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# THE IMPACT OF SANITATION ON INCREASING THE RISK OF STUNTING IN CHILDREN UNDER FIVE: A META-ANALYSIS

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**ABSTRACT**
Stunting among children remains a global public health issue, with as many as 149 milion children under the age of five affected worldwide. One of the contributing factors to stunting is poor sanitation. This research aims to estimate the extent to which poor sanitation contributes to the risk of stunting in children under five years old using a meta- analysis approach. study employed a systematic review and meta-analysis using the PICO framework (Population, Intervention, Controls/Comparisons, Outcome), defined as follows: Population: children under five years old; Intervention: poor sanitation; Comparison: good sanitation; Outcome: stunting. Articles were collected using PRISMA flow diagrams. A total of nine articles that met the quality standards were then included in the quantitative synthesis using meta-analysis. Articles were analysed using the Review Manager 5.3 application. The findings of this meta-analysis indicate a significant association between sanitation conditions and the risk of stunting in children under five. Children who live in environments with poor sanitation are 3.71 times more likely to experience stunting than those living in areas with good sanitation. Poor sanitation constitutes a major risk factor for stunting, which significantly impacts children's growth and development. Enhancing access to improved sanitation facilities and promoting good hygiene practices are priorities to prevent stunting, particularly in areas with high prevalence. These findings offer strong evidence to support the policymakers and other stakeholders in integrating sanitation- based interventions into public health programs to reduce the prevalance of stunting among children under five years of age.

Keywords: children under five; poor sanitation; stunting

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## INTRODUCTION

Nutrition serves as the cornerstone of a child's survival and development. Children who receive adequate nutrition will have better growth, development, learning capacity, play behaviour, resilience, and participation in their environments than those who are malnourished. However, many children still do not receive sufficient nutrition to support optimal development, particularly those from low-income families and those under five years old. Globally, one in three children under the age of five suffers from some form of malnutrition, including stunting. Approximately 144 million children under five are reported to have height that is not appropriate for their age and low cognitive abilities (UNICEF, 2021). Malnutrition is defined as a deficiency in nutrient intake which is major contributor to delayed growth and development. Children who do not receive enough nutrition, especially within the first 1,000 days of life, are more likely to experience stunted growth (Bundy et al., 2018). Malnutrition remains a critical global public health issue, particularly in low and middle-income countries (Rachmi et al., 2016).

The global agenda outlined in the Sustainable Development Goals (SDGs) includes a collective target to reduce the prevalence of stunting by the year of 2030 (United Nations, 2015). Stunting is defined as malnutrition in children (Onis dan Branca, 2016; Delima et al.,

2023; Mustakim et al., 2022). It is a form of chronic malnutrition that is not only characterized by the child's height, but also a major factor affecting the children's physical and cognitive development (Kustanto et al., 2025). Stunting in children remains a global public health concern (Vaivada et al. 2020). An estimated 149 million children under the age of five worldwide suffer stunting (WHO, 2021; WHO, 2022). Stunting is a growth and developmental disorder in children due to chronic malnutrition and recurrent infections, characterized by children's length and height below the age-appropriate standard (WHO, 2020). Children who suffer stunting are at risk of decreased intellectual capacity and a higher likelihood of developing the degenerative disease later in life. Stunting continues to be one of the common health problems among children under five worldwide (Sema et al, 2021). Poor water and sanitation have been identified as contributing factors to stunting (Danaei et al., 2016).

Environmental factors can indirectly affect stunting. Environmental health refers to optimal environmental conditions that contribute positively to achieving optimal health status. The scope of environmental health includes disposal of human waste (faeces), access to clean water, garbage disposal, wastewater disposal, and hygiene behaviour. Poor environmental conditions and inadequate hygiene practices can cause infectious diseases such as diarrhoea and respiratory tract infections, which can contribute to the prevalence of stunting (Apriluana and Fikawati, 2018).Various factors, particularly environmental conditions, influence stunting or disorders in children's growth and development. Sanitation, as a key component of a clean, healthy, and comfortable environment, has been shown to correlate with children's growth and development. Improved sanitation is positively associated with healthy growth patterns, while poor sanitation increases stunting risk (Torlesse et al, 2016).Based on the description, the researcher is interested in conducting research using a systematic review of the meta-analysis approach to investigate relevant studies to examine the impact of sanitation on the risk of stunting among children under five. This study aims to examine the impact of sanitation on the risk of stunting among children under five.

## METHOD

### Study Design

This study was conducted with a systematic review and meta-analysis based on secondary data from previous research results. A systematic review is a method used to synthesize primary research data by utilizing reported data through a systematic search process that explicitly integrates the data included in the review. Meta-analysis involves statistical combination of data from multiple studies addressing the same hypothesis to obtain quantitative summary results. The research data was obtained from three databases: Google Scholar, PubMed, and ScienceDirect. The search used keywords such as "unimproved sanitation" or "poor sanitation" and "Stunting in children" or "child growth". In addition to determining keywords, article eligibility was determined using the PICO framework (Population, Intervention, Controls/Comparisons, Outcome), defined as follows: Population: children under five Intervention: poor sanitation; Comparison: good sanitation; Outcome: stunting.

### Inclusion Criteria

The inclusion criteria in this study were as follows: full-text articles using a cross-sectional study design; the research subjects limited to the children under five; stunting as the primary outcome; and the use of multivariate analysis with adjusted odds ratio (aOR) to measure the estimated effect.

**Exclusion Criteria**

The exclusion criteria for this study were articles published in languages other than English, studies reporting statistical results solely using bivariate analysis, and articles published before 2014.

**Operational Definition of Variables**

Poor sanitation is an environmental factor that can negatively impact physical development, health and overall human well-being.Stunting is a condition of growth failure in children that causes them to be shorter than normal children of the same age.

**Data Analysis**

Data processing in this study involved identifying articles retrieved from several databases, followed by a screening process to obtain those that met the inclusion criteria. Articles that passed this stage were then analysed using revman 5.3 software.

**RESULT**

This study used three primary databases: Google Scholar, PubMed, and ScienceDirect, using keywords such as "unimproved sanitation" or "poor sanitation" and "Stunting in children" or "child growth". The article selection process is illustrated in the PRISMA flow diagram in Figure 1. Research examining on the impact of sanitation on increasing the risk of stunting in children under five involved nine articles, obtained from the initial search that yielded a total of 1,040 articles. After the process of removing duplicate publications, 150 articles remained. Of these, 100 articles met the eligibility criteria for further evaluation. Ultimately, nine articles (as shown in Figure 2 originating from the African and Asian continents) that met the quality standards were included in the quantitative synthesis using meta-analysis.

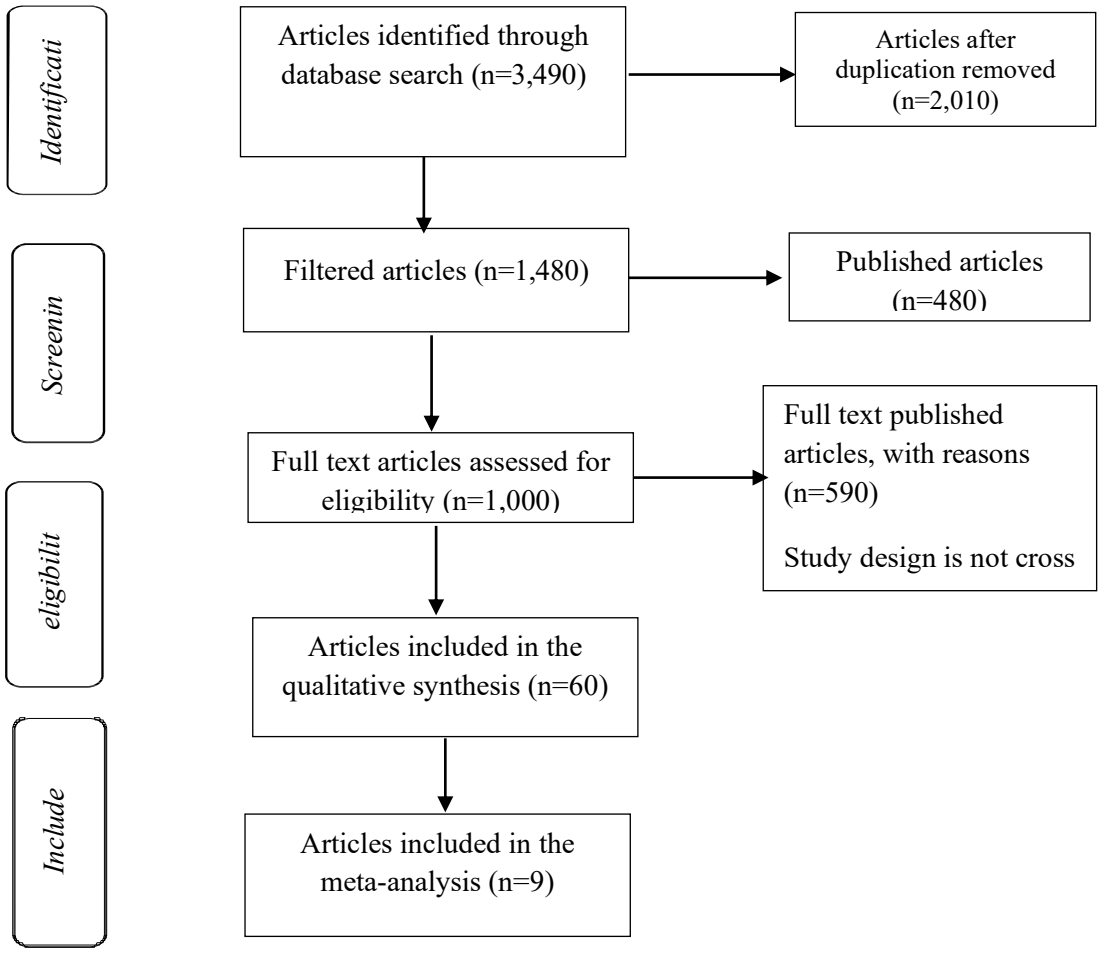


Figure 1. PRISMA Flow Diagram


Figure 2. Map of Research Areas on the Impact of Sanitation on Increasing the Risk on Stunting in Children Under Five: Meta-Analysis

The quality assessment of this study was based on seven question items related to the eligibility articles for the meta-analysis. The checklist items were as follows:

1. Formulation of research questions using the PICO framework.
   a. Was the population in the primary study aligned with the population defined in the PICO meta-analysis?
   b. Was the operational definition of exposure/intervention in the primary study consistent with the definition intended in the meta-analysis?
   c. Does the comparison used in the primary study match the comparison planned in the meta-analysis?
   d. Are the outcome variables studied in the primary study consistent with those planned in the meta-analysis?
2. Methods for selecting research subjects.
   a. For descriptive cross-sectional study (prevalence): was the sample selected randomly?
   b. For analytical cross-sectional study: was the sample selected randomly or purposively?
3. Methods for measuring the comparator (intervention) and outcome variables.
   a. Were the exposure/intervention and outcome variables measured using a consistent instrument (measuring tool) across all primary studies?
   b. If the variables were measured on a categorical scale, were the cutoff points or classification categories used the same across primary studies?
4. Design-related bias
   a. What was the response rate?
   b. Was non-response related to the outcome measured?
5. Methods for controlling confounding.
   a. Was there any confounding in the results/conclusions of the primary study?
   b. Did the primary study researchers use appropriate methods to control for confounding?

6. Statistical analysis methods.
   a. In cross-sectional studies, were multivariate analyses conducted? Multivariate analyses include multiple linear regression, multiple logistic regression, cox regression.
   b. Did the primary study report effect sizes or relationships based on multivariate analyses? (e.g., adjusted or, adjusted regression coefficient).
7. Conflict of interest.
   Were there any conflicts of interest with the sponsor of the study?

Table 1.
Quality Assessment Results of Case Control Study on the Impact of Sanitation in Increasing the Risk of Stunting in Children Under Five

| Authors (years) | Question Criteria | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Guja et.al (2024) | 7 | 4 | 4 | 1 | 3 | 4 | 2 | 25 |
| Torlesse et.al (2016) | 8 | 4 | 4 | 4 | 3 | 4 | 2 | 29 |
| Mulyaningsih et.al (2021) | 6 | 4 | 4 | 4 | 3 | 4 | 2 | 27 |
| Soofi et.al (2023) | 6 | 4 | 4 | 4 | 3 | 4 | 2 | 27 |
| Soe et.al (2023) | 8 | 4 | 4 | 3 | 4 | 4 | 2 | 29 |
| Gaffan et.al (2023) | 8 | 4 | 4 | 2 | 4 | 4 | 2 | 28 |
| Das et.al (2022) | 8 | 2 | 3 | 2 | 3 | 4 | 2 | 24 |
| Ademas et.al (2021) | 8 | 4 | 4 | 2 | 3 | 4 | 2 | 27 |
| Hansakali & mwange (2024) | 8 | 4 | 4 | 3 | 4 | 4 | 2 | 29 |

Description of answer score:
1. Assign a score “0”, if conflict interest is present.
2. Assign a score “2”, if no conflict interest is identified.
3. Assign a score “3”, if conflict interest is uncertain.

Following the quality assessment process, nine cross-sectional studies were identified as eligible as sources of meta-analysis. These studies aimed to evaluate the effect of sanitation on increasing the risk of stunting in children under five. The articles were then extracted and summarized according to PICO framework of the study.

Table 2.
Primary Study Description on the Impact of Sanitation in Increasing the Risk of Stunting in Children Under Five

| Authors (years) | Countries | Sample | P | I | C | O |
|---|---|---|---|---|---|---|
| Guja et.al (2024) | Ethiopia | 660 | Children aged 6-23 months | Poor Sanitation | Good Sanitation | Stunting |
| Torlesse et.al (2016) | Indonesia | 1.366 | Children | Poor Sanitation | Good Sanitation | Stunting |
| Mulyaningsih et.al (2021) | Indonesia | 8.045 | Children | Poor Sanitation | Good Sanitation | Stunting |
| Soofi et.al (2023) | Pakistan | 52.602 | Children | Poor Sanitation | Good Sanitation | Stunting |
| Soe et.al (2023) | Myanmar | 327 | Children aged <5 years old | Poor Sanitation | Good Sanitation | Stunting |
| Gaffan et.al (2023) | Benin/ afrika barat | 11.253 | Children aged <5 years old | Poor Sanitation | Good Sanitation | Stunting |
| Das et.al (2022) | India | 186.875 | Children aged <5 years old | Poor Sanitation | Good Sanitation | Stunting |
| Ademas et.al (2021) | Ethiopia | 630 | Children aged <5 years old | Poor Sanitation | Good Sanitation | Stunting |
| Hansakali & mwange (2024) | Zambia | 232 | Children aged 6-23 months | Poor Sanitation | Good Sanitation | Stunting |

As presented in Figure 3, the forest plot shows the effect of sanitation on increasing the risk of stunting in children under five. This meta-analysis combines data from several studies (such as Ademas et al, Soe et al, Guja et al, and others), resulting in a combined odds ratio (OR) of 3.71 with a 95% confidence interval (CI: 3.22–4.27). It indicates that children living in environments with poor sanitation are 3.71 times more likely to experience stunting compared to children in areas with good sanitation.

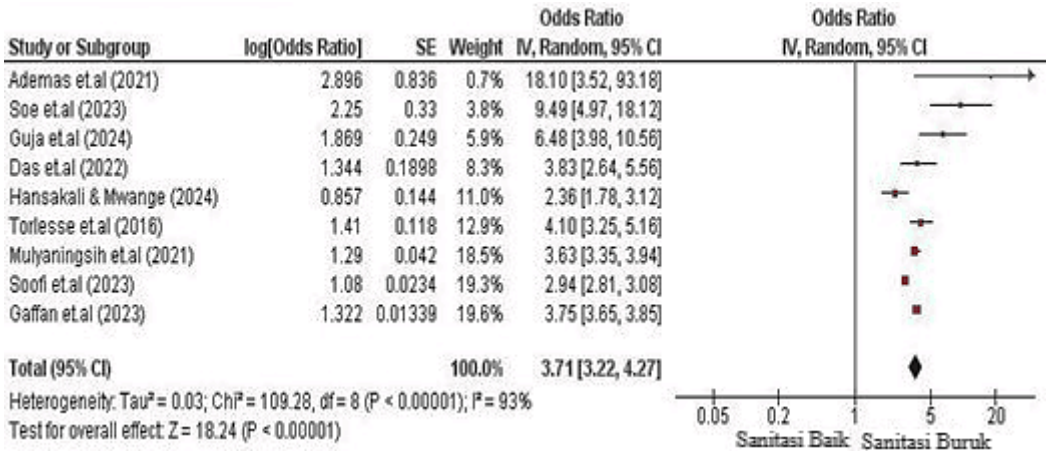


Figure 3. Forest Plot on the Impact of Sanitation in Increasing the Risk of Stunting in Children Under Five

The forest plot shows the results of individual studies, most of which fall to the right side, indicating consistency in the direction of the effect among studies, namely that poor sanitation increases the risk of stunting. The heterogeneity test yielded I2=93%, indicating a very high heterogeneity among the included studies. However, the combined effect showed strong statistical significance (P<0.00001), strengthening the association between poor sanitation and the risk of stunting. These findings emphasize the importance of improving sanitation conditions to reduce the risk of stunting in children under five.

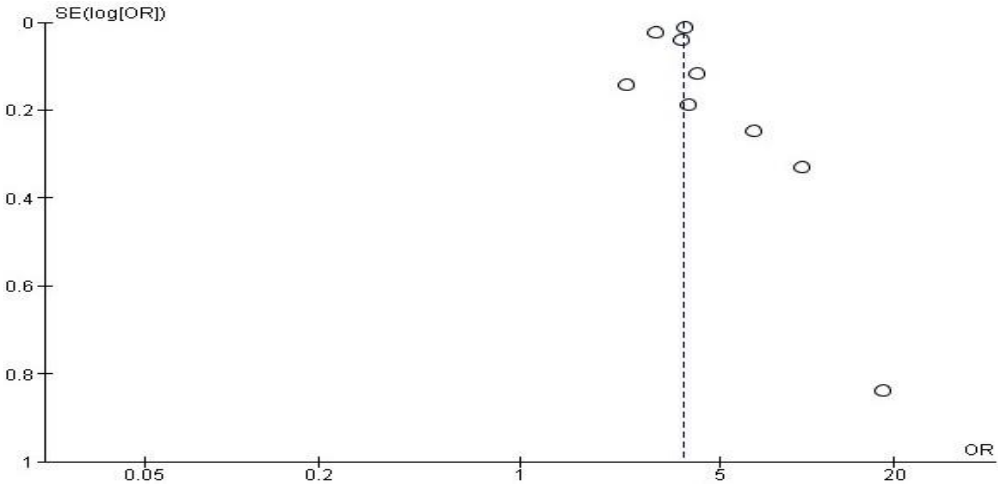


Figure 4. Funnel Plot on the Impact of Sanitation in Increasing the Risk of Stunting in Children Under Five

A funnel plot is a visual method commonly used to assess potential publication bias in meta-analyses. Figure 4. shows the funnel plot assess potential publication bias in a meta-analysis examining the effect of sanitation on the risk of stunting in children under five. The horizontal axis represents the odds ratio (OR) value, while the vertical axis shows the standard error (SE) of the log (OR). The distribution of points in this funnel plot shows that most studies close to

the centre line (dashed line), representing the pooled effect of the meta-analysis. However, there is visible asymmetry on the right side of the plot, with several studies far from the centre line. It may indicate publication bias or heterogeneity among the included studies. It also shows that the results of studies with large effect sizes are more likely to be published than those with smaller effect sizes. A funnel plot is considered symmetrical if small studies (with high standard errors) are evenly distributed on both sides of the centre axis, while studies with large sample sizes are more concentrated near the centre. If the points in the funnel plot are symmetrically distributed, this indicates low publication bias; if the points are concentrated on only one side or spread unevenly, this indicates bias.

## DISCUSSION

The results of the study showed that poor sanitation significantly increased the risk of stunting in children under five. An environment with inadequate access to sanitation increases exposure to infections and diseases, negatively impacting child growth and development. Data analysis revealed a consistent relationship between sanitation and the risk of stunting across the studies, with low publication bias, as seen from the balanced distribution in the funnel plot. It confirms that improving sanitation, such as access to clean water and proper sanitation facilities, is a critical strategy in reducing stunting rates. Thus, interventions that focus on improving sanitation conditions are very important to support children's optimal growth and development and improve overall public health.This meta-analysis study reviewed nine articles examining the effect of sanitation on the risk of stunting in children under five. It consistently showed that poor access to sanitation, access to clean water, and inadequate sanitation facilities increase children's exposure to gastrointestinal infections, which affect on their nutritional status and growth.

In their study, Guja et al. (2024) reported that 49.1% and 49.7% of children experienced stunting and anemia, respectively. Children living in lowland areas were almost twice as likely to experience stunting as those in highland areas. The results of Torlesse et al. (2016) showed that the prevalence of stunting and severe stunting were 28.4% and 6.7%, respectively. The combination of inadequate latrines and untreated drinking water is strongly associated with an increased risk of stunting in Indonesia compared to the better conditions. Thus, policies and programs to address stunting in children in Indonesia to integrate water, sanitation, and hygiene interventions.Mulyaningsih et al. (2021) showed that individual, household, and community characteristics significantly affect stunting. Community-level factors, such as limited access to clean water and sanitation, were also associated with a significant increase in the risk of stunting. This study concluded that the determinants of stunting require multi-level interventions to reduce its prevalence in Indonesia. Similarly, Soofi et al. (2023) showed that stunting in children in Pakistan was closely related to various factors, including gender, age, diarrheal history, place of residence, maternal age and education, number of family members, food and wealth status, and sanitation access. The study emphasized the importance of increasing the availability and affordability of nutritious food and supplements, increasing access to clean water and sanitation, and promoting education for women for long-term reductions in stunting rates.

The findings of Soe et al. (2023) indicated that unsafe sanitation nearly tripled the risk of stunting compared to safe sanitation. A water collection time between 1-15 minutes more than doubled the risk of stunting, while a collection time between 15-60 minutes also elevated the risk. Improper wastewater disposal was associated with almost two times higher risk for stunting. Other factors were male, the lack of vitamin A supplement (increased the risk by 64%), maternal height below 153.4 cm (nearly twofold risk), and lack of dietary diversity (less than four types of food), which increased the risk by 47%. This study concluded that increasing access to safe sanitation, managing wastewater properly, and improving diet and

vitamin A supplementation can reduce the prevalence of stunting in Myanmar. Similarly, Gafftan et al. (2023) showed that stunting was higher in children from households without access to basic clean water and those with open defecation practices- also the risk increases in households without sanitation facilities and limited sanitation services.

The study by Das et al. (2022) demonstrated that inadequate sanitation and unsafe disposal of child feces significantly increase the risk of stunting. The study concluded that regional water availability and sanitation practices have a critical role in influencing stunting in children.Ademas et al. (2021) reported that the prevalence of stunting among children under five was 35.6%. Parental illiteracy, giving birth outside marriage, large family members, short maternal height, unsafe drinking water sources, poor sanitation, and poor hygienic practices were associated with stunting in children under five in Ethiopia. Stunting is a critical public health issue in toddlers. The study also emphasised that the proper use of family planning, good nutrition, parental education, water, sanitation, and hygiene interventions are very important to reduce stunting rates. Hansakali and Mwange (2024) showed a stunting prevalence of 24.1% and a diarrhea prevalence of 19.4%, with 35.6% of children experiencing both. The study stated the factors that significantly contribute to the risk of stunting include the child's gender, household sanitation conditions, and guardian's marital status. Children from households with poor sanitation are at higher risk of stunting. This study highlights the need for community-based interventions to improve sanitation, health education, and feeding practices to reduce the prevalence of stunting and diarrhea in peri-urban areas of Lusaka, Zambia.

The overall findings from nine reviewed articles consistently support the conclusion that improved sanitation plays a significant role in reducing the risk of stunting. This highlights the need for greater attention to sanitation infrastructure and hygiene behaviours to improve the health of children under five. This meta-analysis revealed a significant association between sanitation conditions and the risk of stunting in children under five, indicating that children living in environments with poor sanitation are 3.71 times more likely to experience stunting than those living in environments with good sanitation. Poor sanitation is a significant risk factor for stunting, which can significantly affect children's growth and development. Therefore, increasing access to adequate sanitation facilities and education on good hygiene practices are key to preventing stunting, especially in areas with high prevalence. These findings provide strong evidence for policymakers and other stakeholders to integrate sanitation-based interventions into public health programs to reduce the prevalence of stunting in children under five.

## CONCLUSION

Poor sanitation constitutes a major risk factor for stunting, which significantly impacts children's growth and development. Enhancing access to improved sanitation facilities and promoting good hygiene practices are priorities to prevent stunting, particularly in areas with high prevalence. These findings offer strong evidence to support the policymakers and other stakeholders in integrating sanitation- based interventions into public health programs to reduce the prevalance of stunting among children under five years of age.

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