

ESCHERICHIA COLI CONTAMINATION IN HOUSEHOLD DRINKING WATER AND STUNTING IN CHILDREN UNDER FIVE : A CORRELATIONAL STUDY IN PADANG PANJANG

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ABSTRACT

Background: Stunting is a significant nutritional issue currently faced by many toddlers. The source, quality, and management of water consumed by children can be factors that influence stunting. **Objective:** This study aims to analyze the relationship between the source, physical quality, bacteriological quality, management behavior, and Escherichia coli contamination in household drinking water with stunting in children under 5 years old. **Methods:** This research uses a quantitative design with a cross-sectional approach. The sample consists of 69 households with toddlers, selected using proportional random sampling technique. Data were analyzed bivariately using the chi-square test. **Results:** There are three independent variables that have a significant correlation with the dependent variable, namely the bacteriological quality of household drinking water, household drinking water management behavior, and Escherichia coli contamination in household drinking water. Escherichia coli contamination is the most dominant factor (OR 86.667, CI: 9.389-800.005). **Conclusion:** This study concludes that there is a significant correlation between Escherichia coli contamination in drinking water and stunting in toddlers. It is hoped that through this research, the public can understand and apply the principles of handling and managing safe drinking water at the household level.

Keywords: *Bacteriological, Drinking Water Source, Physical Quality, Stunting*

BACKGROUND

In Asian cultures, including Indonesia, women are often seen as responsible for the household and child-rearing. In low-income families, mothers frequently work to support the family economy (Supadmi et al., 2024). Stunting in children is a major challenge for human development, affecting around 162 million toddlers globally. This condition, which is generally permanent, is caused by malnutrition and recurrent infections during

the first 1000 days of life (World Health Organization, 2023). Stunting is caused by malnutrition, recurrent infections such as diarrhea and worm infestations, as well as environmental factors like poor sanitation, poverty, low maternal education, and limited access to healthcare services (Kementerian PPN/Bappenas, 2018). Stunting is influenced by the complex interaction of specific and sensitive factors, especially during the first 1000 days of life. Its management includes specific

nutritional interventions for direct causes and sensitive nutrition interventions such as providing clean water and access to food. With an estimated 127 million affected toddlers by 2025, additional efforts are needed to meet the World Health Assembly's target of reducing this number to 100 million (UNICEF and the Ministry of Health of the Republic of Indonesia, 2023). Toddlers suffering from stunting due to iodine and iron deficiencies are at risk of permanent brain damage that hinders optimal development (WHO, 2018). The government targets reducing stunting prevalence to 14% by 2024, in line with the RPJMN 2020-2024. The Vice President of the Republic of Indonesia, as the Head of the TP2S, directs policies, makes recommendations, and addresses obstacles in accelerating stunting reduction through a cross-sectoral approach at both central and regional levels. <https://stunting.go.id/>. Various studies have investigated the factors causing stunting. One study showed that environmental factors were not significant; however, boiled water was a risk factor, while exclusive breastfeeding had a protective effect against stunting in toddlers (Nurjazuli et al., 2023). Another study in Zambia.

Evaluating the impact of growth charts and nutritional supplements on child growth using a tiered log-binomial method to analyze stunting predictors (Locks et al., 2024). Additionally, chronic infections such as malaria, anemia, and poor water quality have been identified as indirect causes of stunting (Gaston et al., 2024). Research shows that deworming programs, along with socioeconomic and ecological factors, influence child growth and stunting risk (Adrizain et al., 2024). A study indicates that children in urban areas with working mothers are 1.116 times more likely to experience stunting compared to children in rural areas (95% CI, 1.107–1.124). Furthermore, children under two years old who do not receive breast milk from working mothers are 1.020 times more likely to experience stunting (95% CI, 1.012–1.027), which is a direct contributing factor (Supadmi et al., 2024). Other stunting risk factors include low maternal education (p-

value = 0.017), paternal education (p-value = 0.003), and household income (p-value = 0.005) (Oginawati et al., 2023; Agyen et al., 2024).

Efforts to improve the health status of stunted children include routine deworming and the provision of high-protein animal-based foods (Hermawan et al., 2023). Stunting is positively correlated with poverty, lack of exclusive breastfeeding, low birth weight, and inadequate healthcare services. Conversely, high school education, access to proper sanitation, calorie intake, and protein consumption are negatively correlated with stunting prevalence (Rahardiantoro et al., 2024). Stunting in children is also strongly linked to maternal anemia, especially in developing countries. Preventing anemia in adolescent girls and women before and during pregnancy is an important step in addressing stunting (Nadhiroh et al., 2023). Additionally, body mass index (BMI) during antenatal care (ANC), availability of medical services, and delivery in healthcare facilities have been shown to significantly reduce the risk of stunting (Chowdhury et al., 2023). Factors such as maternal age, the severity of stunting, breastfeeding duration, and maternal anemia are key predictors affecting children's hemoglobin concentrations in stunting. Nutritional interventions focusing on these factors are strategic approaches to improving child health (Htay et al., 2023).

Additionally, the provision of specific supplementary foods combined with social behavior change communication during the first 1000 days of life has proven effective in reducing the prevalence of stunting and low birth weight, while also improving infant and child feeding practices (Soofi et al., 2024). The relationship between various risk factors and stunting occurrence shows that immunization history (p = 0.036; OR 0.189; 95% CI, 0.036–0.996), exclusive breastfeeding (p = 0.002; OR 0.082; 95% CI, 0.015–0.448), infectious diseases (p = 0.005; OR 9.375; 95% CI, 1.748–50.286), and low birth weight history (p = 0.037; OR 5.294; 95% CI, 1.004–27.927) are significantly associated with stunting, contributing a total of 56.9% to the occurrence of stunting (Miranti et al., 2020). Addressing stunting in Indonesia requires holistic regulation and involvement from various sectors. A targeted strategic approach, such as communication for behavior change, is

considered effective in tackling stunting (Marni et al., 2021). Furthermore, access to clean water plays a critical role in preventing stunting and supporting toddler growth (Nisa et al., 2021). Cross-sectoral efforts involving policymakers are essential to address these factors comprehensively and effectively. This approach allows for collaboration between various sectors such as health, education, and social welfare, creating integrated policies that support holistic and sustainable stunting prevention (Jokhu & Syauqy, 2024). Most families in Indonesia still face limitations in accessing safe drinking water. According to data from the Indonesian Central Statistics Agency in 2022, only 11.8% of households have adequate facilities to safely process drinking water (Kementerian Kesehatan RI, 2023). Additionally, only 15% of healthcare institutions still use inadequate drinking water sources or surface water (UNICEF, 2023). Although most healthcare institutions have sufficient water supply, other contributing factors to stunting include water contamination by bacteria, open defecation practices, and inadequate sanitation facilities (Waller et al., 2020). This is consistent with a study by Girma et al. (2021), which shows a significant relationship between the use of surface water as a drinking water source and stunting occurrence.

The Indonesian government has made efforts to prevent stunting through various specific and sensitive interventions, including improvements in diet, caregiving practices, sanitation, and access to clean water. However, stunting is often influenced by non-health factors such as economic, political, social, and cultural conditions, poverty, low female empowerment, as well as environmental damage and water sanitation. This study aims to analyze the relationship between *Escherichia coli* contamination in household drinking water and stunting occurrence in mothers with children under

five, using a correlation study approach that has not been previously conducted.

Materials and Methods

Study Design

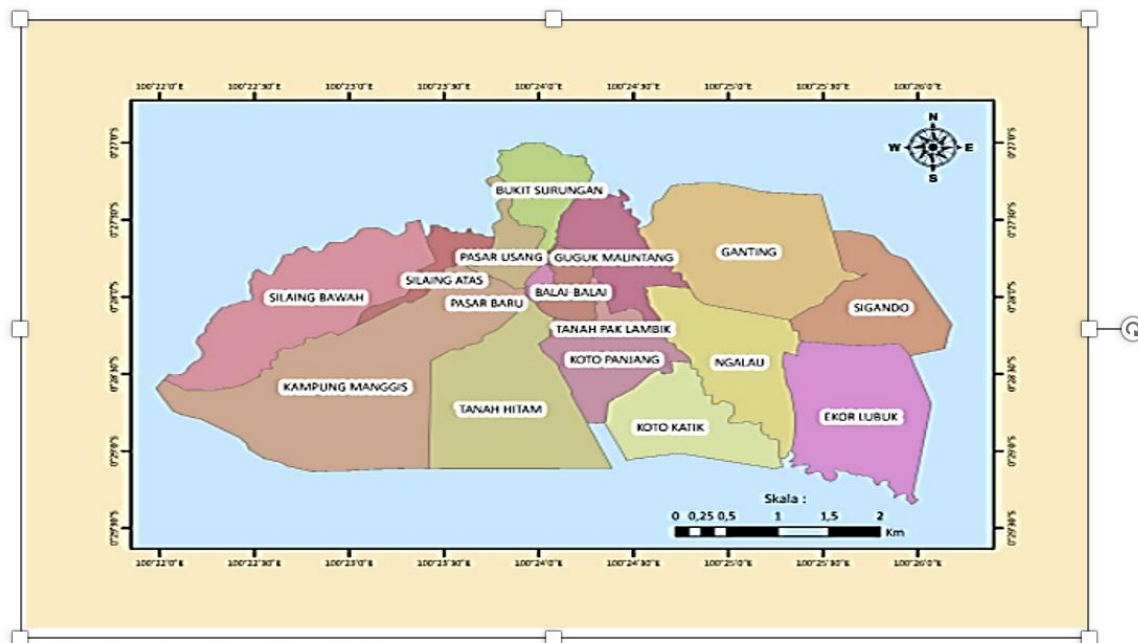
This study was conducted from March 2 to September 24, 2020. The research type used was an analytic survey with quantitative analysis using a cross-sectional research design, allowing observation and data collection to examine the relationship between risk factors and their impacts simultaneously (Notoatmodjo, 2018). This design was chosen because all variables in the study were measured at the same time.

Population and Sample

The population in this study consists of all families with toddlers in Padang Panjang City, Indonesia, totaling 3,691 families. The sampling was conducted using proportional random sampling. The samples selected had to meet the predetermined inclusion and exclusion criteria. The sample consisted of 62 families with toddlers. To reduce the risk of obtaining poor data, the number of respondents in each group was increased by 10%, bringing the total number of respondents in each group to 69.

Geographically, this area is located at coordinates 100° 20' - 100° 27' East Longitude and 0° 27' - 0° 32' South Latitude. This area is a plateau (mountainous) with an elevation ranging from 550 to 900 meters above sea level. More than 40% of its land has a slope of more than 40%. Because it is located between three mountains, namely Mount Merapi, Mount Singgalang, and Mount Tandikat, this area has a cool climate. In 2021, the air temperature in this area ranged from 18°C to 28°C with an average of 22.4°C, while the humidity was recorded at 88.03% (Health Service Profile, 2021).

Map of Padang Panjang City Area



Health Service Profile 2021

Instruments

Data collection was conducted using questionnaires and direct interviews with mothers who had toddlers during baby weight measurements at the community health centers in Padang Panjang City. The questionnaire used was the 2020 Household Drinking Water Quality Assessment Questionnaire (SKAMRT) from the Ministry of Health of the Republic of Indonesia and a questionnaire from the Environmental Health Risk Assessment (EHRA). The reliability and validity tests of the data were conducted using SPSS 23 software. Based on the reliability and validity tests with a significance level of 0.05, df 13, and a table r value of 0.514, all the calculated r values for all items were greater than the table r value. It can be concluded that all items are valid. The Cronbach's alpha test yielded a value of 0.971, which means the calculated value is greater than 0.6, and it can be concluded that the data is reliable.

Testing Method:

The **Compact Dry EC (CD EC) method** is a microbiological technique

used to detect and count the presence of *Escherichia coli* (*E. coli*) and total coliforms in various types of samples, including drinking water. This method uses ready-to-use media (compact dry) that contains nutrients and color indicators to simplify the identification of target microorganisms. The testing procedure includes:

1. Preparing tools and materials, such as CD EC, a sterile 1 mL pipette, sterile sample bottles, a portable incubator (37°C), a colony counter, gloves, and sample ID labels.
2. Collecting water samples using sterile bottles after conducting interviews, filling out questionnaires, and performing a physical examination of the water (color, odor, and taste).
3. Placing 1 mL of the sample into the center of the CD EC media circle using a sterile pipette.
4. Closing the CD EC, inverting it, and incubating it at 35±2°C for 18–24 hours.
5. Observing, recording, and counting the colonies of bacteria that grow. Red or pink indicates coliform, while blue indicates *E. coli*. Total coliforms are



counted by adding together the red and blue colonies.

This study aims to evaluate the presence of *E. coli* and total coliforms in drinking water from households with toddlers using a standardized method.

Data Processing

Data processing was carried out after all data was collected. The processing process included several steps, as follows:

1. Data editing to check for completeness, clarity, and consistency of responses in the questionnaires.
2. Data coding by converting data into numbers, such as for the stunting variable, where the number 1 was used for stunting and the number 2 for non-stunting. Similar coding was applied to other factors such as water sources, physical quality, bacteriological quality, management behavior, and *E. coli* contamination in drinking water, to facilitate analysis and expedite data entry.
3. Children's weight measurement was performed using the Microtoa tool for toddlers aged 24-59 months, and Dacin for toddlers aged 0-23 months. Children were categorized as stunted if their Z-score was < -2 SD, and non-stunted if their Z-score was > -2 SD.
4. Characteristics of good drinking water include features such as being colorless, tasteless, odorless, clean, and with a temperature lower than the ambient temperature. If any of these conditions are not met, the water is likely unhealthy.
5. The bacteriological quality parameters of drinking water were measured based on the total number of coliform bacteria (*E. coli* and coliform) per 1 mL of sample. Healthy drinking water has a total coliform count of 0.
6. *E. coli* contamination parameters are based on the presence of *E. coli* bacteria in drinking water. If the water contains *E. coli*, it is categorized as "contaminated."

7. Drinking water management is the process of separating water from physical, chemical, and biological contaminants. The goal is to obtain clean, healthy water that meets quality standards, so it can be used as drinking water.

Data Collection

Padang Panjang City was chosen as the research location because it has been designated as one of the priority areas in the national action plan for the accelerated reduction of stunting cases in Indonesia, which is ongoing from 2021 to 2024. This is being carried out through various priority activities designed by the central government to prevent and address stunting cases in the region. The local government of Padang Panjang City has designated eight districts as areas for integrated stunting prevention and management, in accordance with the Mayor's Decree Number 113 of 2022. At the Padang Panjang City Health Office, specific intervention policies have been formulated to address the determinants of stunting, one of which is the bacteriological testing of drinking water at households and the observation of water use and management behaviors. However, the Health Office has not conducted investigations into the quality of drinking water in households with toddlers due to limited funding for this program.

Data Analysis

Bivariate analysis using the chi-square test was conducted to identify whether there is a significant relationship between one dependent variable and one independent variable. In this study, this analysis was used to test the relationship between certain factors and the incidence of stunting in toddlers. The analysis was performed using SPSS software, which allows for accurate data processing and provides results that support the interpretation of relationships between variables.

Results

Drinking Water Characteristics

Table 1. Distribution of Drinking Water in Families with Toddlers

Variable	Number (families)	Percentage (%)
Source of Drinking Water		
Water from water depots	42	60.9
Boiled water	27	39.1
Physical Quality		
Does not meet the standards	3	4.3
Meets the standards	66	95.7
Bacteriological Quality		
Does not meet the standards	46	66.7
Meets the standards	23	33.3
Management Behavior		
Non-hygienic	33	47.8
Hygienic	36	52.2
E. Coli Contamination		
Contaminated	11	15.9
Not contaminated	58	84.1
Total	69	100

Table 1 shows that of the 69 families studied: Approximately 60.9% of families rely on water depots for their drinking water needs. Around 4.3% of families use drinking water that does not meet the physical quality standards.

About 66.7% of families consume water that is contaminated with bacteria.

Based on management behavior and E. coli contamination parameters, 47.8% of the drinking water used is non-hygienic, and 15.9% of the drinking water is contaminated with E. coli bacteria.

Correlation Between Parameters and Stunting Cases

Table 2. Correlation Between Parameters and Stunting Cases

Variable	Stunting Cases				Total		p-value	OR
	YES		NO		N	%		
	n	%	n	%				
Drinking Water Source								
Depot water	10	23.8	32	76.2	42	100	1.000	1.09
Boiled water	6	22.2	21	77.8	27	100		
Physical Quality								
Does not meet the standards	2	66.7	1	33.3	3	100	0.132	7.43
Meets the standards	14	21.2	52	78.8	66	100		
Bacteriological Quality								



Does not meet the standards	16	34.8	30	62.2	46	100		
Meets the standards	angka 0	angka 0	23	100	23	100	0,003	0,65
Management Behavior								
Non-hygienic	13	39.4	20	60.9	33	100		
Hygienic	3	8.3	33	91.7	36	100	0,006	7.15
E. Coli Contamination								
Contaminated	10	90.9	1	9.1	11	100		
Not contaminated	6	10,3	52	89.7	58	100	0.000	86.67

Based on Table 2, the analysis shows that: The bacteriological quality of drinking water, water management behavior, and E. coli contamination have a significant relationship with the occurrence of stunting ($p\text{-value} \leq 0.05$). The source of drinking water and the physical quality of water do not have a significant correlation with the occurrence of stunting ($p\text{-value} > 0.05$). The bacteriological quality of drinking water has an Odds Ratio (OR) of 0.65, which indicates that drinking water with bacteriological quality that does not meet health standards has a 0.652 times greater chance of causing stunting in children compared to drinking water with good quality. Water management behavior has an Odds Ratio (OR) of 7.150, meaning that unhygienic water management behavior has a 7.150 times greater chance of causing stunting in children compared to hygienic water management behavior. Drinking water contaminated with E. coli has an Odds Ratio (OR) of 86.667, meaning that drinking water contaminated with E. coli has an 86.667 times greater chance of stunting a child's growth compared to non-contaminated drinking water.

Discussion

Bacteriological Quality

In this study, the bacteriological quality of drinking water had a significant relationship with stunting ($p\text{-value} 0.003$). Water with good bacteriological quality reduced the likelihood of stunting by 0.65 times compared to water with poor quality. Bacteriological examination of drinking water is essential as a preventive measure

and early detection of waterborne diseases. The use of contaminated water can interfere with nutrient absorption, cause low body weight, and increase the risk of infections such as worm infestations and diarrhea in toddlers, all of which contribute to stunting (Kementerian Kesehatan RI, 2018). In line with this study, previous research has also reported that the bacteriological and physical aspects of water are indirect factors that can cause stunting (Nisa et al., 2021). Previous studies have shown a bacteriological correlation between stunting and factors like total coliform, water temperature, and pH (Kamila & Salami, 2022). Other studies have highlighted a strong connection between stunting and wasting among children in Cambodia who live in areas with poor water quality, inadequate sanitation, and unhygienic environments (Manzoni et al., 2019). Acute diseases can contribute to the link between wasting and stunting by increasing the frequency of prolonged illnesses, ultimately raising the risk of stunting (Hondru et al., 2019).

Water Management Behavior

In this study, water management behavior significantly affects the incidence of stunting ($p\text{-value} 0.006$). The risk of stunting is 7.15 times higher in cases where the water management behavior is unhygienic compared to those with hygienic practices. Poor water management behavior can lead to water contamination, which in turn can disrupt the digestive system, causing conditions like diarrhea.

Although diarrhea is not a direct cause of stunting, it interferes with the absorption of food in the body, hindering the fulfillment of nutritional needs and thereby affecting a child's growth and development (Budge et al., 2019). The lack of hygiene in daily water handling can cause infections like diarrhea and intestinal worms, disrupting nutrient absorption, which leads to weight loss in toddlers. Chronic infections can trigger stunting in young children (Nisa et al., 2021). The prevalence of stunting in 2-year-old children in Mamuju Regency is influenced by drinking water sources, water treatment, and waste management (Khairunnisa Wahid et al., 2020). High stunting rates are also influenced by maternal behaviors, such as not regularly washing hands with soap, as well as insufficient antenatal care for children aged 12-47 months and frequent fever. Therefore, it is important to encourage and support handwashing practices as part of water management, which should be complemented with proper handwashing techniques (Yuliani Soeracmad, 2019). Previous research has shown that regular handwashing is an effective way to prevent stunting (Sema and Azage, 2002). (According to Irawan & Hastuty, 2022), improper handwashing practices can lead to contamination of food and water.

One indirect factor causing stunting is water, sanitation, and hygiene (WASH), which includes drinking water sources, its physical quality, sanitation facilities, and handwashing habits (Irawan & Hastuty, 2022). A comprehensive and systematic WASH approach is needed to have a significant impact on child health and prevent growth disruptions (Wilson-Jones et al., 2019). On the other hand, a study in India found that WASH interventions did not reduce stunting but significantly reduced the incidence of diarrhea (Humphrey et al., 2019). Poor WASH standards can hinder nutrient absorption in the intestines, ultimately leading to stunting (Mbuya & Humphrey, 2016). Previous studies have shown that 36.5% of children

under five lack access to adequate sanitation, and 12.4% report poor environmental quality (Jubayer et al., 2022). This study confirms that stunting rates are highly influenced by sanitation and drinking water quality (Bulan Nasution et al., 2022). Household sanitation and water treatment that do not meet requirements are strong predictors of stunting in children aged 0-23 months (Torlesse et al., 2016). Household water access indirectly affects stunting through the quality of food consumed. The frequency of stunting is related to how food, drinks, and waste are handled (Royyan et al., 2022). Previous research has reported that household drinking water quality significantly correlates with stunting due to gastrointestinal infections that disrupt food absorption, leading to growth and developmental delays (Lauer et al., 2018). The phenomenon shows that the risk of stunting increases drastically when access to water is inadequate (Choudhary et al., 2021). In line with this, earlier studies have shown that water management behavior is closely related to the prevalence of stunting (Kwami et al., 2019). Water management behavior is linked to the provision of clean water, including attention to water reservoirs and the transmission system. Non-compliant transmission systems can degrade water and air quality, thereby contributing to higher stunting cases (Chen et al., 2021). These findings are consistent with previous research, which indicates that stunting in young children can occur indirectly due to factors such as limited access to clean water and poor waste management (Inamah, Ahmad, Sammeng, & Rasako, 2021). This study lays the groundwork for academic research on the relationship between stunting and water hygiene. The demand for such research is increasing. Stunting status, maternal inflammation exposure in the past, and household WASH conditions affect antibacterial immune function in 18-month-old children in low-income environments. Children exposed to WASH interventions



(n = 33) showed higher LPS levels (GMD (95% CI): 10.48 pg/mL (1.84, 60.31), p = 0.008) and higher MPO-specific HKST levels (5.10 pg/mL (1.77, 14.88), p = 0.003) compared to children who did not receive WASH interventions (Mutasa et al., 2022). Poor WASH conditions, particularly those related to drinking water standards at home, need to be considered when designing initiatives to improve nutrition (Lauer et al., 2018).

Escherichia Coli Contamination

In this study, *E. coli* contamination showed a significant correlation with stunting (p-value 0.000). Water contaminated with *E. coli* poses a significantly higher risk of stunting, with an 86.67-fold increase compared to uncontaminated water. *E. coli* is a normal microbe found in the human gut. (Soetoko & Suprijono, 2021). Certain bacteria, such as coliform, fecal coliform, and *E. coli*, are used as indicators of bacterial contamination in drinking water. Although these bacteria aid in human digestion, the presence of *E. coli* and high concentrations of coliform and fecal coliform exceeding safe limits (23×10^3 - 11×10^4 MPN/100 mL) can endanger health. (Zainun & Simbolon, 2012). However, an increase in these microbes beyond a certain threshold can cause gastrointestinal disorders, such as diarrhea. (Soetoko & Suprijono, 2021). (Sudarman et al., 2021) Previous research reported that high levels of *E. coli* and coliform in water could reduce dissolved oxygen and trigger diarrhea and digestive problems. Ihsan et al. also found that water contaminated with *E. coli* and poor hygiene can indirectly contribute to stunting through diarrhea. (Ihsan et al., 2012). Stunting can occur due to exposure to contaminated environments, increasing the risk of fecal-oral transmission and leading to

environmental enteropathy, a condition of subclinical inflammation. In low- and middle-income countries, young children are often exposed to fecal pathogens due to unhygienic environments and hand-to-mouth habits. (Fregonese et al., 2017). According to Cameron et al., exposing children to open defecation in their environment can lead to height loss and cognitive decline over time (Cameron et al., 2021). Child growth and development can also be disrupted by unhygienic, poor-quality, and inappropriate sanitation facilities (Cameron et al., 2021). Child growth and development can also be disrupted by unhygienic, poor-quality, and inappropriate sanitation facilities (Cameron et al., 2021).

Research in Ethiopia found that handwashing, access to clean drinking water, and proper latrine hygiene are key factors contributing to stunting in the country. (Kwami et al., 2019) Stunting is more likely to occur in children under two years of age who live in unhealthy conditions and are frequently exposed to open defecation. The prevalence of stunting also increases due to poor household sanitation, as found in a study in Jember, Indonesia. (Ainy et al., 2021). According to a previous study by Trisnani et al. (2018), *E. coli* in water can originate from human or warm-blooded animal feces. A prior study investigated the relationship between stunting and nitrate concentrations in drinking water across South America, finding that high nitrate levels can worsen malnutrition in children. (Coffman et al., 2021). Research showed that nitrate concentration could affect weight loss and low birth length in children (Coffman et al., 2021). Another study found that household drinking water quality was significantly associated with stunting; if drinking water



is contaminated, the risk of stunting increases up to ninefold (Joseph et al., 2019).

Conclusion

This study demonstrates that the bacteriological quality of water, water management, and *E. coli* contamination are significantly associated with stunting. Efforts to improve drinking water management and prevent contamination are crucial to preventing stunting. Recommendations from this study include: Strengthening bacteriological quality control to ensure water is free of harmful microorganisms. Providing sufficient access to clean water sources to reduce contamination risk. Enhancing monitoring of household drinking water providers to ensure safe water distribution. Raising public awareness of infection symptoms, such as vomiting and diarrhea caused by contaminated water, and encouraging proper water management practices. Encouraging water providers to routinely inspect water sources to ensure cleanliness. Implementing these recommendations could serve as a long-term strategy to reduce stunting rates.

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