related to the current stunting status of toddlers. This is supported by research that stated that Bacillus Calmette—Guérin vaccination does not affect or have a low effect on stunting in children.

The same goes for diphtheria—tetanus—pertussis and measles vaccines [25]. A previous study found that 34% of children aged over 3 months who were considered fully vaccinated and 85% of children with incomplete vaccinations still had a z score below −1 SD for both body weight and height for age [26]. Antenatal care was not significantly related to the current stunting status of children under five. However, antenatal care, including nutritional interventions and advice from health care providers during pregnancy, is supposed to be a stunting prevention measure. Mothers who did not perform antenatal check-ups were more likely to develop stunted babies than mothers who had antenatal care visits four times or more [27]. The medical history of toddlers was not significantly related to the current stunting, as 85% of children under five in this study had experienced illnesses such as diarrhea, vomiting, fever, and respiratory infections. The degree of disease could be categorized as severe if the toddlers have been hospitalized (18%), moderate if they were treated as an outpatient (50%), and mild if they were not taken to health services (16%). Stunted toddlers in this study have appetite disorders (45%) with an average frequency of eating 2.96 times a day with small portions. Low nutritional intake can cause toddlers to be susceptible to disease. Infectious diseases can worsen stunting by reducing the appetite, leading to decreased nutritional intake and absorption. An extended period and severe illness can disrupt the growth and development of toddlers, and they become susceptible to disease [17].

There was no direct evidence related to environmental factors affecting stunting conditions found in this study. Boiling the drinking water consumed by toddlers has no significant relationship with the current stunting status. However, based on the prevalence ratio and 95% confidence interval, boiling drinking water was a risk factor for stunted children under five. Children with uncooked drinking water consumption had a 1.46 times greater risk of experiencing stunting than those who drink boiled water. This is consistent with India's research that shows that children who consumed uncooked water were more likely to be stunted than children who consumed processed drinking water [28]. Through boiling, disease-causing microorganisms in the drinking water and their transmission can be killed and cut off. It is also necessary to pay attention to drinking water containers, such as the availability of covers, stored in a clean place, inaccessible by animals, and must be cleaned at least three times a week to maintain the water quality [29]. Boiling drinking water has a protective effect against diarrhea. Diarrhea contributes to decreased food intake and nutrient absorption leading to malnutrition and impaired physical and cognitive growth [30].

Most respondents (59%) used tap water for daily needs, 33% respondents depended on well water, and the rest used other sources. However, these types of water sources had no significant correlation with stunting. A study in India showed that children from rural India who received safely managed drinking water were less likely to be underweight but insignificant to affect stunting conditions [31]. Another study in India also showed that total coliforms, including *E. coli*, were found in large numbers in well water samples. Bacterial contamination of well water sources is mostly caused by watershed erosion, drainage, and septic holes [32]. Open defecation can increase the spread of infectious diseases through fecal-oral, including diarrhea, typhoid, and hepatitis, which can cause malnutrition due to disruption of the absorption of nutrients in the body [19]. In contrast to this study that found no significant effect, research conducted in Bangladesh showed a significant relationship between the type of latrine and child stunting. Lack of access to healthy latrines and unhygienic toilet conditions were significantly associated with a higher incidence of stunting in children [33]. This study found that 52.4% of the infiltration wells were less than 10 meters away. In the distance, contamination might occur and cause diarrhea and infectious diseases in toddlers. Unqualified latrines can cause health and ecological impacts related to microbiological contamination and the chemical content of water [34]. Although the sewerage was found to be not related to stunting in this study, Mamuju stated that there was a significant relationship between waste management and the incidence of stunting. Poor waste management and open sewerage can contaminate the soil and trigger diseases, such as diarrhea and unpleasant odors. Open sewers and clogged water flow may become a breeding ground for disease vectors. These vectors become intermediaries in contaminating food and beverages consumed by humans and cause stunted growth and development [35]. A study in Tanzania contradicts the findings of this study by suggesting that the waste collection system was proven to have an impact on reducing diarrhea and stunting [36]. The households observed in this study discharge their waste by burning or littering into the river. Unsafe waste management can increase the risk of children being exposed to infectious and parasitic diseases that tend to worsen the nutritional status of children [37]. Those findings are useful as evaluation materials and future strategic actions in alleviating the stunting problem, especially in the Semarang area, Indonesia. However, quantitative measurements of food intake were not performed. Thus, it is still unknown whether stunted toddlers are affected by food intake or other factors. Therefore, the results of this study need to be followed up by examining why the 46 toddlers are still stunted even though they have grown and developed and received guidance from health workers until they are 3 years old.

Conclusion

Environmental factors do not significantly correlate with the incidence of stunting children under five years old in Salatiga city. Boiled water is considered a risk factor for stunting condition. Boiling water is crucial to inactivate or eliminate waterborne pathogens contributing to stunting conditions. Furthermore, exclusive breastfeeding correlates with stunting and provides a protective factor against malnutrition. Further studies on the exclusive breastfeeding behavior and nutritional intake of children are required to understand the stunting cases in Salatiga city. Additionally, it is critical

to conduct interventions such as promoting and counseling exclusive breastfeeding and integrated nutritional interventions to reduce child stunting cases.

Disclosure of interest

The authors declare that they have no competing interest.

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