Children's Health Outcomes Associated with Access to Water, Sanitation and Hygiene (WASH): A Systematic Review of Empirical Gaps Related to Diarrhoea in Low- and Middle-Income Countries

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Abstract

Sustainable Development Goal 3 (SDG 3) mandates global action to ensure healthy lives and promote well-being for all. However, child mortality in low- and middle-income countries (LMICs) remains alarmingly high due to inadequate access to clean water, hygiene, and sanitation. This systematic review critically examines empirical research linking water, sanitation, and hygiene (WASH) access to child health outcomes across LMICs, aiming to identify key empirical gaps related to diarrhoea, child development and stunting, and acute infections. A systematic literature review, conducted in June 2025 in accordance with PRISMA guidelines, searched databases including Taylor & Francis, EBSCOhost, and PubMed. Of 230 initial records, 48 empirical studies met the inclusion criteria of focusing on primary research examining children's health outcomes. Data were analyzed thematically to categorize dependent variables and assess research trends. Findings revealed a disproportionate focus on diarrhoea, which accounted for 62.5% of all dependent variables, underscoring its enduring global health significance. Child development and stunting accounted for 29.17%, while acute infections were the least studied (8.33%), exposing substantial research gaps. Geographically, studies were heavily concentrated in Ethiopia (29.0%) and India (25.8%), followed by Bangladesh, Kenya, Nigeria, Senegal, South Africa, and Nepal. Most research targeted children under five (83.3%), highlighting their vulnerability. "Specific WASH Components" (e.g., water supply, sanitation, handwashing) emerged as the most common independent variables. Significant theoretical, methodological, and empirical gaps were identified: 92.6% of studies lacked explicit theoretical frameworks, most relied on cross-sectional designs, and 96.6% failed to examine mediating or moderating variables. These limitations hinder understanding of the causal pathways linking WASH to child health outcomes. Future research should adopt longitudinal designs, integrate theoretical and socio-cultural determinants, and systematically explore mediating mechanisms to strengthen causal inference and inform effective, context-specific policies supporting SDG 3 targets.

Keywords: WASH, Child Health, Diarrhoea, Stunting, Systematic Review, Acute Infections, Public Health

1.0 Introduction and Background

Access to safe water, sanitation, and hygiene (WASH) is not merely a matter of public policy or infrastructure development; it is universally recognized as a fundamental human right and serves as the absolute cornerstone of global public health. The profound health benefits of adequate WASH services are well-established, yet despite considerable global progress, billions of people worldwide continue to lack these essential services, a deficiency that carries devastating consequences. This pervasive lack of access disproportionately impacts the most vulnerable population: children. Indeed, the absence of adequate WASH is a leading, yet entirely preventable, cause of disease and death, particularly for children who have not yet reached their fifth birthday. This systematic review synthesizes the current empirical evidence to delineate the critical and often tragic link between inadequate WASH and adverse child health outcomes, analyzing the problem through its biological, epidemiological, and policy dimensions at global, regional, and national scales.

Globally, the statistics detailing the deficit in basic WASH services are profoundly alarming. According to the World Health Organization (WHO) and UNICEF Joint Monitoring Programme (JMP) reports, vast populations are still without safely managed services. As of 2022, an estimated 2.2 billion people globally lacked safely managed drinking water, while an even higher number, 3.5 billion, lacked safely managed sanitation. Furthermore, approximately 2.3 billion people, nearly three in ten people worldwide, were unable to perform the most basic hygiene practice of washing their hands with soap and water at home. These staggering shortfalls have the most devastating effect on children, whose developing immune systems make them acutely vulnerable to infectious diseases.

The direct consequence of inadequate WASH is a wide spectrum of acute and chronic health issues in the child population. Diarrheal diseases stand out as the most prominent and deadliest outcomes of poor WASH. This category includes highly infectious conditions such as cholera, typhoid, and rotavirus. The annual burden is catastrophic: there are nearly 1.7 billion documented cases of childhood diarrheal disease globally each year. This results in an estimated 395,000 deaths among children under five years old annually, a mortality figure that is almost entirely preventable. These diseases are directly and tragically attributable to unsafe drinking water, inadequate sanitation

infrastructure, and poor personal and environmental hygiene. Beyond diarrhoea, a poor WASH environment is a fertile ground for the spread of other debilitating infections, including intestinal worms (such as roundworm and hookworm), polio, hepatitis, and trachoma, the latter being a leading cause of preventable blindness.

The impact of poor WASH extends far beyond acute infection to affect the long-term nutritional status and physical growth of children. Chronic exposure to faecal pathogens, even in cases where overt diarrhoea is not present, leads to a debilitating condition known as Environmental Enteropathy (EE). EE causes damage to the gut lining, which severely impairs the absorption of essential nutrients. This gut damage precipitates chronic malnutrition and, subsequently, stunting, which is characterized by impaired linear growth. Globally, an estimated 150.2 million children under five are stunted, a massive public health burden that is significantly linked to inadequate WASH through both EE and recurrent infections. Each new episode of diarrhoea acts to further exacerbate the existing malnutrition, creating a vicious, self-perpetuating cycle of illness, malabsorption, and poor growth that is difficult to break. Furthermore, inadequate WASH contributes to an increased risk of skin and eye infections (like impetigo and scabies) and reproductive and urinary tract infections, particularly affecting girls who lack private, safe sanitation facilities. The daily struggle for clean water and the profound lack of privacy for sanitation also inflict psychosocial impacts, including stress, anxiety, and shame, while also contributing to reduced school attendance, which further perpetuates cycles of poverty and gender inequality.

The magnitude of the challenge posed by inadequate WASH is most acutely felt in Sub-Saharan Africa (SSA). In this region, decades of systemic underinvestment in infrastructure, compounded by rapid population growth and entrenched socioeconomic disparities, have created a dire situation. As of 2022, only 31% of the population in SSA had access to safely managed drinking water, and an even smaller 24% had access to safely managed sanitation. Most alarmingly, 208 million people in the region still practice open defecation, a major driver of disease transmission. This pervasive lack of WASH services translates directly into a devastating health burden for the region's children. Diarrheal disease is ranked as the second leading cause of death for children under five in SSA, a region that disproportionately bears 53% of all WASH-attributable child

deaths globally. Stunting prevalence is also extremely high, affecting an estimated 35% of children aged 6–59 months.

Within Sub-Saharan Africa, Kenya serves as a potent example of the complex and persistent nature of these WASH-related challenges. While some progress has been made, significant disparities in WASH access remain, particularly in rural and informal urban settlements. Approximately 28 million Kenyans lack access to safe water, and 41 million lack access to improved sanitation facilities. A critical and specific public health threat is that 9.9 million people in Kenya rely on drinking directly from contaminated surface water, exposing them to an extremely high risk of waterborne diseases. For Kenyan children, these deficits result in a substantial burden of preventable illnesses. Diarrhoea consistently ranks among the top five causes of morbidity and mortality for children under five in the country. The Kenya Demographic and Health Survey (KDHS) 2022 reported that 14% of children under five had experienced diarrhoea-related symptoms in the two weeks preceding the survey. An estimated 80% of all childhood diseases in Kenya are directly attributable to unsafe drinking water. Furthermore, chronic WASH deficiencies significantly contribute to Kenya's high rate of childhood stunting, which affects over two million children (26% prevalence) nationally, with rates soaring as high as 46% in some counties. This evidence underscores an undeniable and multifaceted association between WASH and child health, highlighting the urgent need for robust, evidence-based, and sustained global action.

The problem, therefore, is an enduring deficiency in essential WASH services that creates a cascade of adverse health outcomes, with children bearing a disproportionately heavy burden. The absence of a comprehensive understanding of the complex pathways linking WASH deficiencies to poor child health, encompassing biological mechanisms, epidemiological patterns, and socioeconomic factors, inhibits the development of effective, evidence-based interventions. A thorough review of existing literature, as conducted here, is essential to synthesize evidence, identify empirical gaps, and inform targeted policy and programmatic actions to mitigate this preventable public health crisis and secure the well-being of children worldwide.

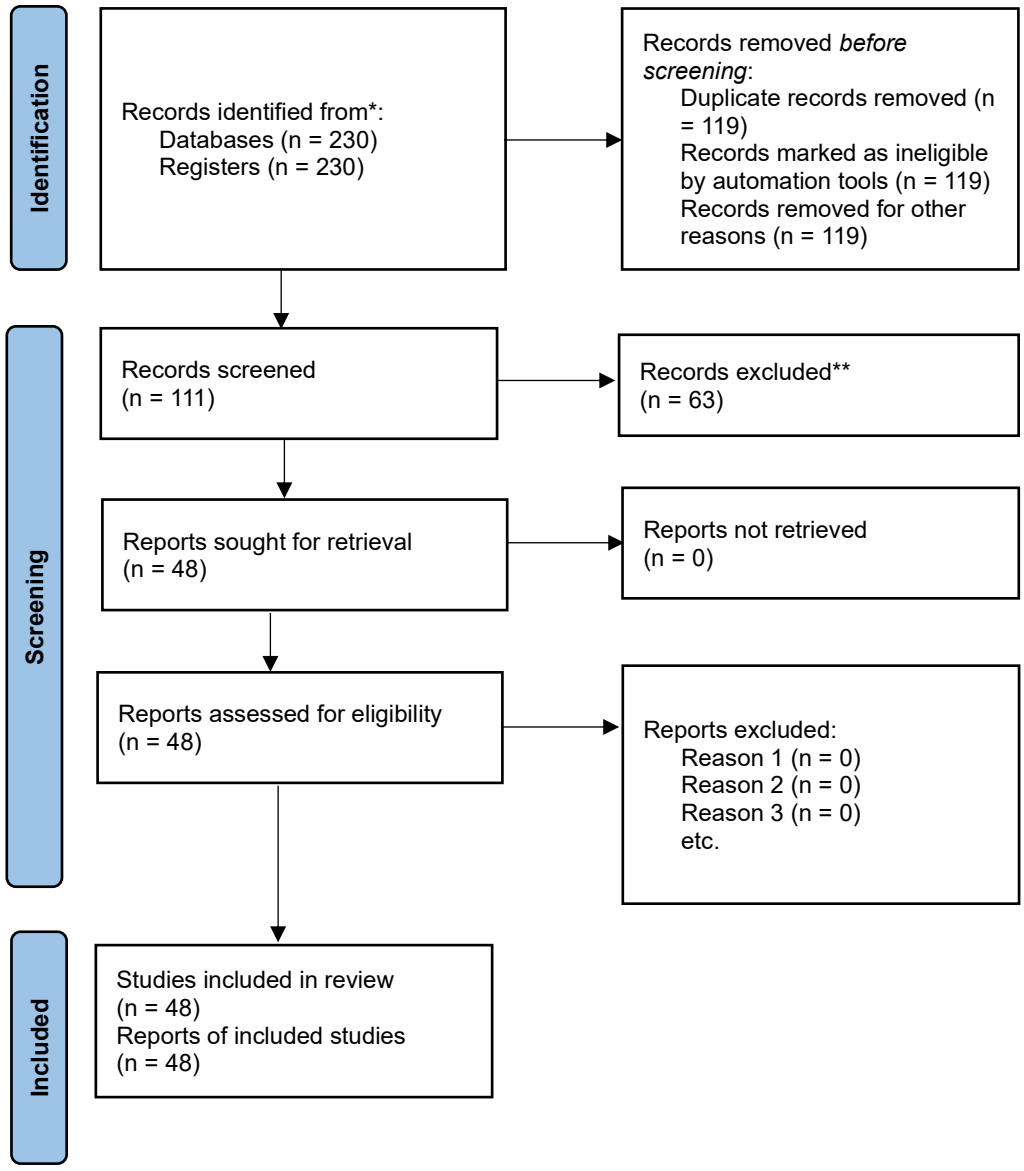
2.0 Systematic Review Findings on Diarrhoea and WASH

2.1 Methodology: The Systematic Review Process

The systematic review was conducted in June 2025 with the specific aim of identifying relevant empirical studies that link WASH to child health outcomes. The entire process adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which ensures a transparent and complete account of the research process, allowing readers and reviewers to appraise the work critically. The search queries were rigorously designed to capture research focusing on "Children's Health Outcomes Associated with Access to Water, Sanitation and Hygiene". Key search terms utilised included: Water, Sanitation and Hygiene (WASH), Children's health outcomes, Diarrhoea, Acute infections, and Child development. Multiple academic databases were employed to ensure a comprehensive search, including Taylor and Francis, Ebscohost, PubMed, Scopus, and Web of Science.

The PRISMA flow diagram illustrates the systematic refinement of the initially identified studies. The process began with a broad initial search that yielded 230 records across various databases. The first systematic step involved removing all duplicate records, which amounted to 119 eliminations, leaving a corpus of 111 unique records for screening. The screening phase involved assessing the remaining 111 records against strict inclusion and exclusion criteria based on their titles and abstracts. Inclusion Criteria mandated that the study be published in an empirical journal focused on primary research, with dependent variables directly related to children's health outcomes, nutritional status, or developmental indicators. Studies with multiple relevant outcomes were also included. Exclusion Criteria mandated the removal of non-empirical journals (e.g., theoretical papers, opinion pieces), secondary reviews or meta-analyses, and studies that did not employ inferential statistical methods. This stringent screening resulted in the exclusion of 63 records, leaving 48 reports for assessment of eligibility. All 48 full-text articles that proceeded to the eligibility phase were assessed and ultimately included, forming the final, highly relevant sample for in-depth content analysis.

PRISMA Flow Diagram



2.2 Diarrhoea as the Dominant Research Outcome

The content analysis, performed using a thematic approach, categorised the dependent variables from the 48 selected articles into three themes: Diarrhoea, Child Development & Stunting, and Acute Infections. The findings demonstrate that research efforts have been overwhelmingly concentrated on the topic of diarrhoea.

2.2.1 Frequency of Dependent Variables

Diarrhoea emerged as the most investigated Dependent Variable (DV), accounting for 30 instances, which represents a significant 62.50% of all outcomes tracked in the systematic review. This dominance underscores that the relationship between WASH interventions and diarrheal disease remains the central focus of public health research in this domain. The sheer volume of research on this topic underscores its ongoing status as a critical global health burden. In contrast, the second most-researched area, Child Development & Stunting, accounted for 14 mentions (29.17%), while Acute Infections (non-diarrheal) received the least attention, with only 4 mentions (8.33%).

Themes	Number of Dependent Variables	Percentage
Diarrhea	30	62.50%
Acute infections	4	8.33%
Child development & Stunting	14	29.17%

2.2.2 Focus of Research Questions

The intense focus on diarrhoea is further underscored by the nature of the research questions posed in the studies. The research question category: "Assess/Investigate/Evaluate the Impact/Association of WASH on Diarrhoea," stood in overwhelming prominence. This single category represented a staggering 23 instances, which accounts for a monumental 88.5% of all research questions and hypotheses encountered in the diarrhoea-related literature. This high concentration unequivocally confirms that the vast majority of studies are laser-focused on quantifying the direct relationship, measuring the effectiveness, and establishing the causal links between various WASH interventions and diarrheal disease outcomes. The objective of finding evidence-based solutions clearly drives the research agenda. In stark contrast, descriptive research questions aimed at merely assessing the current prevalence or status of diarrhoea and WASH practices appeared only 3 times, making up a mere 11.5% of the total. This suggests the field has

largely progressed beyond simply describing the problem to rigorously investigating actionable solutions.

2.2.3 Operationalization and Target Population

The primary method used for operationalizing diarrheal disease was "Caregiver/Mother Reported Diarrhoea," a method utilized in 64.5% of all instances. This approach typically follows the World Health Organization (WHO) guideline, which defines diarrhoea as three or more loose stools in a 24-hour period. The data collection most often relied on questionnaires and interviews conducted with mothers and caregivers.

The target population for this body of work was distinctly skewed towards the most vulnerable age bracket. Children under five (0–59 months) were the focus of a commanding 83.3% of all studies on diarrhoea. This intense concentration reflects the critical understanding that this age group has the highest vulnerability to diarrheal disease and that its impact is most significant on global childhood mortality rates.

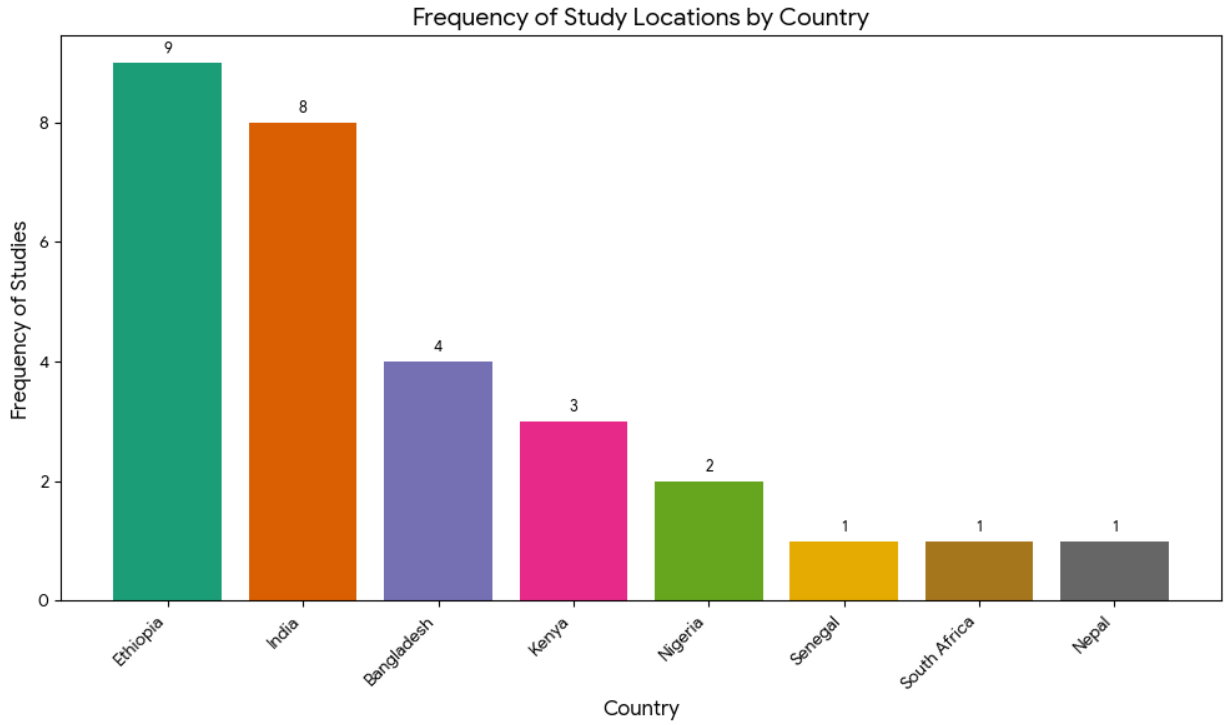
2.3 Geographical Concentration and Research Design

The systematic review identified a significant geographical concentration in the conducted research, raising questions about the generalizability of findings to other contexts.

2.3.1 Dominant Study Locations

Out of the 31 countries mentioned across the studies, a strong majority were concentrated in a handful of nations. Ethiopia was at the forefront of the research landscape, contributing 9 mentions (29.0%). This strong presence suggests either a high burden of WASH-related health issues, robust research infrastructure, or focused funding initiatives within the country. Following closely was India, with 8 instances (25.8%), whose vast population and diverse health challenges naturally position it as a frequent site for public health research efforts. Together, these two countries accounted for over half of all study locations identified. Bangladesh followed as the third most researched location (12.9%, n=4), with Kenya appearing 3 times (9.7%), and Nigeria contributing 2 mentions (6.5%). A final cluster of countries, including Senegal, South Africa, and Nepal,

appeared only once each (3.2% individually). The narrative is overwhelmingly defined by Ethiopia and India as the dominant research hubs, painting a picture that may not be globally representative.



2.3.2 Methodological Limitation: Over-reliance on Cross-Sectional Designs

A critical methodological finding across the studies, especially those concerning diarrhoea, was the reliance on a specific study design. The vast majority of the research employed a "Cross-sectional Study" design. While this design is useful for efficiently describing the prevalence of a disease and identifying simple statistical associations between variables, it has a significant limitation: it can only capture a single "snapshot" in time. This inherent limitation makes it difficult to establish definitive causal links between WASH interventions and diarrhoea outcomes, or to understand the disease's trajectory over time. This highlights a recognized and persistent gap in the research for more robust longitudinal studies that can effectively establish causality.

2.4 Gaps in Theoretical and Empirical Rigour

The systematic review highlighted profound gaps in the theoretical and empirical underpinnings of the research on WASH and diarrhoea, suggesting a prioritisation of pragmatic empirical investigation over deeper causal understanding.

2.4.1 Pervasive Theoretical Gaps

The most overwhelming finding regarding study theories was the category "No Specific Theory Mentioned / Not Explicitly Stated," which accounted for 25 instances, representing a monumental 92.6% of all mentions of theoretical frameworks. This absence of explicit theoretical engagement paints a clear picture: much of the research is driven by a pragmatic, problem-focused agenda, prioritizing the assessment of intervention effectiveness rather than formally situating the work within a defined theoretical lens.

This deficiency presents a major challenge for the field, as theoretical frameworks explaining diarrhoea in relation to WASH remain fragmented. Classic public health models, such as the F-diagram, are effective for mapping faecal–oral transmission routes but are insufficient for integrating emerging determinants. They inadequately account for complex factors such as climate variability, the challenges of rapid urbanization, and persistent socioeconomic inequality, which are known to influence exposure and vulnerability. Furthermore, behavioral compliance is severely under-theorized. For example, the persistence of open defecation despite the provision of improved latrines in places like Ethiopia and Odisha illustrates that infrastructure alone is not enough, yet socio-ecological factors like maternal agency, entrenched norms, and intra-household decision-making are often only described and not systematically integrated into formal theories of diarrhoea prevention. Finally, the vast majority of prevailing models fail to extend beyond diarrhoea as a short-term outcome, completely neglecting the crucial long-term developmental implications of recurrent episodes, such as cognitive delays and stunting. The absence of multi-level frameworks that integrate WASH, nutrition, environmental change, and socio-economic resilience severely limits the predictive capacity for emerging risks, such as climate-driven flooding, altering diarrheal transmission patterns.

2.4.2 Limited Analysis of Mediating and Moderating Variables

A significant empirical gap lies in the investigation of complex causal pathways. The concept of mediating variables, which explain *how* an intervention works, was found to be almost entirely neglected in the reviewed literature. The category "Not Applicable / Not Explicitly Tested / Not Stated" accounted for a staggering 28 instances, representing a monumental 96.6% of all mentions related to mediating variables. This indicates that the vast majority of studies were designed to assess direct impact rather than delving into the intricate 'how' or 'why' through mediating pathways.

Similarly, the investigation of moderating variables, which define *under what conditions* an intervention works best, also showed significant gaps. The category "Not Applicable / Not Explicitly Tested / Not Mentioned" accounted for 56.3% of all mentions related to moderation. This suggests a primary focus on establishing a general, main effect, without exploring how that effect might differ across various subgroups (e.g., age, gender, ethnicity) or contextual factors (e.g., wet vs. dry season, urban vs. rural). Without understanding these critical pathways and conditionalities, policymakers are left with an incomplete picture of how to implement best and optimize WASH programs for diverse populations.

2.4.3 Empirical Measurement Limitations

Beyond the gaps in causal modelling, empirical evidence linking WASH to reduced diarrhoea faces practical measurement limitations. Many studies rely solely on the aforementioned caregiver-reported diarrhoea, which is inherently vulnerable to both recall bias (accuracy decreases over time) and social desirability bias (a tendency to report desirable hygiene behaviours), and critically lacks clinical or microbiological confirmation of the etiological agents. Furthermore, while water contamination is a known precursor, environmental exposure mapping is rarely systematically paired with health outcomes. For example, even studies that found associations between sanitation, water purification, and child anthropometry in places like Nepal lacked the pathogen-specific data required to confirm that the observed reduction in diarrhoea risk was indeed due to reduced contamination. Finally, the disaggregation of findings by age, gender, and

socioeconomic status is also frequently limited, obscuring the identification of high-risk subgroups who require targeted interventions.

3.0 Conclusion

This systematic review provides a synthesized and critical view of the empirical evidence concerning the relationship between Water, Sanitation, and Hygiene (WASH) interventions and child health, with a pronounced focus on the outcome of diarrhoea. The analysis of 48 empirical studies revealed a clear picture of the research landscape: it is heavily skewed toward a singular area of inquiry. Diarrhoea emerged as the most frequently studied topic, accounting for 62.5% of the dependent variables analyzed, underscoring its continued status as a paramount global public health burden and the persistent focus of academic research. This concentration, while logical given the mortality burden, suggests an under-investigation of other critical outcomes, such as Acute Infections (8.34%).

The current body of evidence, however, is characterized not only by its breadth of focus on diarrhoea but also by significant methodological and theoretical limitations that restrict the utility and strength of its conclusions. The single most critical methodological gap is the heavy reliance on cross-sectional studies. This design, by its nature, is incapable of establishing the definitive cause-and-effect relationships necessary to make strong, evidence-based claims about the true efficacy of WASH interventions. Furthermore, there is a severe and notable absence of a consistent theoretical framework to guide the research, with 92.6% of studies failing to reference a specific theory. This makes it difficult to build a cumulative, coherent, and predictive body of knowledge, as the underlying causal mechanisms are not formally explored.

The research is also limited by its lack of geographical diversity, with studies heavily concentrated in a few settings, most notably Ethiopia and India. This concentration raises significant concerns about the generalizability of findings to other contexts with vastly different cultural, economic, and environmental conditions. Finally, the evidence base is profoundly weak in its exploration of mediating and moderating variables. Without a robust understanding of the pathways through which an intervention works (mediators, 96.6% not tested) or the contextual conditions that

influence its effectiveness (moderators), policymakers are provided with an incomplete and insufficient picture of how to implement these programs optimally in the real world.

To overcome these pervasive limitations, future research must adopt more rigorous, longitudinal designs to move beyond simple association and establish definitive causality. It is imperative to explicitly integrate socio-cultural determinants and formal theoretical frameworks into study designs to understand better the 'why' and 'how' of the WASH-health link. Furthermore, a systematic exploration of mediating and moderating variables is essential for fully understanding the complex pathways linking WASH to child health outcomes and for developing interventions that are tailored, effective, and sustainable across diverse settings. Future efforts must also adopt an explicit equity focus, ensuring that disaggregated analyses are used to identify who is being reached, who is being excluded (based on socio-economic status, gender, ethnicity), and why, thereby ensuring that solutions are not only technically feasible but also politically viable and culturally resonant.

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