an idea health journal
ISSN (online): 2797-0604

Volume 6 No 3, Page 625-634
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OPEN ACCESS

The Relationship Between Environmental Health Factors and the Incidence of Stunting

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Article Info:
Received: 20 April, 2026
Revised: 27 July, ,2026
Accepted: 30 July, 2026

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How to Cite:
Sitorus MEJ, Purba IE, Nababan D. The Relationship Between Environmental Health Factors and the Incidence of Stunting . An Idea Health Journal.2026; 6(03): 625-634
https://doi.org/10.53690/ihj.v6i03.764

Abstract

Background: Stunting is a form of chronic undernutrition that impairs children's linear growth and development, particularly during the first 1,000 days of life. It remains a major public health problem in many developing countries. Stunting is defined as a length- or height-for-age z-score below −2 standard deviations according to the World Health Organization child growth standards. Environmental health conditions may indirectly contribute to the occurrence of stunting. This study aimed to examine the association between environmental health factors and stunting among children in the working area of the Batang Beruh Health Center, Sidikalang.

Methods: This study employed an analytical observational design with a quantitative cross-sectional approach. A total of 64 respondents were recruited using convenience sampling. Data were analyzed using univariate analysis and bivariate analysis with the chi-square test..

Result: Drinking water sources were significantly associated with stunting status ($p < 0.001$). A significant association was also found between the physical quality of drinking water and stunting ($p < 0.001$). In contrast, drinking water treatment was not significantly associated with stunting ($p = 0.366$). Latrine ownership and waste management were significantly associated with stunting status (both $p < 0.001$).

Conclusion: Drinking water sources, the physical quality of drinking water, latrine ownership, and waste management were significantly associated with stunting. However, drinking water treatment was not associated with stunting. Health center personnel should strengthen community education regarding safe water, sanitation, and appropriate waste management practices as part of stunting prevention efforts among children under five.

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Keywords: Stunting, Waste Management, Drinking of Water.

BACKGROUND

Stunting is a form of impaired linear growth, defined as a length-for-age or height-for-age z-score below −2 standard deviations from the median of the World Health Organization Child Growth Standards (1). It reflects the cumulative effects of inadequate nutrition, recurrent infections, and suboptimal care, particularly from conception to the first two years of life. Stunting may adversely affect children's physical growth, cognitive development, educational achievement, and health later in life.

Stunting remains a major global public health problem. In 2022, approximately 22.3% of children under five years of age worldwide were affected by stunting (2). In Indonesia, the prevalence of stunting decreased from 24.4% in 2021 to 21.6% in 2022 (3). Although this decline indicates progress, the prevalence remains substantial and requires sustained interventions addressing both nutritional and non-nutritional determinants.

The causes of stunting are multifactorial and interrelated. The immediate determinants include inadequate dietary intake and infectious diseases, whereas the underlying determinants include maternal nutritional status, inappropriate infant and young child feeding, household food insecurity, limited access to health services, socioeconomic disadvantage, and poor water, sanitation, and hygiene conditions (4, 5). Therefore, nutritional interventions alone may be insufficient when children continue to be exposed to unhealthy environmental conditions.

Inadequate water, sanitation, and hygiene conditions may impair child growth through several pathways. Unsafe drinking water and poor sanitation increase children's exposure to enteric pathogens, which may cause recurrent diarrhea, intestinal parasitic infections, and environmental enteric dysfunction (6). Environmental enteric dysfunction is a subclinical inflammatory condition of the intestine that can reduce nutrient absorption and contribute to impaired linear growth, even in children without clinically apparent diarrhea.

Household water conditions include the source, accessibility, storage, treatment, and quality of drinking water. Although the physical characteristics of water, such as color, odor, taste, and turbidity, do not directly confirm its microbiological safety, they may indicate potential water-quality problems. Water obtained from unsafe sources or stored and treated improperly may become contaminated with disease-causing microorganisms. Repeated exposure to contaminated water can increase the occurrence of gastrointestinal infections and interfere with children's nutritional status.

Sanitation facilities and household waste management are also relevant environmental determinants. The absence of an improved household latrine and the practice of open defecation may increase fecal contamination of water, food, soil, and the domestic environment. Similarly, inappropriate management of solid and liquid waste may create breeding sites for flies, cockroaches, mosquitoes, and rodents, which can contribute to the transmission of environmentally related diseases. However, the strength of the association between individual waste-management indicators and stunting may vary across populations and settings.

Previous research has demonstrated an association between inadequate WASH conditions and childhood stunting. A systematic review and meta-analysis involving studies from developing countries found that limited access to safe water, sanitation, and hygiene was associated with an increased risk of stunting, with sanitation showing a particularly important contribution (7). In Indonesia, Torlesse et al. reported that children living in households with both unimproved sanitation and untreated drinking water had greater odds of stunting (8). A national systematic review also identified unimproved sanitation and unsafe or untreated water as important household and community-level risk factors for childhood stunting (9).

Nevertheless, the evidence is not entirely consistent across all WASH indicators. A recent systematic review and meta-analysis found that improved drinking water quality, water accessibility, and sanitation facility type were more consistently associated with lower odds of stunting. In contrast,

the evidence regarding drinking water sources, household water treatment, child feces disposal, and household garbage disposal remained inconsistent (10). These variations indicate that the relationship between environmental health and stunting may depend on local infrastructure, household practices, pathogen exposure, and socioeconomic conditions.

The Indonesian Government has recognized the importance of environmental interventions through Presidential Regulation Number 72 of 2021 on the Acceleration of Stunting Reduction. The national strategy includes improving access to safe drinking water and adequate sanitation as part of nutrition-sensitive interventions (11). However, evidence at the local level is still needed to determine which environmental factors should be prioritized in specific communities.

Routine records from the Batang Beruh Health Center documented 172 children with stunting between January and April 2023 (12). Despite this local burden, limited evidence is available regarding the combined associations of drinking water sources, the physical quality and treatment of drinking water, latrine ownership, and household waste management with stunting in this area. Therefore, this study aimed to examine the associations between environmental health factors and stunting status among children under five in the working area of the Batang Beruh Health Center, Sidikalang.

METHODS

Study Design

This study used an analytical observational design with a quantitative cross-sectional approach.

Sample/Participants

The study population consisted of 175 mothers with children under five who resided in the five selected villages. The minimum sample size was calculated using the Slovin formula, resulting in a required sample of 64 respondents. Participants were recruited using convenience sampling based on their availability and eligibility during the data collection period. Inclusion criteria such as mothers with children aged 0–59 months, permanent residence within the study area, and willingness to participate. Exclusion criteria such as children with congenital abnormalities affecting growth or respondents with incomplete data.

Data Collection

Data were collected from eligible mothers with children under five in the five selected villages. Before data collection, the respondents received information about the purpose, procedures, potential risks, and benefits of the study. Written informed consent was obtained from each respondent. Information on household environmental health conditions was collected through face-to-face interviews.

Data Analysis

Data were analyzed using SPSS Version 27. Descriptive statistics were used to summarize respondent characteristics, environmental health factors, and stunting status. Categorical variables were presented as frequencies and percentages.Bivariate analysis was performed using the chi-square test to examine the associations between drinking water sources, the physical quality of drinking water, drinking water treatment, latrine ownership, household waste management, and stunting status. A p-value of less than 0.05 was considered statistically significant. When the assumptions of the chi-square test were not met, Fisher's exact test should be used.

Ethical Consideration

Ethical approval for this study was obtained from the Health Research Ethics Committee of Universitas Sari Mutiara Indonesia under approval number 2461/F/KEP/USM/IX/2023. Participation was voluntary, and all respondents provided written informed consent before data collection. Respondent confidentiality and anonymity were maintained throughout the study, and the collected data were used exclusively for research purposes.

RESULT AND DISCUSSION

RESULT

Table 1 presents the demographic characteristics, environmental health conditions, and stunting status of the children included in the study.

Variable	Category	n	%
Child's sex	Male	36	56.3
	Female	28	43.8
Drinking water source	Protected	40	62.5
	Unprotected	24	37.5
Physical quality of drinking water	Met the required standards	35	54.7
	Did not meet the required standards	29	45.3
Drinking water treatment	Treated	35	54.7
	Untreated	29	45.3
Healthy latrine ownership	Yes	42	65.6
	No	22	34.4
Household waste management	Good	32	50.0
	Poor	32	50.0
Stunting status	Stunted	36	54.7
	Not stunted	29	45.3

Most children were male (56.3%). Protected drinking water sources were used by 62.5% of households, while 54.7% had drinking water that met the required physical quality standards and treated their drinking water before consumption. Most households had a healthy latrine (65.6%). Waste management practices were evenly distributed between the good and poor categories (50.0% each). Overall, 54.7% of the children were classified as stunted (Table 1).

Table 2. Associations between environmental health factors and stunting status among children under five (n = 64)

Environmental health factor	Category	Stunted, n (%)	Non-stunted, n (%)	Total, n (%)	p-value
Drinking Water Source	Protected	15 (37.5)	25 (62.5)	40 (100.0)	<0.001[a]
	Unprotected	20 (83.3)	4 (16.7)	24 (100.0)	
Physical quality of drinking water	Met the required standards	11 (31.4)	24 (68.6)	35 (100.0)	<0.001[a]
	Did not meet the required standards	24 (82.8)	5 (17.2)	29 (100.0)	
Drinking water treatment	Treated	31 (52.5)	28 (47.5)	59 (100.0)	0.366[b]
	Untreated	4 (80.0)	1 (20.0)	5 (100.0)	
Healthy latrine ownership	Yes	0 (0.0)	22 (100.0)	22 (100.0)	<0.001[b]
	No	35 (83.3)	7 (16.7)	42 (100.0)	
Household waste management	Good	5 (15.6)	27 (84.4)	32 (100.0)	<0.001[a]
	Poor	30 (93.8)	2 (6.2)	32 (100.0)	

a.Chi-square test.

[b]Fisher's exact test was used because one or more expected cell frequencies were below five.Percentages were calculated within each environmental health category.

Children from households using unprotected drinking water sources had a higher proportion of stunting than those using protected sources (83.3% vs. 37.5%; $p < 0.001$). Similarly, stunting was more common among children whose household drinking water did not meet the required physical quality standards than among those whose water met the standards (82.8% vs. 31.4%; $p < 0.001$).

Although the proportion of stunting was higher among children from households that did not treat their drinking water than among those that treated it (80.0% vs. 52.5%), the association was not statistically significant ($p = 0.366$). All children from households with a healthy latrine were non-stunted, whereas 83.3% of children from households without a healthy latrine were stunted ($p < 0.001$). Stunting was also more common among children from households with poor waste management than among those with good waste management (93.8% vs. 15.6%; $p < 0.001$).

DISCUSSION

This study examined the associations between household environmental health factors and stunting status among children under five in the working area of the Batang Beruh Public Health Center. The findings showed significant associations between stunting status and drinking water source, the physical quality of drinking water, healthy latrine ownership, and household waste management. In contrast, drinking water treatment was not significantly associated with stunting. These results support the importance of water, sanitation, and hygiene conditions as underlying determinants of child growth. Nevertheless, because stunting is multifactorial and the present study used a cross-sectional design, the findings should be interpreted as associations rather than causal relationships.

Drinking Water Source and Stunting Status

Children living in households that used unprotected drinking water sources had a substantially higher proportion of stunting than those whose households used protected sources (83.3% vs. 37.5%; $p < 0.001$). This finding suggests that the source from which households obtain drinking water may be an important environmental factor associated with child growth. Unprotected water sources are more vulnerable to contamination by human and animal feces, household waste, surface runoff, and stagnant water. This risk may be greater when wells or other water sources are located close to latrines, livestock enclosures, waste-disposal areas, or wastewater channels. Water contaminated with enteric pathogens can increase children's exposure to diarrhea, intestinal parasitic infections, and other gastrointestinal diseases. Repeated infection may reduce food intake, increase nutrient loss, and impair nutrient absorption, thereby contributing to restricted linear growth (13-15).

Poor water and sanitation conditions may also contribute to environmental enteric dysfunction, a subclinical inflammatory disorder of the small intestine associated with chronic exposure to fecal pathogens. Environmental enteric dysfunction can damage intestinal structure, increase intestinal permeability, and reduce nutrient absorption, even when a child does not experience clinically apparent diarrhea (6, 14). This mechanism may partly explain why children exposed to unsafe water sources experience impaired growth over time.

The present result is consistent with an Indonesian case-control study showing that limited access to safe drinking water was associated with stunting among children aged 6–23 months (20). Torlesse et al. also reported that Indonesian children living in households with unimproved sanitation and untreated drinking water had higher odds of stunting (8). These findings suggest that drinking water conditions should be considered together with sanitation and household hygiene practices.

However, previous evidence has not been entirely consistent. Rah et al. found that household sanitation was associated with stunting among Indonesian children, whereas the type of drinking water source was not independently associated with stunting after adjustment for socioeconomic and child-related factors (17). Similarly, a recent meta-analysis found more consistent associations for water quality and accessibility than for the classification of drinking water sources alone (10). A water source

categorized as protected may still become contaminated during collection, transportation, storage, or household handling. Therefore, source classification alone may not fully represent the water that is ultimately consumed by children. The findings indicate that interventions should address the entire household water chain, including the protection of water sources, hygienic transportation, safe storage in covered containers, appropriate treatment, and prevention of contamination during serving. Microbiological testing would also provide stronger evidence than source classification alone.

Physical Quality of Drinking Water and Stunting Status

The proportion of stunting was higher among children from households whose drinking water did not meet the required physical quality standards than among those whose water met the standards (82.8% vs. 31.4%; $p < 0.001$). This finding indicates a significant association between the physical quality of household drinking water and stunting status.

Physical characteristics such as color, odor, taste, and turbidity may indicate problems related to water sources, storage conditions, suspended materials, or environmental contamination. Water with unacceptable physical characteristics may discourage consumption or indicate inadequate household water management. However, apparently clear, odorless, and tasteless water is not necessarily microbiologically safe. Therefore, the physical assessment of water should be regarded as an initial indicator rather than definitive evidence of the absence of pathogenic microorganisms. The association observed in this study may reflect broader household environmental conditions. Poor physical water quality may coexist with unprotected sources, inadequate storage, unsafe wastewater disposal, poor sanitation, and limited household resources. These interconnected factors may increase children's exposure to infections and indirectly interfere with their nutritional status and linear growth.

The present finding is supported by the recent systematic review and meta-analysis showing that improved drinking water quality was associated with lower odds of childhood stunting in low- and middle-income countries (10). However, the evidence for individual physical water parameters remains variable across studies. Differences in the definitions of acceptable water quality, assessment methods, geographical conditions, and microbiological contamination may explain the inconsistent results.

Future studies should combine household observations with objective water-quality examinations. Tests for Escherichia coli, total coliforms, turbidity, pH, total dissolved solids, and relevant chemical contaminants would provide a more comprehensive assessment. Such measurements could clarify whether the observed association is primarily related to microbiological contamination, the physical acceptability of water, or broader household sanitation conditions.

Drinking Water Treatment and Stunting Status

Although stunting was more common among children from households that did not treat their drinking water than among those that did (80.0% vs. 52.5%), the difference was not statistically significant ($p = 0.366$). Therefore, household drinking water treatment was not associated with stunting status in this study.

Several factors may explain this finding. First, only five households were categorized as not treating their drinking water. This small subgroup may have reduced the statistical power to detect an association. Second, categorizing water treatment as treated or untreated does not capture the type, frequency, and consistency of the treatment method. Boiling, filtration, chlorination, and the use of commercially supplied drinking water may differ in their effectiveness in removing pathogens. Third, water may be recontaminated after treatment through unsafe storage, uncovered containers, contaminated utensils, unwashed hands, or repeated contact with drinking vessels. Consequently, households that report treating water may still provide microbiologically unsafe water to children. Evidence indicates that point-of-use water treatment is most effective when accompanied by safe storage and appropriate hygiene practices (15).

The finding is consistent with a recent meta-analysis reporting no consistent pooled association between household water treatment and childhood stunting (10). Nevertheless, it differs from evidence showing that untreated drinking water, particularly when combined with unimproved sanitation, may increase the likelihood of stunting (8). These differences suggest that water treatment may not operate as an isolated determinant. Its effectiveness may depend on the original water quality, the treatment method, household compliance, safe storage, sanitation conditions, and exposure to pathogens from other sources.

Drinking water treatment should therefore remain part of public health education, despite the absence of a statistically significant association in this study. However, education should emphasize correct and consistent treatment methods, safe storage, and hygienic handling rather than merely advising households to treat water.

Healthy Latrine Ownership and Stunting Status

Healthy latrine ownership was significantly associated with stunting status ($p < 0.001$). All children living in households with a healthy latrine were classified as non-stunted, whereas 83.3% of children from households without a healthy latrine were stunted. This finding demonstrates a strong association between household sanitation and child growth in the study population. Adequate latrines help separate human feces from household members and the surrounding environment. In contrast, the absence of a healthy latrine may result in open defecation or unsafe disposal of feces, increasing the contamination of soil, water, food, hands, and household surfaces. Young children are particularly vulnerable because they frequently crawl, play on the ground, and place contaminated objects or hands in their mouths.

The fecal–oral transmission pathway can lead to recurrent diarrhea, intestinal parasitic infections, and environmental enteric dysfunction. Over time, these conditions may impair nutrient intake and absorption and contribute to growth failure (14, 16). A systematic review and meta-analysis found that improved sanitation was protective against diarrheal disease and was associated with better height-for-age outcomes, although the quality and magnitude of evidence varied across studies (16).

The present finding is consistent with research among Indonesian children under three years of age, which showed that improved household sanitation was associated with lower odds of stunting after controlling for child, maternal, and socioeconomic characteristics (17). Evidence from Ethiopia also showed that unimproved toilet facilities and open defecation were associated with higher odds of childhood stunting (19). These findings reinforce the importance of adequate sanitation in reducing children's exposure to fecal pathogens.

Nevertheless, latrine ownership does not necessarily mean that a latrine is consistently used, properly maintained, safely connected to a containment system, or accessible to all household members. The present study categorized latrine ownership as a household-level variable but did not appear to evaluate the frequency of use, cleanliness, functionality, fecal-sludge disposal, or sanitation coverage in the surrounding community. These conditions may influence the actual level of protection provided by a latrine. The complete absence of stunting in the healthy-latrine category also produced a zero cell in the contingency table. Given the small sample size, this very strong association should be interpreted cautiously. Larger studies using multivariable analysis are needed to determine whether latrine ownership remains independently associated with stunting after controlling for household income, parental education, child feeding, infection history, maternal nutrition, and other confounding factors.

Household Waste Management and Stunting Status

Household waste management was significantly associated with stunting status ($p < 0.001$). Stunting was found in 93.8% of children from households with poor waste management, compared with 15.6% of children from households with good waste management. This marked difference suggests that

inappropriate waste management may be an important indicator of an unhealthy household environment.

Improperly stored or openly discarded solid waste can attract flies, cockroaches, rodents, and other vectors. These vectors can transfer pathogens from waste and fecal materials to food, drinking water, utensils, and household surfaces. Unmanaged liquid waste may also create stagnant water, unpleasant odors, and breeding places for insects. These environmental conditions may increase children's exposure to gastrointestinal and other infectious diseases, indirectly affecting their nutritional status and growth.

The present finding is consistent with a national analysis of 9,688 Indonesian children under two years of age, which identified garbage removal and waste management as factors associated with stunting (21). Poor waste-management practices may also indicate broader household deprivation, including inadequate sanitation infrastructure, low socioeconomic status, overcrowding, and limited access to public waste-collection services. However, evidence concerning garbage disposal and stunting remains less consistent than evidence concerning drinking water quality and sanitation facilities. A recent meta-analysis found no consistent overall association between garbage disposal and childhood stunting across low- and middle-income countries (10). Differences in the definition of good waste management, waste types, collection systems, environmental conditions, and socioeconomic characteristics may account for the variation between studies.

The association found in the present study should therefore not be interpreted as evidence that household waste management directly causes stunting. Poor waste management may function as a proxy for several interrelated environmental and socioeconomic disadvantages. Further studies should separately assess solid-waste storage, frequency of collection, open dumping, waste burning, wastewater drainage, vector presence, and proximity of waste to children's play and food-preparation areas.

CONCLUSION

Environmental health conditions were significantly associated with stunting status among children under five in the working area of the Batang Beruh Public Health Center. Children from households using unprotected drinking water sources, drinking water that did not meet the required physical quality standards, unhealthy latrines, and poor waste management had a higher proportion of stunting. In contrast, household drinking water treatment was not significantly associated with stunting status. These findings highlight the importance of improving access to safe drinking water, healthy sanitation facilities, and appropriate household waste management as part of integrated stunting prevention strategies. However, because this study used a cross-sectional design and bivariate analysis, the findings should not be interpreted as causal. Further studies with larger representative samples and multivariable analyses are needed to identify the independent contribution of environmental health factors to childhood stunting

ACKNOWLEDGEMENT

The author gratefully acknowledges the Chairperson of the Sari Mutiara Foundation and the Rector of Universitas Sari Mutiara Indonesia for providing financial support for the publication of this study. The author also extends sincere appreciation to the management and staff of the Batang Beruh Public Health Center, Sidikalang, Dairi Regency, for granting permission and facilitating the conduct of the research.

AUTHOR'S CONTRIBUTION STATEMENT

: Conceptualization, Methodology, Data Collection, Investigation, Formal Analysis, Writing – Original

Draft, Writing – Review & Editing, Funding Acquisition. : Conceptualization, Methodology, Supervision, Validation, Corresponding Author, Manuscript Review & Editing.

CONFLICT OF INTEREST
None.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS
The Authors acknowledge the use of AI-Assisted Technologies to support language improvement, improve clarity, and improve the overall readability and structure of the manuscript.

FUNDING
This research received None external funding

DATA AVAILABILITY
The dataset generated and analyzed during the current study is available from the corresponding author upon request.

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