The Relationship of Water and Sanitation with the Incidence of Stunting: A Bibliometric Analysis

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This research analyzes trends in studies regarding the relationship between water, sanitation, and stunting in children under five through bibliometric analysis. Water, sanitation, and hygiene (WASH) interventions are recognized as critical factors in addressing childhood stunting, yet the research landscape remains fragmented across disciplines. A total of 130 publications from the Scopus database covering 2010-2024 were analyzed using VOSViewer software. Co-occurrence analysis, co-authorship analysis, and citation analysis were performed to identify research patterns, collaboration networks, and knowledge clusters. The results reveal that medical sciences dominate the field (34.6%), followed by nursing (15.4%) and environmental sciences (13.8%), with research articles comprising 77.2% of publications. The United States leads in publication output with 35 documents, while Johns Hopkins Bloomberg School of Public Health emerges as the most prolific institution with 8 publications. Publication trends show significant growth from 2010 to 2020, peaking at 23 publications in 2020. International collaboration analysis demonstrates strong cooperation networks, particularly between the United States and the United Kingdom. Keyword co-occurrence analysis identified three distinct clusters: Cluster 1 focusing on growth disorders and child development, Cluster 2 emphasizing stunting epidemiology and risk factors, and Cluster 3 addressing WASH interventions and pathogen exposure. The research landscape reveals disciplinary fragmentation that may explain contradictory findings and limited intervention effectiveness. Enhanced interdisciplinary collaboration and integration of clinical, epidemiological, and intervention perspectives are essential for developing comprehensive stunting prevention strategies, particularly in low- and middle-income countries.

Keywords: Stunting, Water, Sanitation, Toddlers, Bibliometric Analysis

INTRODUCTION

Environmental degradation, particularly water contamination, poses significant threats to global health outcomes. Water pollution cases involving E. coli pathogens and chemical contaminants have spread across various regions, triggering degenerative diseases in affected populations (Yuniarti et al., 2024; Yuniarti et al., 2024). These environmental changes have become a major concern for global health, especially regarding access to clean water and water quality.

This crisis has gained international attention through the Sustainable Development Goals (SDGs), specifically Goal 6, which emphasizes clean water and proper sanitation access (Nazila & Ahlan, 2024). Research demonstrates that access to clean water and sanitation can significantly reduce waterborne diseases, decrease mortality rates, and improve overall quality of life (McGarvey et al., 2008). Good water and sanitation access is particularly crucial for vulnerable populations, including children under five years old.

Poor water quality and inadequate sanitation directly contribute to stunting in children under five years old. Stunting represents a serious public health concern, affecting approximately 155 million children globally or about 23% of children under five years (Budge et al., 2019). In Indonesia, particularly in West Sumatra Province, stunting prevalence among toddlers (aged 24-59 months) reaches 36.2%, which is higher than the national prevalence of 30.8%, ranking the province 17th out of 34 provinces experiencing stunting (Azzahra et al., 2024). This condition has long-term consequences on physical and cognitive development (Bourke et al., 2016).

Children with stunting show higher mortality risks compared to non-stunted children (Mutasa et al., 2022; Olofin et al., 2013). Research indicates that toddlers and children who suffer from stunting have both visible and invisible symptoms that significantly impact their

development (Amadi et al., 2021). The severity of stunting makes it a critical indicator of child health and development in global health monitoring.

The relationship between water, sanitation, and hygiene (WASH) conditions and stunting occurs through three primary mechanisms: recurrent diarrhea, soil-transmitted helminth infections, and environmental enteropathy (Action Against Hunger USA, 2011, 2017). These health problems are directly related to inadequate WASH conditions and can affect children's growth biologically. Poor WASH conditions also affect nutritional status indirectly through social and economic factors (Budge et al., 2019).

Research demonstrates that each diarrheal episode increases stunting risk by 2.5% by age two, with children experiencing more than five episodes during their first 1000 days contributing to 25% of all stunting cases (Checkley et al., 2008; Raharini & Yuniarti, 2023). This finding emphasizes the critical importance of preventing diarrhea in early childhood to maintain healthy growth. The first 1000 days of life represent a crucial window for interventions to prevent stunting.

WASH programs typically include improving water quality and quantity, enhancing sanitation facilities, and providing hygiene education (Action Against Hunger USA, 2011, 2017). These interventions focus on safe disposal of feces, hand washing practices, and maintaining food and environmental hygiene. However, implementation challenges often arise in resource-limited settings where these programs are most needed.

Despite extensive research on WASH interventions, results remain inconsistent across different contexts and populations. While some studies suggest that complete WASH coverage (99%) would reduce stunting by only 2.5% (Checkley et al., 2004; Fenn et al., 2012), other research shows positive correlations between improved water quality and child growth (Rah et al., 2015). This inconsistency indicates a need for comprehensive analysis of existing research patterns to understand the varying effectiveness of WASH interventions.

Bibliometric analysis provides a systematic approach to examine research trends and patterns in scientific literature. This quantitative method evaluates citation patterns, identifies influential works, and maps research networks to understand knowledge development in specific fields. The approach has proven valuable in health research for identifying research gaps and emerging areas of investigation.

Previous bibliometric studies have demonstrated the growing importance of stunting research, with significant increases in publications from 2010-2023, dominated by medical fields and characterized by strong international collaboration involving countries such as Indonesia, the United States, and India, reflecting the global recognition of stunting as a major health challenge requiring cross-country efforts (Azzahra et al., 2025).

Current literature lacks a systematic overview of research trends and developments in the relationship between water, sanitation, and stunting. This study addresses this gap by employing bibliometric analysis to map existing scientific literature, identify research trends and patterns, and highlight areas requiring further investigation. Through this approach, this study seeks to provide insights for future research planning and effective policy development in addressing stunting through improved water and sanitation interventions.

METHODS

This study utilized the Scopus database as the primary data source for bibliometric analysis, covering publications from 2010 to 2024. Scopus was selected because it is widely recognized as a comprehensive and high-quality database for bibliometric studies, with rigorous peer-review processes that ensure publication quality (Verma & Gustafsson, 2020; Samsara, 2022). The search strategy employed the TITLE-ABS-KEY field to capture relevant documents where keywords appeared in the title, abstract, or author-specified keywords.

The detailed search parameters and filtering criteria are presented in Table 1. The primary search query used was "Stunting environment and water or sanitation" applied to the TITLE-ABS-KEY field. Document types were filtered to include only journal articles, conference papers, and review articles to ensure comprehensive coverage while maintaining academic rigor. The search was limited to English-language publications to facilitate analysis and interpretation.

The initial search yielded 145 documents from Scopus-indexed publications. A systematic screening process was applied to ensure document quality and relevance. Documents were included if they: (1) focused on the relationship between stunting and water/sanitation factors, (2) were published in peer-reviewed journals or conference proceedings, and (3) provided empirical data or systematic reviews. Editorials, letters to editors, book chapters, and notes were excluded to maintain analytical rigor.

The bibliometric analysis employed multiple analytical techniques to comprehensively examine the research landscape. Co-authorship analysis was conducted to identify collaboration patterns between researchers, institutions, and countries. Co-occurrence analysis was performed to map keyword relationships and identify research themes and trends. Citation analysis was used to determine the most influential papers and authors in the field.

VOSViewer version 1.6.18 was utilized as the primary tool for bibliometric analysis and visualization. The software was configured with specific parameters to ensure meaningful analysis: minimum occurrence threshold of 3 for keyword co-occurrence analysis, minimum citation threshold of 5 for document citation analysis, and minimum collaboration threshold of 2 for co-authorship analysis. Three visualization modes were employed: network visualization to display relationship structures, overlay visualization to show temporal trends, and density visualization to identify research concentration areas.

The VOSViewer analysis was conducted using the following specific parameters and thresholds. For co-

occurrence analysis of keywords, a minimum occurrence threshold of 3 was applied to focus on significant terms while maintaining comprehensiveness. For co-authorship analysis, a minimum threshold of 2 collaborative publications was set to identify meaningful research partnerships. Citation analysis employed a minimum citation threshold of 5 to highlight influential works in the field.

The exported Scopus data underwent systematic processing to ensure accuracy and consistency. Duplicate entries were identified and removed, author names were standardized to account for variations in spelling and formatting, and institutional affiliations were normalized to facilitate accurate co-authorship analysis. The final dataset was validated through cross-referencing with original Scopus records to ensure data integrity and completeness.

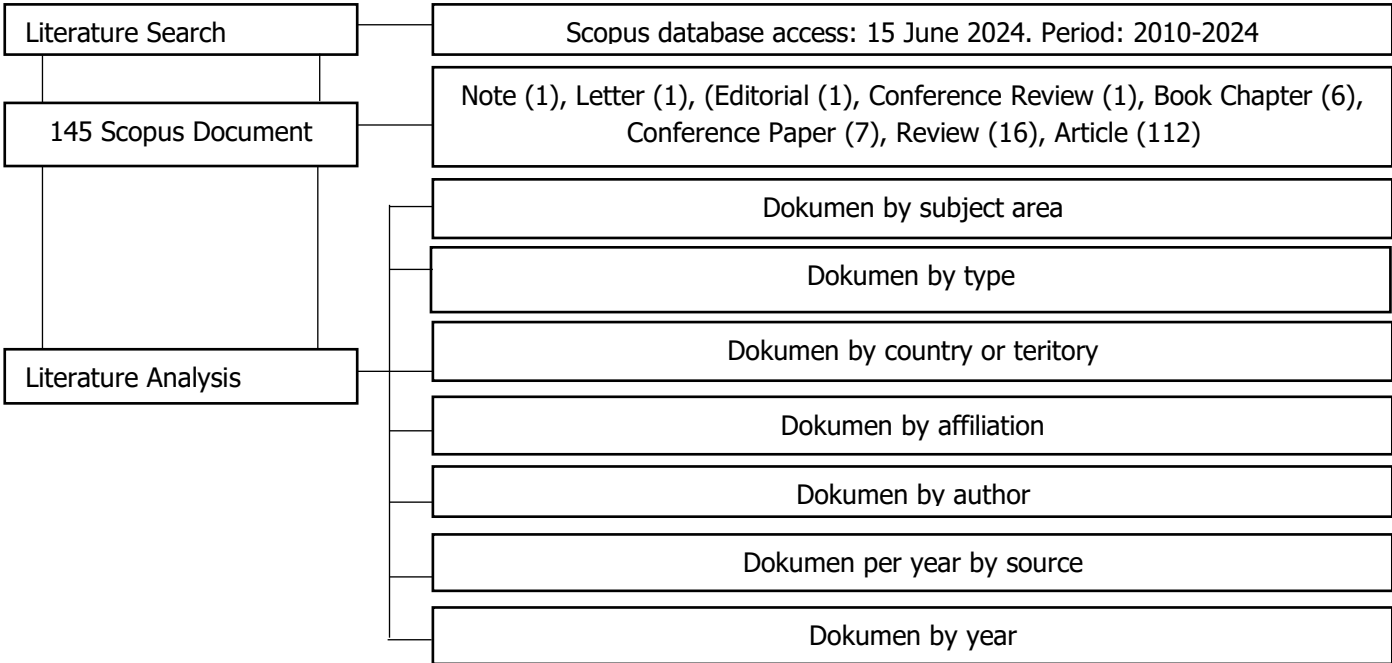The flow of this research can be seen in the following figure.

Literature Search	Scopus database access: 15 June 2024. Period: 2010-2024
145 Scopus Document	Note (1), Letter (1), (Editorial (1), Conference Review (1), Book Chapter (6), Conference Paper (7), Review (16), Article (112)
Literature Analysis	Dokumen by subject area
	Dokumen by type
	Dokumen by country or teritory
	Dokumen by affiliation
	Dokumen by author
	Dokumen per year by source
	Dokumen by year

Figure 1. The flow of data collection

The purpose of the data analysis and visualization in Figure 1 was to identify publication trends based on subject area, type, country or territory, affiliation, author, source, and year. The bibliometric analysis used the VOSViewer application to map research trends in stunting, water, and sanitation linkage research. VOSViewer is software for creating and visualizing web bibliographies. VOSViewer is primarily used when working with small and large data sets. It displays data maps and various analytical analyses (Shah et al., 2020).

RESULTS AND DISCUSSION

The results of research and discussion regarding the relationship between water and sanitation with the incidence of stunting in toddlers can be seen below.

a) Publication Trends by Subject Area
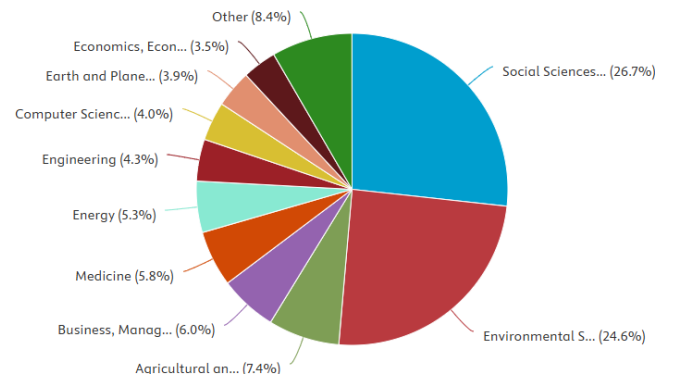Analysis of publication trends by subject area, as presented in Figure 2.

Figure 2. Percentage of publications by subject area
Source: Scopus Analysis

The bibliometric analysis reveals a multidisciplinary landscape in water, sanitation, and stunting research, with Medicine dominating at 34.6% of publications (Figure 2). This medical dominance suggests that the research field initially approached stunting as a clinical problem rather than a multifaceted developmental challenge. However, the substantial representation of Environmental Science (9.4%) and Social Sciences (7.5%) indicates an evolving understanding that stunting requires interdisciplinary

solutions. The prominence of Environmental Science and Social Sciences reflects a paradigm shift toward recognizing stunting as a complex socio-environmental problem. Otsuka et al., (2019) demonstrated this complexity by linking drinking water sources, water management, and hand-washing habits with both nutritional status and diarrhea prevalence, while also identifying socioeconomic factors such as household income as critical determinants. This disciplinary evolution suggests that early research may have been limited by narrow medical perspectives, potentially missing crucial environmental and social interventions that could be more cost-effective than clinical treatments.

b) Publication Trends by Document Type

Research articles dominate the publication landscape at 77.2% (Figure 3), indicating a field rich in original research but potentially lacking in synthesis and practical implementation guidance. The relatively low percentage of review articles suggests fragmented knowledge that may hinder policy development and clinical practice.
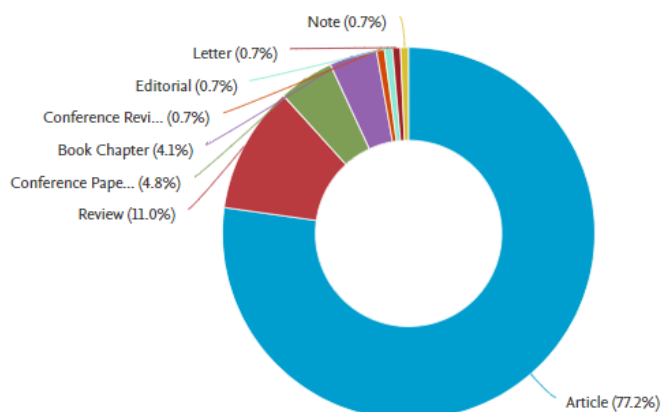

Figure 3. Percentage of publications by type
Source: Scopus Analysis

McKenna et al. (2017) exemplified the research depth by revealing the complex relationship between intestinal parasite infections (hookworm/Necator americanus) and stunting through environmental enteropathy mechanisms. This research demonstrates how poor sanitation creates pathogenic exposure pathways that inhibit linear growth, but the predominance of individual studies over systematic reviews may limit the translation of such findings into coherent intervention strategies. The high proportion of original research without corresponding synthesis work suggests that evidence-based policy development may be hampered by scattered findings rather than consolidated knowledge frameworks.

c) Geographic Research Patterns and Global Health Inequities

The United States leads with 64 publications, followed by the United Kingdom with 20 publications (Figure 4). This geographic distribution reveals a critical paradox: high-income countries with low stunting prevalence dominate research on a problem that predominantly affects low- and middle-income countries.
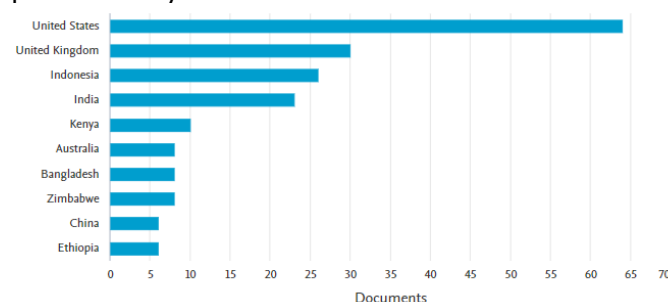

Figure 4. Percentage of publications by country or territory
Source: Scopus Analysis

This geographic imbalance raises questions about research relevance and applicability. While the United States and United Kingdom contribute valuable methodological rigor and funding, their research contexts may not adequately reflect the realities of resource-constrained settings where stunting is most prevalent. The emergence of Indonesia and other Asian countries in the research landscape suggests a positive trend toward more contextually relevant research, but the citation patterns indicate that Western research continues to dominate discourse, potentially perpetuating intervention approaches that may not be optimal for different socioeconomic contexts.

d) Institutional Leadership and Research Concentration

Johns Hopkins Bloomberg School of Public Health leads institutional productivity (Figure 5), followed by Cornell University and Emory University. This concentration of research in elite institutions has both advantages and limitations.
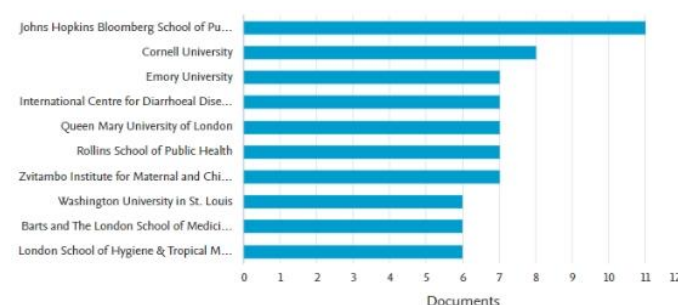

Figure 5. Percentage of publications by affiliation
Source: Scopus Analysis

Gough et al., (2020) from Johns Hopkins demonstrated sophisticated research on WASH interventions and environmental enteric dysfunction (EED), but the concentration of research expertise in wealthy institutions may limit the development of locally appropriate solutions and capacity building in affected regions. The involvement of institutions like the London School of Hygiene & Tropical Medicine and Zvitambo Institute for Maternal and Child Health Research indicates some geographic diversification, but the overall pattern suggests potential disconnect between research capacity and problem burden.

e) Author Productivity and Research Sustainability

Humphrey, J.H, et al., (2014)leads with 7 publications, while most other authors contribute 3-5 publications (Figure 6). This distribution suggests limited research sustainability and potential knowledge fragmentation.
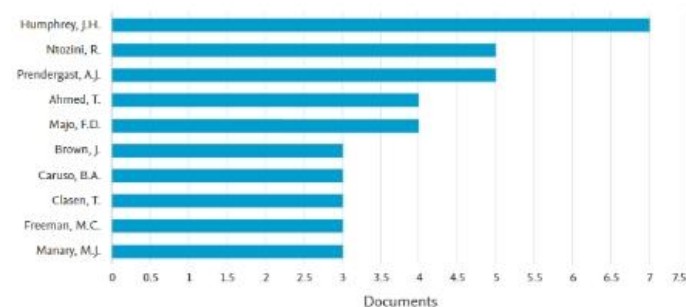

Figure 6. Percentage of publications by author
Source: Scopus Analysis

The research portfolio of leading authors like Humphrey, J.H. spans water quality impacts, pathogen exposure mechanisms, intervention evaluations, and longitudinal developmental studies. However, the relatively low publication numbers even among top researchers suggest that this field may lack the sustained, programmatic research efforts needed to build comprehensive evidence bases.

f) Journal Distribution and Research Focus Evolution

Maternal and Child Nutrition" shows the highest publication variability, peaking at 3 documents in 2019 (Figure 7). This pattern reflects shifting research priorities and potential publication bias toward specific aspects of the stunting-WASH relationship.
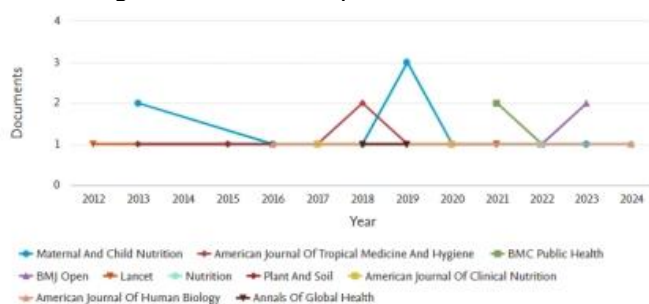

Figure 7. Graph of publications by source
Source: Scopus Analysis

De Vita et al. (2019) published in BMC Public Health demonstrated the field's evolution by examining environmental sanitation conditions in Banggai District, Indonesia, involving 1,889 families and 617 children aged 0-59 months. The study revealed 33.88% stunting prevalence and 24.96% underweight prevalence, but the publication pattern suggests that such large-scale epidemiological studies may be underrepresented in favor of smaller intervention trials. The diversity of journals

(including The Lancet, American Journal of Tropical Medicine and Hygiene, and American Journal of Human Biology) reflects the multidisciplinary nature of the field but may also indicate fragmented communication channels that limit knowledge integration.

g) Temporal Publication Trends and Research Momentum

Publications peaked in 2020 with 23 documents (Figure 8), followed by a decline, raising questions about research sustainability and priority shifts.
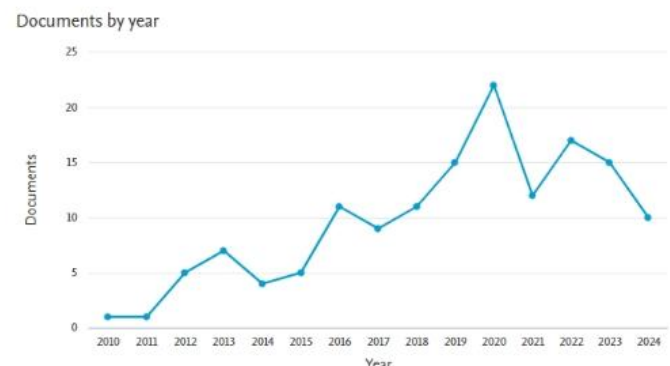

Figure 8. Graph of publications by year
Source: Scopus Analysis

The 2020 peak coincides with global health crises that may have redirected research attention and funding toward WASH-related health issues. McQuade et al., (2020) contributed to this peak with comprehensive WASH-stunting research, while other studies explored microplastic contamination (Bhattacharya & Khare, 2020), toxic chemical exposure (Raiten & Bremer, 2020), and household water safety. Ellis et al. (2020) examined environmental sanitation, child feces disposal practices, and clean play environments, representing the field's expanding scope. However, the post-2020 decline suggests that research momentum may be vulnerable to external funding cycles and competing global health priorities.

h) International Research Collaboration Patterns

The collaboration network reveals 5 distinct clusters (Figures 9 and 10), with the United States maintaining the highest total link strength (10,684), followed by the United Kingdom (7,358). This pattern suggests potential research colonialism where high-income countries drive research agendas in low-income settings.
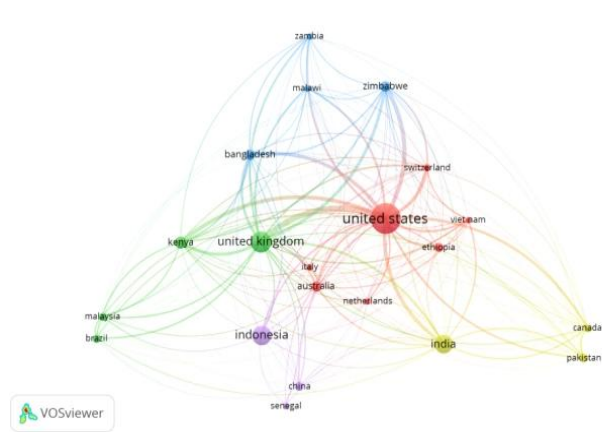
Figure 9. Collaboration between countries
Source: VOSViewer Analysis

Figure 9 shows cooperation between countries, as evidenced by the links between the country circles in the figure. This relationship reflects that there is a research collaboration that occurs between researchers from different countries in studying the relationship between stunting and water and sanitation. Figure 9 also shows that 5 clusters can be distinguished based on the color of the circles, namely clusters with red, blue, yellow, green, and purple circles. These clusters indicate that there are groups of countries that have a higher level of collaboration between them in the field of stunting. More details on cross-country research collaborations in the context of stunting-water-sanitation linkages can be seen in Figure 10, which provides a more detailed mapping of the cross-country linkages, the level of collaboration, and the clusters formed within the research collaborations. This information can provide a deeper understanding of the relationship between stunting and water and sanitation.

Table 1.
Bibliography Coupling Countries

No	Country	Documents	Citations	Total Link Strength
1	Zambia	3	223	1152
2	Malawi	3	108	1049
3	Viet Nam	3	90	1017
4	Netherlands	3	224	441
5	Italy	3	61	424
6	Senegal	3	1	298
7	Switzerland	4	675	1728
8	Canada	4	340	1253
9	Malaysia	5	452	689
10	Brazil	5	534	668
11	Pakistan	6	337	943
12	China	6	86	545
13	Zimbabwe	8	767	3248
14	Bangladesh	8	540	2427
15	Australia	8	285	1190
16	Kenya	10	922	3033
17	India	23	493	2721
18	Indonesia	26	306	899
19	United Kingdom	30	1764	7358

Source: VOSViewer Analysis

The threshold of minimum 3 documents reveals that only 21 countries meet basic collaboration criteria, suggesting that research capacity remains concentrated in relatively few countries. While the United States leads in publications (64) and citations (3,627), this dominance may reflect resource advantages rather than contextual expertise. The formation of regional clusters (South Asian, Southeast Asian) suggests promising developments toward more locally relevant research partnerships, but the overall pattern indicates that global research capacity building remains insufficient for addressing the worldwide stunting challenge.

i) Co-occurrence Analysis and Research Theme Integration

The co-occurrence analysis reveals three primary research clusters (Figure 10), but the keyword distribution suggests incomplete thematic integration that may limit comprehensive intervention development.
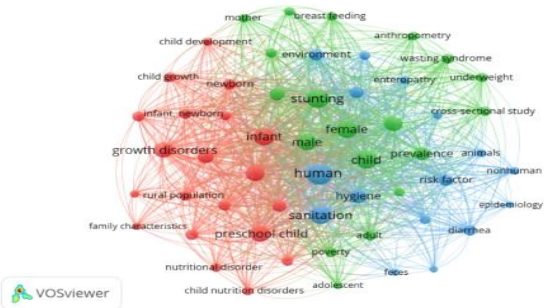
Figure 10. Co-occurrence of documents
Source: VOSViewer Analysis

Based on the cluster analysis conducted, there are three specific clusters that reflect fragmentation in stunting research. Cluster 1 (Red - Growth Disorders) represents a clinical-developmental perspective that focuses on measuring and understanding stunting outcomes through keywords such as "growth disorders," "infants," "preschool children," "malnutrition," "anthropometry," "birth weight," "cognitive development," and "motor development," however this cluster tends to inadequately address environmental causation pathways that influence stunting. Cluster 2 (Green - Stunting Epidemiology) emphasizes population-level patterns and risk identification with keywords including "stunting," "child," "prevalence," "risk factors," "determinants," "socioeconomic status," "household," "rural," "urban," and "gender," and while it successfully identifies risk factors at the population level, it lacks specific and actionable intervention guidance. Meanwhile, Cluster 3 (Blue - WASH Interventions) focuses on intervention mechanisms with keywords "sanitation," "human," "hygiene," "water quality," "diarrhea," "infection," "environmental enteropathy," "pathogen exposure," and "handwashing," which provides attention to concrete intervention strategies but tends not to adequately consider long-term developmental outcomes in children. The separation of these three clusters indicates potential disconnection between clinical understanding, epidemiological patterns, and intervention strategies in stunting research, where this fragmentation is suspected to be the main cause of contradictory research findings and limited effectiveness of interventions that have been implemented thus far.

CONCLUSION

This bibliometric analysis reveals critical research gaps in water, sanitation, and stunting research despite substantial multidisciplinary growth. Medicine dominates with 34.6% of publications, followed by nursing, agricultural, biological, and environmental sciences, with 77.2% being empirical studies. However, the dominance of research by the United States (64 publications) and United Kingdom creates a fundamental disconnect between research capacity and problem burden, where high-income countries drive research agendas for problems predominantly affecting low- and middle-income countries. Critical research gaps include contradictory intervention outcomes, where some studies report up to

Table 2.
Detailed Co-occurrence Cluster Analysis

Cluster	Color	Keywords (n)	Primary Focus	Representative Keywords	Critical Analysis
Cluster 1	Red	20	Growth disorders and child development	Growth disorders, infants, preschool children, malnutrition, anthropometry, birth weight, cognitive development, motor development	Clinical-developmental focus may miss environmental causation
Cluster 2	Green	19	Stunting epidemiology and prevalence	Stunting, child, prevalence, risk factors, determinants, socioeconomic status, household, rural, urban, gender	Epidemiological approach may lack intervention focus
Cluster 3	Blue	16	WASH interventions and hygiene	Sanitation, human, hygiene, water quality, diarrhea, infection, environmental enteropathy, pathogen exposure,	Intervention-focused but may lack long-term developmental perspective

20% stunting reduction through WASH interventions (Bhutta et al., 2013) while others demonstrate minimal impact (2.5% reduction), indicating gaps in understanding intervention mechanisms and contextual factors.

The peak in publications during 2020 followed by decline reveals concerning research sustainability driven by external funding cycles rather than sustained inquiry. Co-occurrence analysis reveals three distinct research clusters (growth disorders, sanitation/hygiene, and stunting prevalence) operating in isolation, representing fragmented research approaches. Future research must prioritize building research capacity in high-burden countries, developing integrated intervention frameworks that bridge biological, environmental, and social determinants, and establishing long-term longitudinal studies with adequate follow-up periods. Implementation science research specifically for WASH-stunting interventions, advanced methodological approaches incorporating systems science, and research addressing climate change impacts on WASH infrastructure are essential. The field requires a fundamental shift toward coordinated, problem-focused research networks that prioritize local expertise and long-term programmatic research to develop evidence-based, culturally appropriate interventions for effective implementation at scale.

SUGGESTION

Despite the progress made, there remain significant gaps in understanding effective interventions to combat stunting, especially in developing countries. The findings from this analysis highlight the need for continued

research to better understand the intersection of water, sanitation, and child health. More interdisciplinary efforts and international collaboration will be crucial in addressing the global stunting crisis.

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