

Systematic Review - Meta-Analysis

Water, Sanitation and Hygiene (WASH) and its Association with Stunting in Developing Countries in Asia: A Systematic Review

Muhammad Addin Rizaldi¹, Khaidar Ali^{2*}, Swara Mega Hasanah Rara³, Bintang Sri Rezeki Panjaitan⁴

¹ Department of Public Health, Faculty of Health Sciences, Universitas Jenderal Soedirman, Jl. Dr. Soeparno, Karangwangkal, Karang Bawang, Grendeng, Kec. Purwokerto Utara, Purwokerto, Jawa Tengah 53122, Indonesia; ² Department of Environmental Health, Faculty of Health Sciences, Universitas Jenderal Soedirman, Jl. Dr. Soeparno, Karangwangkal, Karang Bawang, Grendeng, Kec. Purwokerto Utara, Purwokerto, Jawa Tengah 53122, Indonesia; ³ Department of Environmental Health, Faculty of Public Health, Universitas Sriwijaya, Indralaya Campus, Kampus, Indralaya Indah, Indralaya, Ogan Ilir Regency, South Sumatra, Indonesia; ⁴ Department of Public Health, Faculty of Sport Science and Public Health, Universitas Negeri Manado, Jl. Kampus Unima, Kelurahan Tonsaru, Kecamatan Tondano Selatan, Manado, Indonesia

ABSTRACT

Background: Stunting is a vital health issue in developing Asian countries, where millions of individuals suffer from chronic malnutrition. Stunting not only is caused by chronic malnutrition but is also influenced by inadequate water supply, sanitation problems, and poor hygiene practices in the community. However, research on water, sanitation, and hygiene (WASH) and its association with stunting is limited, particularly in developing countries. **Objective:** This study aimed to analyze the associations between water, sanitation, and hygiene practices and the occurrence of stunting in Asia. **Methods:** This article is a systematic literature review using the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. A total of 1,002 articles were reviewed, of which 560 were published. Additionally, articles could be selected and dropped because they had no original research. After duplicate articles were removed, 168 articles were removed. The screening and extraction results revealed 14 articles eligible for review. After the article was reviewed and read, only five articles were eligible, and only 5 articles could be reviewed because the article discussed WASH and stunting in developing countries in Asia. **Results:** Inadequate WASH practices were strongly associated with stunting among children under five years of age. An insufficient water supply and access to safe drinking water contribute to this condition, as inadequate water availability can increase the risk of stunting. Additionally, groundwater unfit for consumption increases the likelihood of undernutrition, including stunting, underweight, and wasting in children. Access to improved drinking water sources is essential for reducing stunting, as households with such access report lower stunting rates. **Conclusion:** Solutions to address stunting in children under five years of age include enhancing drinking water sources, improving sanitation facilities, and promoting better hygiene practices. Local governments should provide adequate water provision and accessible drinking water.

KEYWORDS

Stunting, water, sanitation, hygiene, toddler, public health, environmental health

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EDITOR

Dr. dr. Budi Utomo,
M.Kes.

CORRESPONDENCE

Khaidar Ali,
Department
of Public Health,
Faculty of Health
Sciences, Universitas
Jenderal Soedirman,
email: khaidar.ali@
unsoed.ac.id

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INTRODUCTION

The global prevalence of stunting in early childhood is a critical impediment to human development potential worldwide. Chronic nutritional deficiencies during the formative years of development precipitate stunting, which manifests as profound long-term consequences, including compromised cognitive function, suboptimal physical development, reduced academic performance, elevated risk of obstetric complications, and increased susceptibility to degenerative conditions. Stunting has emerged as a pervasive health challenge of global significance as a manifestation of malnutrition. Projections have indicated that approximately 20% of children would experience stunting by 2020 [1].

Previous research has established correlations between stunting and adverse body composition outcomes as well as noncommunicable disease risk factors, including predisposition to obesity, hypertension, and dyslipidemia in adulthood [2]. Recent epidemiological data from 2022 reveal that approximately 148.1 million children under five years of age (22.3%) exhibit stunting, whereas 45 million suffer from wasting and 37 million from overweight conditions [3]. Contemporary data from the Asia-Pacific region demonstrate a declining trend in stunting prevalence, which is consistent with global patterns; however, this reduction has proceeded at an insufficient rate [4]. According to World Health Organization assessments, Asia maintains a substantial stunting prevalence of 22.3%, representing 76.6 million affected individuals, which approximates the global average prevalence [3].

Stunting is an essential public health issue in many developing countries in Asia, where millions of children under the age of five suffer from chronic malnutrition. Stunting is not only caused by chronic malnutrition but also influenced by several factors. One of the factors that affects the occurrence of stunting is inadequate water supply, sanitation problems, and poor hygiene practices in the community [5]. It is estimated that approximately 149 million preschool children who are approaching the age of 5 years or are less than 5 years old in many developing countries are stunted [6]. Research has shown that malnutrition problems, such as stunting, can also be caused by unsafe water, sanitation, and hygiene [7]. Adequate hygiene and sanitation can help prevent the occurrence of infectious diseases where infectious diseases can be at risk of causing nutritional problems in toddlers [8–10].

Stunting is a multifaceted problem with factors ranging from maternal health and nutrition to environmental conditions [11]. Water, sanitation, and hygiene (WASH) are critical determinants that influence various pathways contributing to stunting [11,12]. Inadequate access to clean water, proper sanitation facilities, and basic hygiene practices can lead to the spread of enteric infections, which are strongly linked to stunted growth in children [11]. Insufficient access to safe water resources coupled with substandard sanitation and hygiene practices constitute significant risk factors for childhood stunting. While research on the effectiveness of water, sanitation, and hygiene (WASH) interventions in mitigating stunting has produced mixed results, the fundamental importance of enhanced WASH practices remains critical for optimal childhood nutrition, health outcomes, and developmental trajectories. The Sustainable Development Goals framework explicitly acknowledges the centrality of WASH to sustainable development objectives; specifically, SDG 6 emphasizes universal accessibility to adequate and safe water resources, sanitation facilities, and hygiene practices [13].

Contemporary research has established correlations between stunting prevalence and WASH parameters; findings indicate that children under five years of age exhibit particular vulnerability to stunting, with contamination of water delivery systems, specifically hand pumps and tank water resources, identified as primary contributing factors [14]. The mechanistic pathways connecting WASH conditions and stunting manifestations demonstrate considerable complexity and multidimensionality. Suboptimal WASH conditions can negatively impact multiple dimensions of food security, including availability, accessibility, stability, and utilization, all of which represent essential components of comprehensive food and nutrition security. Furthermore, enteric infections resulting from inadequate WASH practices can compromise intestinal function and nutrient absorption capacity, thereby exacerbating nutritional deficiencies and potentially accelerating stunting progression.

Despite the limited research on water, sanitation, and hygiene (WASH) associations with stunting in developing nations, this study aims to examine the relationship between WASH practices and stunting occurrence across Asia. Through systematic analysis of data from studies conducted within the past decade throughout various Asian countries, this review endeavors to assess the impact of WASH practices on the prevalence of stunting in developing regions.

MATERIALS AND METHODS

Search strategy

This systematic literature review assessed the association between WASH and stunting in children under five years of age in Asia. The literature search was performed until September 2024. The databases used to search for articles were Scopus, ScienceDirect, and PubMed, with the keywords (Table 1), "Water," "Sanitation," "Hygiene," "WASH," "Stunting," "Growth disorders," "Malnutrition," "Growth retardation," "Rural," "Village," "Countryside," and "Asia." All identified articles were imported into Mendeley to manage the articles and select duplicate articles. Following a systematic screening approach, the articles underwent initial evaluation on the basis of the relevance of their titles to WASH and stunting parameters. The selected articles were subsequently subjected to an abstract review for further assessment. Articles meeting the predetermined eligibility criteria were subjected to comprehensive examination, whereupon relevant publications addressing WASH and stunting relationships were systematically evaluated for inclusion in the analysis.

Table 1. Search terms

Database	Search term	Total Article (n = 174)
PubMed	((("water"[MeSH Terms] OR "water"[All Fields]) OR ("sanitation"[MeSH Terms] OR "sanitation"[All Fields]) OR ("hygiene"[MeSH Terms] OR "hygiene"[All Fields]) OR WASH[All Fields]) AND (("growth disorders"[MeSH Terms] OR ("growth"[All Fields] AND "disorders"[All Fields]) OR "growth disorders"[All Fields] OR "stunting"[All Fields]) OR ("malnutrition"[MeSH Terms] OR "malnutrition"[All Fields]) OR "growth retardation"[All Fields])) AND (rural[All Fields] OR countryside[All Fields] OR villages[All Fields] OR remote[All Fields])) AND ("asia"[MeSH Terms] OR "asia"[All Fields])	8
Science Direct	(WASH) AND (stunting OR "growth retardation") AND (rural OR villages) AND Asia	151
Scopus	(TITLE-ABS-KEY("water" OR "sanitation" OR "hygiene" OR "WASH") AND TITLE-ABS-KEY("stunting" OR "malnutrition" OR "growth retardation") AND TITLE-ABS-KEY("rural" OR "countryside" OR "villages" OR "remote") AND TITLE-ABS-KEY("Asia"))	15

Inclusion and exclusion criteria

The systematic review employed a rigorous selection process for articles, following established scholarly protocols. The articles included in this review met specific criteria: they were original research studies published in English and indexed in the Scopus, ScienceDirect, or PubMed databases. The temporal scope was limited to a ten-year period (2014-2024), and the geographical focus was restricted to developing countries in Asia. This geographical delimitation is particularly relevant considering the disproportionate burden of stunting across the Asian continent. Articles were excluded if they were conducted outside Asia or if they failed to address the relationships among water, sanitation, and hygiene interventions and stunting outcomes. The eligibility assessment was systematically conducted according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram protocol, ensuring transparency and reproducibility of the selection process [15].

Article selection and data extraction

A comprehensive data extraction methodology was implemented to ensure a consistent and thorough analysis of the included literature. Each eligible article underwent a systematic extraction procedure, and relevant data were independently documented. The extraction protocol captured several key parameters: publication year, article type, research setting within Asia, and specific WASH components investigated in relation to stunting outcomes. This standardized approach to data extraction facilitated a robust comparative analysis across studies and minimized potential extraction bias. The independent extraction process further enhanced the reliability of the collected data, providing a solid foundation for the subsequent analytical procedures.

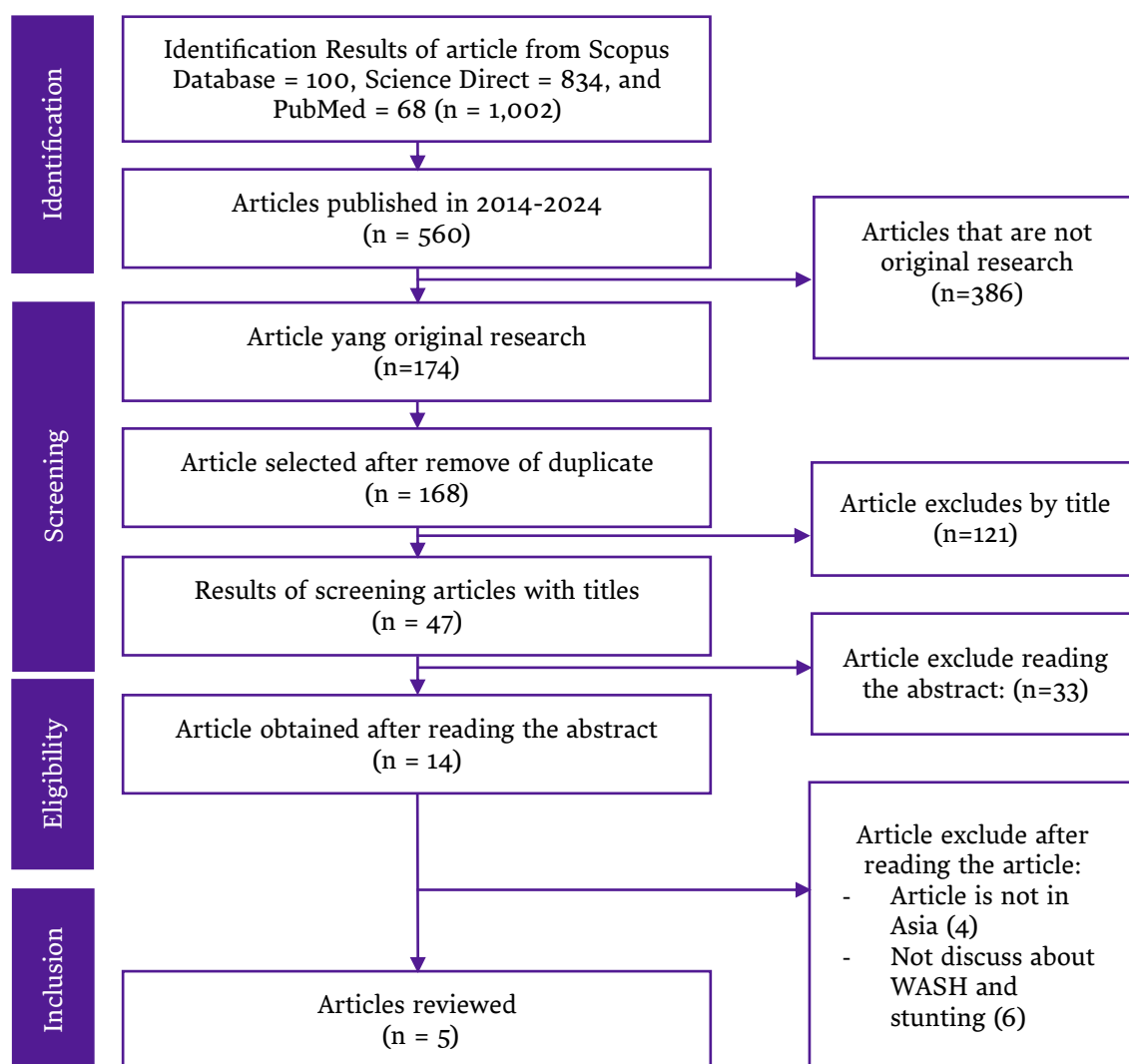


Figure 1. Flow diagram of the study selection process

Review and analysis framework

All included articles are summarized in the extraction table. To complement the systematic review, a bibliometric analysis was conducted to quantitatively assess the research landscape of the field. This bibliometric approach identified emerging trends, frequently occurring keywords, and specific WASH factors that demonstrated significant correlations with stunting in the included studies. The combined methodological framework enabled both qualitative insights into the evidence base and quantitative mapping of the research terrain, effectively highlighting critical focus areas while simultaneously identifying substantial knowledge gaps in the literature examining the association between WASH interventions and childhood stunting in developing Asian countries.

Table 2. A review article titled Water, Sanitation and Hygiene (WASH) and its association with stunting in developing countries in Asia

Ref.	Year	Country	Type of study	WASH with Stunting	Age	Conclusion	Area
Conway et al. [16]	2020	Nepal	Mixed methode approached, with 4 types of inquiry employed including a systematic scoping literature review, retrospective quantitative data analyses, a comprehensive review of nutrition-specific and -sensitive policies and programs, and retrospective qualitative data collection and analyses.	Research demonstrates that water, sanitation, and hygiene (WASH) interventions contribute positively to enhanced child growth outcomes. WASH implementations effectively reduce open defecation practices, which has demonstrated considerable benefits in decreasing infectious disease transmission and mitigating poor nutritional status among children, particularly regarding stunting.	<5 Years	The multifactorial decline in stunting prevalence across Nepal during the past two decades cannot be attributed to any single intervention. Analysis of combined factors reveals that Nepal's commendable progress in addressing chronic child malnutrition stems from an integrated approach focusing on poverty alleviation, expanded healthcare accessibility, educational advancement, and improved sanitation infrastructure.	Rural area
Rahut et al. [17]	2023	India, Bangladesh, Pakistan, Nepal, Cambodia, Timor Leste.	Explore the geospatial and environmental determinats of undernutrition. Use Poisson Regression and the date from recent round of the Demographic and health survey (DHS)	Evidence demonstrates that unsafe water consumption exhibits positive and statistically significant correlations with both stunting and wasting in pediatric populations	0-59 months	Climate change intensification disproportionately affects agrarian communities, with substantial implications for childhood nutritional status outcomes. Agricultural productivity disruptions, water resource alterations, and economic instability resulting from environmental changes function as determinants of child malnutrition prevalence in vulnerable regions	Rural area

Ref.	Year	Country	Type of study	WASH with Stunting	Age	Conclusion	Area
Dimitrova et al. [18]	2020	India	The impact of rainfall anomalies on child stunting in India: (1) health data from a nationally representative survey and (2) gridded climate data. The two datasets are combined using geo-referenced information of household clusters collected in the survey.	Recent epidemiological research indicates that improved hygiene practices correlate with reduced stunting incidence among children. Analysis of rainfall variation effects reveals a notable interaction: children whose mothers implement enhanced hygiene protocols demonstrate no statistically significant increase in stunting risk during periods of elevated rainfall anomalies, whereas children whose mothers report suboptimal hygiene practices exhibit marked increases in stunting prevalence under identical precipitation conditions	<5 Years	Empirical findings from this investigation document that excessive precipitation events heighten stunting risk across Indian populations. The research establishes that pediatric health outcomes reflect both the magnitude of climate-related disruptions and preexisting vulnerability factors within communities. This association underscores how socioeconomic, infrastructural, and behavioral determinants modify climate exposure effects on child nutritional status	Urban and Rural area
Shofifah et al. [19]	2022	Indonesia	This study used a case-control research design and an analytical observational approach. Bivariate analysis was utilized together with Chi-square test to examine the variables.	Epidemiological assessment demonstrates a significant relationship between environmental sanitation conditions and stunting prevalence among toddlers. Children residing in households characterized by inadequate environmental sanitation exhibited a 5.9-fold increased risk of stunting compared to counterparts from environments with sufficient sanitation infrastructure. This substantial risk differential emphasizes the critical relationship between	≤ 5 Years	The data analysis reveals a statistically significant correlation between stunting occurrence and suboptimal environmental sanitation conditions (OR = 5.921). Residences characterized by inadequate housing materials, insufficient sanitation facilities, and problematic hygiene behaviors among household members contribute to elevated infectious disease risk in toddler populations. The investigation further	Rural area

Ref.	Year	Country	Type of study	WASH with Stunting	Age	Conclusion	Area
				household sanitary conditions and developmental outcomes in early childhood populations		establishes that environmental sanitation quality within domestic settings demonstrates a significant association with infectious disease susceptibility (OR = 4.400), highlighting the interconnected pathways between residential environmental conditions and pediatric health outcomes	
Cameroon et al. [20]	2021	Indonesia	The data from Indonesia life survey (IFLS). The research to investigated the effect of early exposure to improve water dan sanitation on nutrition and cognitive outcomes later in life.	Research demonstrates a significant relationship between sanitation standards and anthropometric indicators in pediatric populations. Communities that maintain controlled defecation practices during the critical developmental window of toddlerhood show strong associations with reduced stunting prevalence. Evidence supports established connections between sanitation conditions and nutritional outcomes, with water, sanitation, and hygiene (WASH) interventions demonstrating measurable effects on cognitive development parameters among toddlers	≤ 5 Years	Epidemiological analysis establishes clear associations between drinking water access and sanitation conditions during pregnancy and early childhood with both nutritional status indicators and cognitive performance outcomes in children. The statistical findings demonstrate that children from households implementing sanitation quality improvements during the critical 1,000-day developmental window experienced a 5% reduction in stunting probability compared to counterparts without such environmental enhancements	Rural area

Remarks: Data tabulation and extraction in this study were performed manually by the authors by reviewing each selected paper.

RESULTS

Article characteristics

A total of 1,002 articles were initially identified through peer-reviewed databases, of which 560 articles were original articles. After screening and removing duplicates, 168 articles remained. The screening and extraction of articles from several databases yielded 14 articles eligible for review. After the articles were reviewed and read, five were included in this study because they discussed WASH and stunted in developing countries in Asia (Figure 1).

Summary of articles

A summary of all article findings is provided in Table 2. The articles reviewed were obtained from several databases. The results of the review of the five articles revealed that WASH is related to the occurrence of stunting and that poor WASH practices can influence the event of stunting. On the basis of the review of the article, seven countries in Asia, mainly Indonesia, India, Nepal, Pakistan, Cambodia, and Timor Leste, from the included studies, it is known that the respondents are children under five years of age, but one article has respondents who are adolescents. Stunting is a high risk in children under five years of age because the first 1000 days of life are the golden age in the growth period. Therefore, poor nutritional intake and poor WASH practices have great potential to cause stunting in children under 5 years of age. According to the included studies, the study areas were primarily rural, indicating that research from urban areas is needed. Rural areas usually do not have adequate WASH practices in place. This finding indicates the presence of risk factors for stunting.

On the basis of this empirical evidence, water, sanitation, and hygiene (WASH) interventions can yield positive outcomes for child growth parameters, with unsafe waste management practices showing significant positive associations with both stunting and wasting in children. Additional systematic review findings confirm that both sanitation infrastructure and water quality represent critical risk factors contributing to stunting; specifically, sanitation improvements warrant particular attention, as inadequate sanitation conditions demonstrate a consistent association with stunting outcomes. Further empirical research has established a clear relationship between environmental sanitation conditions and the prevalence of stunting among toddlers. Notably, a key study revealed that toddlers from households characterized by poor environmental sanitation faced a substantially elevated risk—5.9 times greater—of experiencing stunting than did their counterparts residing in households with adequate sanitation facilities and practices.

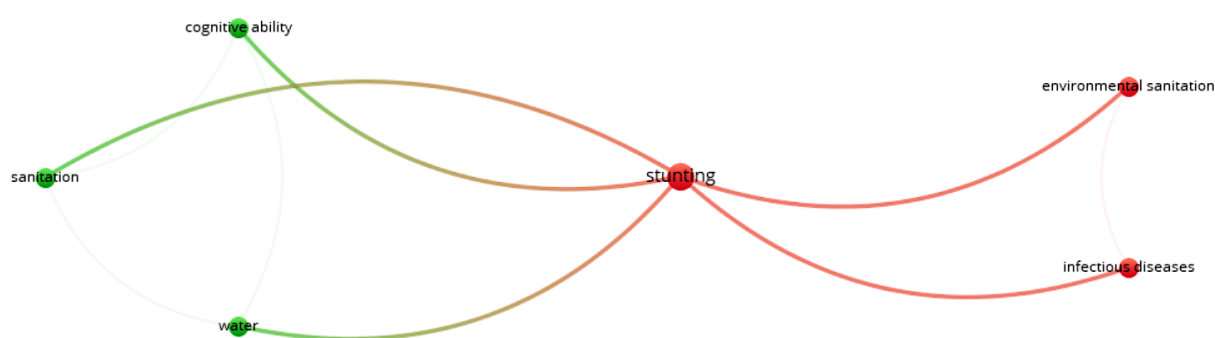


Figure 2. Bibliometric analysis of WASH and its association with stunting.

Bibliometric analysis

The bibliometric analysis of WASH and stunting via keywords is shown in Figure 2. According to Figure 2, the bibliometric analysis of the five selected articles revealed that stunting is centrally linked to various factors associated with WASH. Poor sanitation directly influences stunting and is also associated with cognitive ability, indicating potential long-term impacts on child development. Additionally, environmental sanitation is strongly linked to infectious diseases,

which play a significant role in stunting. These findings highlight the interconnectedness of WASH components, emphasizing that improving sanitation and environmental hygiene is critical for addressing stunting in developing Asian countries.

DISCUSSIONS

Stunting is impaired growth and development that children experience due to poor nutrition, repeated infection, inadequate sanitation, and low psychosocial stimulation. Stunting can start from early life, particularly in the first 1,000 days of life [21], because early life, especially the first 1000 days of life, is essential for improving a child's nutritional status to prevent stunting. Stunting affects not only childhood but also long-term physical and cognitive development. Impaired growth from stunting can lead to adverse outcomes, including reduced cognitive ability, poor educational performance, lower adult wages, and decreased productivity. When combined with excessive weight, stunting increases the risk of nutrition-related chronic diseases in adulthood [21,22].

Stunting is a primary global concern, particularly in developing Asian countries such as Indonesia, India, Nepal, Pakistan, Cambodia, and Timor-Leste, as highlighted by recent studies. Children under five years of age are at high risk of stunting. Research in East Nusa Tenggara revealed the highest prevalence of stunting among children aged 12–23 months [23]. Another study concluded that children younger than three years of age had a 20% lower risk of stunting than did preschool-aged children [24]. In another study, age groups of 12–23 months and 24–35 months were associated with significantly increased odds of stunting [25]. Children under 5 years are potentially stunted if they do not receive adequate nutrition, proper WASH practices, and other essential care during the first 1,000 days of life. This period is crucial, as it represents a critical window for growth and development in early childhood.

Another study demonstrated that inadequate WASH practices significantly contribute to stunting in developing countries. Repeated exposure to fecal pathogens from poor WASH practices can lead to nutrient malabsorption and nutrient loss through diarrheal diseases, ultimately causing malnutrition and impaired growth. This impact can have long-lasting, damaging effects across the lifespan [6,26,27]. A review of articles concluded that WASH practices are crucial in influencing stunting. An analysis of five reviewed studies indicated a significant association between water supply, sanitation, and hygiene practices and stunting. The findings revealed that improved hygiene practices correlated with a reduced risk of stunting, emphasizing that adequate hygiene can lower this risk. Furthermore, a bibliometric analysis revealed that terms such as sanitation, water, and environmental sanitation frequently appeared in studies examining their relationships with or influence on stunting.

Research indicates that the risk of stunting in toddlers can be mitigated through consistent hygiene practices, particularly by washing hands with soap after defecation, which may reduce the risk by 14%. Furthermore, implementing handwashing with soap before feeding children was associated with a 15% reduction in the risk of stunting [28]. A study in Indonesia supports these findings, demonstrating that proper hygiene practices lower the risk of stunting by a factor of 2.442 compared with children with inadequate hygiene [29]. Hygiene practices are closely associated with personal hygiene, including habits such as washing hands with clean water and soap and cleaning dishes and cooking utensils with water [29].

According to empirical research, personal hygiene practices are significantly associated with stunting outcomes in toddlers. A comprehensive study conducted in Indonesia identified specific hygiene behaviors that exhibited statistically significant relationships with stunting incidence ($p < 0.05$), including indoor smoking practices, proper washing of dishes and drinking utensils with soap and running water, handwashing with soap and water, and maintenance of children's nail hygiene through regular trimming. Notably, among these identified hygiene factors, inadequate dish washing practices—specifically, failing to use soap and running water—emerged as presenting a comparatively greater risk for stunting development in children than other hygiene practice deficiencies examined in the research [30]. Parental knowledge of personal hygiene is correlated with stunting, as parents play a crucial role in providing food for their children. Research has revealed a significant relationship between parents' understanding of

hygiene and the incidence of stunting [31]. Therefore, improving personal hygiene practices is essential, as adequate hygiene can help reduce stunting in toddlers. Good personal hygiene minimizes the presence of bacteria or germs, which can impair nutritional absorption in toddlers.

Access to sanitation remains a global challenge, with 46% of the world's population requiring more safely managed sanitation facilities. This highlights the difficulties in promoting systemic public policies that improve sanitation and, consequently, support children's nutritional status [6]. According to a review article, environmental sanitation is associated with the prevalence of stunting in toddlers, making it a significant risk factor for this condition. A study conducted in Ogan Ilir, South Sumatra, Indonesia, revealed that factors related to environmental sanitation, including the quality of clean water, sewage systems, and latrines, contribute to the incidence of stunting in children aged 12–59 months [32]. Another study revealed that environmental sanitation contributes strongly to the incidence of stunting in school-aged children [33].

Another study indicated that environmental sanitation is linked to the incidence of stunting, with an odds ratio of 10.535. This means that poor environmental sanitation increases the risk of stunting by 10.535 times [34]. Another study conducted in Indonesia reported a significant relationship between household food sanitation and the incidence of stunting in toddlers, with an odds ratio of 2.562. This finding indicates that inadequate food sanitation increases the likelihood of stunting in toddlers by 2.562 times [35]. One of the contributing factors to stunting in toddlers is open defecation and limited access to proper sanitation facilities. Additional research indicates that both open defecation and anemia can lead to stunting, wasting, and underweight in children [36]. Open defecation continues to hinder children's growth and is linked to a greater risk of stunting, wasting, and being underweight [36–40].

Open defecation significantly impairs children's growth and is associated with a greater risk of stunting, wasting, and being underweight. This issue arises primarily because open defecation facilitates the spread of enteric infections, which are detrimental to the nutritional status of children. Children exposed to unsafe environments are more likely to suffer from diarrhea and other infections, leading to nutrient loss and impaired growth [41,42]. Research indicates that improved sanitation and hygiene practices can mitigate these risks. For example, studies have shown that areas with better sanitation facilities are correlated with reduced rates of stunting among children [42]. Other studies have indicated that a high prevalence of stunting is linked to inadequate dietary intake, poor hygiene and sanitation, frequent enteric infections, and environmental enteric dysfunction [43]. Stunting risk factors are influenced by various factors, with poor sanitation being a major contributor. Improving sanitation and hygiene can help prevent stunting by reducing the frequency of recurrent enteric infections in children.

An inadequate water supply and a lack of safe drinking water are associated with stunting, as they can increase infection risks, such as diarrhea, which may lead to malnutrition. The source of drinking water plays a critical role, as unsafe sources increase infection risk, contributing to conditions such as stunting, wasting, and being underweight in children [44–46]. Contaminated groundwater can increase the risk of malnutrition, including stunting. Studies indicate that poor-quality groundwater increases the odds of undernutrition, including stunting, being underweight, and wasting in children. The regular consumption of unsafe groundwater can exacerbate malnutrition, significantly affecting child health [47]. Contaminated water can lead to diarrhea, a communicable disease that contributes to stunting by causing nutrient loss in children. Therefore, access to safe water is crucial for children's health. Studies have shown that chronic diarrhea and acute respiratory infections (ARIs) are the leading risk factors for stunting in children under five years of age, with an odds ratio of 6.56, indicating that children with diarrhea or ARIs face a 6.56-fold greater risk of stunting [48].

Another study demonstrated a significant link between drinking water sources and stunting. The study revealed that 41% of children in households lacking improved drinking water sources were stunted. This association suggests that improved access to water and sanitation can help reduce the incidence of infectious diseases [49,50]. Access to improved drinking water sources is essential for reducing the prevalence of child stunting. Research indicates that households with access to better water sources have contributed to a decrease in stunting among children [51]. On the basis of these findings, local governments should provide effective clean water

management across communities. This action is necessary where it provides accessible, clean water that reduces the incidence of stunting among the population [52,53].

Public health implications

The findings of this systematic review underscore several critical public health implications regarding WASH interventions and childhood stunting in developing Asian countries. The consistent association between inadequate WASH practices and stunting highlights the need for integrated approaches in public health programming. Improved water sources, proper sanitation facilities, and enhanced hygiene practices should be prioritized in nutritional intervention packages targeting vulnerable communities. The strong correlation between environmental sanitation and stunting prevalence (with a 5.9 times higher risk in environments with poor sanitation) demonstrates that public health initiatives must address environmental determinants alongside nutritional interventions. The finding that open defecation significantly increases stunting risk calls for targeted community-level behavioral change campaigns and infrastructure development. Moreover, the bibliometric analysis revealing the interconnection between WASH components, stunting, and cognitive development implies that WASH interventions can yield benefits beyond physical growth, potentially enhancing cognitive outcomes and long-term human capital development. These insights suggest that strengthening WASH infrastructure and promoting hygiene education should be incorporated into national nutrition policies and stunting reduction strategies in developing Asian countries.

Limitations

This study has several limitations, namely, 1) the quality assessment of the included studies and the heterogeneity test were not performed, which may have led to potential bias in this study, and 2) these studies were analyzed via only a descriptive approach.

CONCLUSIONS

This systematic review demonstrated a significant association between WASH practices and childhood stunting in developing Asian countries. These findings reveal that an inadequate water supply, poor sanitation facilities, and suboptimal hygiene behaviors contribute substantially to the prevalence of stunting among children under five years of age. Environmental sanitation emerged as a predominant risk factor, with children living in households with poor sanitation having nearly six times higher odds of developing stunting. Open defecation represents a particular concern, facilitating enteric infections that impair nutrient absorption and physical development. Groundwater contamination and limited access to improved drinking water sources further exacerbate these risks. The bibliometric analysis confirmed the interconnected nature of WASH components and their collective impact on childhood growth. Addressing stunting effectively requires multisectoral approaches that enhance water infrastructure, improve sanitation facilities, and promote hygiene education in vulnerable communities. Local government initiatives should prioritize providing accessible clean water and adequate sanitation systems while implementing complementary educational programs related to proper hygiene practices. Such integrated interventions hold promise for reducing the substantial burden of childhood stunting across developing regions in Asia.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision: M.A.K., K.A.

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ABBREVIATIONS

ARI, Acute Respiratory Infections; DHS, Demographic and Health Survey; IFLS, Indonesia Life Survey; MICS, Multiple Indicator Cluster Survey; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SDGs, Sustainable Development Goals; WASH, Water, Sanitation, and Hygiene; WHO, World Health Organization.

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