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Review Article

The Malnutrition-Infection Cycle in Children Under Five: A Systematic Review and the GROW-WELL Integrated Nutrition and WASH Model

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ABSTRACT

Malnutrition and infection are closely interrelated in children under five, with inadequate nutrition increasing susceptibility to infection and illness further compromising nutritional status. Water, sanitation, and hygiene (WASH) conditions can intensify this cycle, yet nutrition and WASH interventions are often implemented separately. This review examines the evidence on the relationship between malnutrition and infection and the potential value of integrated approaches. A systematic review was conducted using searches of PubMed, ScienceDirect, Dimensions AI, and the World Health Organization repository. The review included 16 publications: 11 empirical studies and five policy documents. Two reviewers independently screened records, and methodological quality was assessed using the Mixed Methods Appraisal Tool (MMAT, 2018) for empirical studies and the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument for policy documents. Findings were synthesized narratively. The included literature highlighted interconnected relationships among nutritional status, infectious disease, and environmental conditions, including inadequate water, sanitation, and hygiene. Nutrition-specific interventions and WASH measures addressed complementary pathways, although findings on the effectiveness of combined interventions were heterogeneous. The evidence therefore supports considering nutrition and WASH together while underscoring the need to account for contextual factors, implementation challenges, and differences in intervention design. Drawing on the synthesis, the review proposes the GROW-WELL integrated nutrition and WASH model to illustrate how coordinated actions could address multiple pathways contributing to the malnutrition–infection cycle. The findings highlight the importance of understanding malnutrition and infection as interconnected challenges and suggest that coordinated nutrition and WASH strategies warrant further investigation. GROW-WELL is an evidence-informed conceptual framework derived from the reviewed literature; it has not yet been validated through pilot implementation or empirical evaluation. Future research should assess its feasibility, acceptability, and effectiveness in diverse settings before conclusions about its practical impact can be drawn.

Keywords: *Child Development, Children Under Five, Health Literacy, Infection, Integrated Interventions, Malnutrition, Wash*

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1. INTRODUCTION

Childhood malnutrition and infectious diseases remain major threats to child survival and development, particularly in low- and middle-income countries (LMICs) (Ijaiya *et al.*, 2024). Despite progress in global child health, undernutrition remains widespread, with stunting, wasting and underweight reflecting persistent inequalities in children's living conditions and access to essential services. The 2023 Joint Child Malnutrition Estimates reported that approximately 148 million children under five years were affected by stunting and 45 million by wasting globally in 2022, with the burden concentrated in Africa and Asia (UNICEF, World Health Organization, & World Bank Group, 2023). Malnutrition increases susceptibility to infections, including diarrhoea, pneumonia and malaria, through impaired immune function and reduced physiological resilience. Infection, in turn, can worsen nutritional status, contributing to preventable morbidity and mortality (Morales *et al.*, 2023). The consequences may extend beyond immediate illness to impaired cognitive development, educational attainment and long-term productivity (Morales *et al.*, 2023; Mwene-Batu *et al.*, 2020).

The relationship between malnutrition and infection is bidirectional. Inadequate nutrient intake can weaken immune responses and compromise the body's ability to resist pathogens. Conversely, infections can reduce appetite, increase metabolic requirements, cause nutrient losses and impair absorption, particularly during diarrhoeal illness. These processes can interrupt normal growth and contribute to recurrent illness and persistent growth faltering (Munteanu & Schwartz, 2022). Consequently, addressing nutritional deficiencies without reducing infection risks—or managing infections without supporting nutritional recovery—may leave important contributors to the cycle unresolved.

This cycle is also shaped by social, behavioural and environmental conditions. Poverty, household food insecurity, limited dietary diversity, unsafe water, inadequate sanitation and poor hygiene can increase children's exposure to infection and constrain recovery. Caregiver knowledge, feeding practices, cultural contexts and access to health information may further influence the use of preventive and therapeutic measures (Lubis, 2025). These interacting determinants indicate that childhood malnutrition cannot be understood solely as a problem of insufficient food intake; it must also be considered in relation to household environments, infection exposure and access to health services.

Existing responses include Community-based Management of Acute Malnutrition (CMAM), infant and young child feeding programmes, growth monitoring, Integrated Management of Childhood Illness (IMCI), oral rehydration therapy and water, sanitation and hygiene (WASH) interventions. Although these approaches address important aspects of child health, they may be delivered through separate programmes, funding arrangements and monitoring systems. Nutrition interventions primarily target dietary intake and nutritional status, whereas WASH interventions seek to reduce environmental exposure to pathogens. However, improvements in one area may be insufficient when risks in the other remain unaddressed. Coordinated delivery is therefore a plausible strategy for addressing the multiple pathways involved, although the effectiveness of combined interventions must be assessed in light of differences in intervention design, context and outcomes.

Previous reviews have examined nutrition interventions, behavioural strategies and WASH approaches, while evidence on integrated nutrition–WASH interventions also highlights the importance of implementation and delivery arrangements. However, synthesising intervention outcomes alongside the practical requirements for coordination across community and primary healthcare systems remains important (Adugna *et al.*, 2026). The contribution of this review is to bring together evidence on the biological, environmental and social pathways linking malnutrition and infection, findings on integrated intervention approaches, and considerations affecting their implementation. It also uses the synthesis to develop the GROW-WELL Integrated Nutrition and WASH Model as an evidence-informed conceptual framework. The model is proposed to organise complementary actions across household, community and health-service levels; it is not presented as a validated intervention.

1.1. Accordingly, This Systematic Review Had Four Objectives

- To synthesise evidence on the biological, environmental and social pathways contributing to the malnutrition–infection cycle among children under five years.
- To examine evidence on the effectiveness of integrated nutrition and WASH interventions in comparison with single-sector or standard approaches.
- To identify implementation barriers and facilitators that influence the delivery of integrated nutrition and WASH interventions.
- To develop the GROW-WELL Integrated Nutrition and WASH Model from the synthesised evidence and relevant policy guidance, identifying priorities for future implementation and evaluation.

2. LITERATURE REVIEW

2.1. The Malnutrition–Infection Cycle: Biological and Environmental Pathways

The relationship between nutrition and infection is reciprocal rather than linear. Inadequate nutrient intake can compromise immune function, while infection can reduce food intake, increase nutrient requirements and interfere with nutrient absorption. These processes can reinforce one another, leaving children vulnerable to repeated illness and impaired growth. Evidence concerning the effects of malnutrition on immune function supports the importance of considering nutritional status and infection risk together rather than as independent clinical concerns (Morales *et al.*, 2023; Munteanu & Schwartz, 2022). The long-term consequences of severe childhood malnutrition also extend beyond physical growth, with evidence of associations with later cognitive, academic and behavioural outcomes (Mwene-Batu *et al.*, 2020).

Environmental conditions can intensify these biological pathways. Unsafe water, inadequate sanitation and poor hygiene increase opportunities for exposure to enteric pathogens, while food insecurity and limited dietary diversity can constrain children's nutritional recovery. The association between household WASH conditions and undernutrition suggests that nutritional outcomes are influenced by conditions extending beyond food availability alone. Caregiver knowledge and practices also shape feeding, hygiene and care-seeking behaviours, although the extent to which knowledge translates into sustained behaviour depends on household resources and access to services (Lubis, 2025). Taken together, these findings support a multilevel understanding of the malnutrition–infection cycle involving biological vulnerability, environmental exposure and the conditions under which families provide care.

2.2. Nutrition and WASH Interventions: Complementary Aims and Uneven Evidence

Nutrition interventions, including infant and young child feeding support, growth monitoring and the prevention and management of acute malnutrition, seek to improve dietary intake, identify nutritional risk and support recovery. WASH interventions target environmental routes of pathogen transmission through measures such as safer water, sanitation and handwashing. These intervention categories address different but potentially interacting determinants of child health. Their conceptual complementarity, however, does not establish that combining them will consistently produce better outcomes than implementing them separately.

Research on integrated nutrition and WASH interventions has examined outcomes including child growth, diarrhoeal disease, feeding practices, dietary diversity and hygiene behaviours. Findings across intervention studies have not been uniform, reflecting differences in programme components, implementation intensity, populations, settings and outcome measures. Consequently, evidence of improvement in one outcome or setting should not automatically be interpreted as evidence of an equivalent benefit across all nutritional and infectious outcomes. Integrated approaches should therefore be assessed according to the specific intervention delivered, the outcomes measured and the context in which implementation occurred.

The literature on integrated nutrition and early-childhood interventions also highlights the relevance of delivery arrangements and complementary support. Dulal *et al.* (2021) examined integrated nutrition and stimulation interventions, while Adugna *et al.* (2026) considered associations between exposure to nutrition and WASH interventions and children's academic performance. Such work broadens the discussion beyond immediate anthropometric outcomes and reinforces the importance of examining how intervention combinations relate to wider aspects of child development. Nevertheless, evidence from different intervention types and outcomes must be interpreted carefully; findings from nutrition-and-stimulation programmes, for example, cannot be assumed to demonstrate the effectiveness of every nutrition–WASH combination.

2.3. Implementation, Caregiver Engagement and Health-System Coordination

Intervention effectiveness depends not only on what is delivered but also on how services reach children and caregivers. Community-based platforms can support nutrition counselling, feeding practices, growth monitoring, hygiene promotion and referral to formal healthcare. Caregiver engagement is particularly relevant because the sustained adoption of recommended practices may depend on whether families have the knowledge, resources and practical support required to implement them. Integrated delivery may also create opportunities to coordinate services and reduce fragmentation, but coordination itself requires functioning referral pathways, appropriate staff capacity and alignment between programme responsibilities.

The literature therefore points to an important distinction between the theoretical value of integration and its operational feasibility. Combining nutrition and WASH activities may address several contributing pathways, yet poorly coordinated implementation may create additional demands without ensuring that children receive effective or continuous support. Assessment of integrated programmes should consequently consider implementation barriers and facilitators alongside health outcomes. Relevant considerations include community participation, caregiver support, service accessibility, workforce capacity and the ability of primary healthcare systems to connect preventive and

therapeutic activities. These issues are essential to understanding whether integrated approaches can be delivered consistently and adapted to different settings.

2.4. Research Gap and Rationale for the GROW-WELL Framework

The literature establishes a strong rationale for addressing nutritional vulnerability, infection exposure and environmental risks as interconnected concerns. It also shows why intervention effects should be interpreted in relation to programme design and context. However, evidence about individual intervention components, combined outcomes and implementation requirements does not by itself provide a single operational structure for organising coordinated action across household, community and healthcare levels. A further synthesis is therefore needed to connect the pathways sustaining the malnutrition–infection cycle with intervention options and the practical considerations that influence delivery.

This review addresses that need by synthesising empirical studies alongside relevant policy and guideline documents. The empirical evidence informs understanding of observed health outcomes and implementation experiences, while policy documents contribute recommendations for service delivery and multisectoral coordination. These sources serve related but distinct purposes: policy recommendations can guide programme design, but they should not be treated as equivalent to empirical demonstrations of intervention effectiveness.

The resulting GROW-WELL Integrated Nutrition and WASH Model is proposed as an evidence-informed conceptual framework for organising complementary actions in growth monitoring, responsive feeding, oral rehydration and infection management, water safety and sanitation, caregiver empowerment, and linkage to health services. Its purpose is to connect interventions that may otherwise operate separately and to make their intended relationships explicit. The framework is a synthesis-derived proposal rather than a tested intervention. Its feasibility, acceptability, implementation requirements and effects on child health outcomes require evaluation before its practical effectiveness can be established.

3. METHODOLOGY

3.1. Review Design and Reporting Framework

This systematic review was conducted to synthesise evidence on the malnutrition-infection cycle among children under five years and evaluate the effectiveness of integrated nutrition and Water, Sanitation and Hygiene (WASH) interventions. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement, which provides guidance for transparent and reproducible reporting of systematic reviews (Page *et al.*, 2021). A structured review approach was adopted to identify, appraise and synthesise evidence relevant to biological pathways, intervention effectiveness and implementation strategies addressing childhood malnutrition and infection.

3.2. Protocol Registration

This review was not prospectively registered in PROSPERO or another systematic review database. However, methodological procedures, including eligibility criteria, search strategy, study selection, quality appraisal and synthesis methods, were predefined and documented to improve transparency and reproducibility.

3.3. Eligibility Criteria

Studies were selected using the Population, Intervention, Comparator, Outcomes and Study design (PICOS) framework (Amir-Behghadami & Janati, 2020). Eligible empirical studies included research published from January 2015 to the search date (August 9, 2026) involving children under five years where outcomes related to malnutrition, infection, growth, morbidity or child health were reported.

Studies were included if they evaluated nutrition interventions, WASH interventions, integrated nutrition-WASH approaches, or examined relationships between nutritional status, infectious diseases, environmental exposures and caregiver practices. Eligible interventions included infant and young child feeding support, micronutrient interventions, growth monitoring, water quality improvement, sanitation promotion, hygiene interventions, infection prevention and management, and combined nutrition-WASH strategies delivered through household, community or primary healthcare platforms.

Eligible comparators included standard care, no intervention or single-sector interventions such as nutrition-only or WASH-only approaches. Outcomes of interest included anthropometric indicators, childhood infection morbidity, diarrhoeal disease, caregiver knowledge and practices, intervention coverage, implementation processes and health-system factors influencing integrated delivery.

Eligible study designs included randomised controlled trials, cluster randomised controlled trials, quasi-experimental studies, cohort studies, cross-sectional studies, mixed-methods studies and qualitative studies reporting relevant implementation findings. In addition, policy and guideline documents developed by recognised international

organisations, including WHO, UNICEF and other United Nations agencies, were included when they provided evidence-informed recommendations related to childhood malnutrition prevention, WASH integration, early childhood development, wasting management or public health implementation strategies.

Studies were excluded if they involved children older than five years without separately reported under-five data, assessed interventions unrelated to nutrition or WASH, lacked relevant child health outcomes, or were protocols, editorials, commentaries, conference abstracts, case reports, systematic reviews or meta-analyses. Non-English publications and documents lacking sufficient methodological or contextual information were also excluded.

3.4. Information Sources and Search Strategy

A comprehensive search was conducted to identify empirical studies and policy or guideline documents relevant to the malnutrition-infection cycle and integrated nutrition-WASH interventions among children under five years. Electronic databases, including PubMed, Dimensions AI and ScienceDirect, were searched for peer-reviewed empirical studies published from January 2015 to August 9, 2026. The World Health Organization (WHO) institutional repository was searched separately for relevant policy documents, technical reports and evidence-based guidelines addressing childhood malnutrition, wasting prevention and management, early childhood development, nutrition actions and integrated WASH strategies.

The search strategy incorporated controlled vocabulary and free-text terms related to childhood malnutrition, infectious diseases, WASH interventions and integrated child health approaches. PubMed searches included Medical Subject Headings (MeSH) terms to improve retrieval consistency through standardised biomedical concepts (Lipscomb, 2000). Boolean operators were applied, with “OR” used to combine related terms and synonyms and “AND” used to connect conceptual domains and improve search specificity (Bramer *et al*., 2018).

The complete search strategies are provided in the Supplementary File. Reference lists of included empirical studies and policy documents were screened to identify additional eligible publications.

3.5. Study Selection Process

All retrieved records were exported, and duplicate records were removed before screening. Titles and abstracts were independently assessed by two reviewers against the predefined eligibility criteria, followed by full-text assessment of potentially eligible records. Disagreements between reviewers during title and abstract screening and full-text assessment were resolved through discussion until agreement was reached. The reasons for excluding records at the full-text stage were documented. The final selection process is presented in the PRISMA flow diagram (Figure 1).

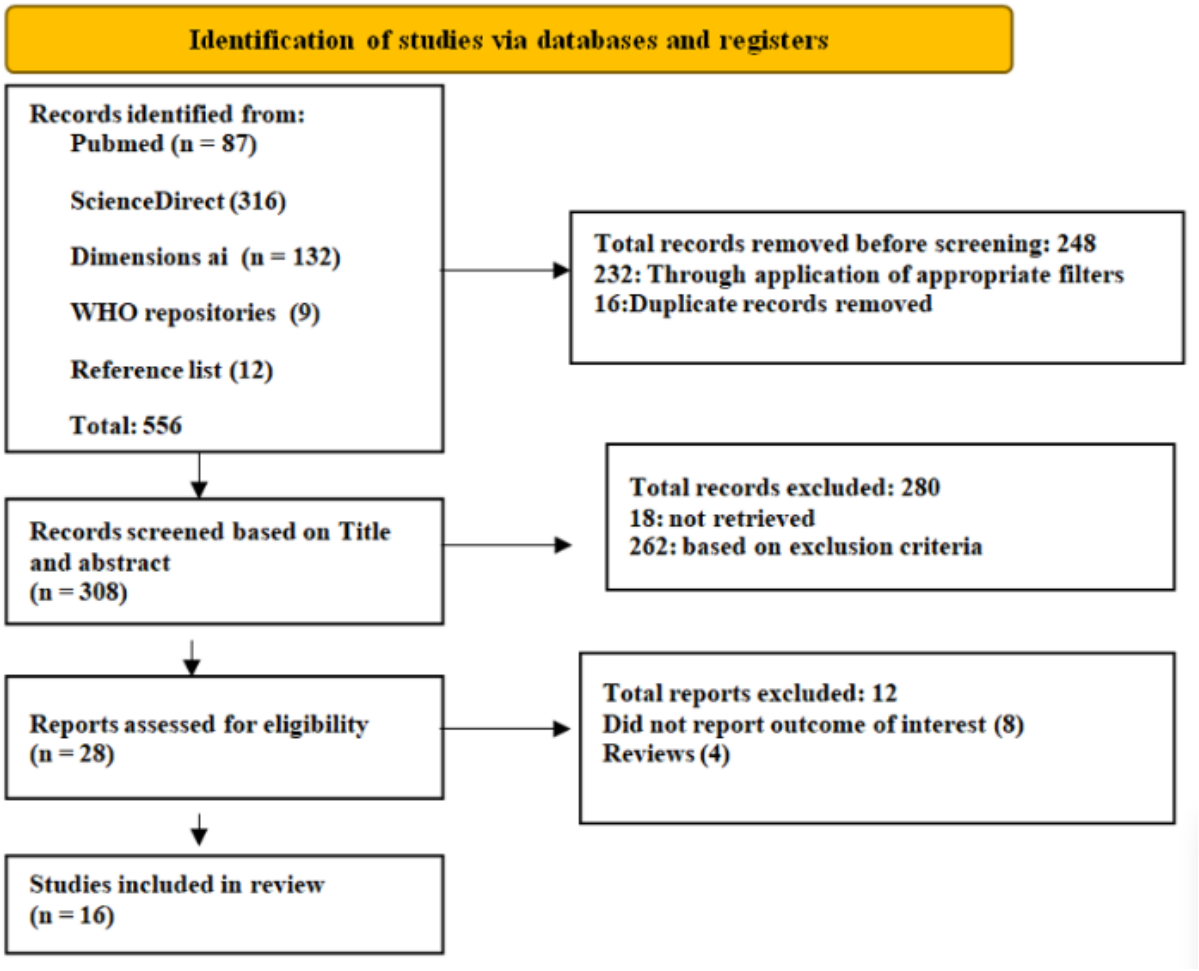


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Flow Diagram.

3.6. Data Extraction

A standardised data extraction framework was used to collect information from both empirical studies and policy documents. For empirical studies, extracted data included author and year of publication, country, study setting, design, population characteristics, sample size, intervention or exposure characteristics, comparator, intervention duration, delivery platform, outcomes, major findings and implementation factors.

For policy and guideline documents, extracted information included issuing organisation, publication year, geographical scope, document purpose, target population, major recommendations, implementation priorities and relevance to the development of the GROW-WELL Integrated Nutrition and WASH Model.

Data extraction focused on identifying intervention components, mechanisms of action, barriers, facilitators and delivery approaches across both evidence categories. Findings were organised into evidence tables and used to guide thematic synthesis and development of the GROW-WELL framework.

3.7. Quality Assessment

Quality appraisal was conducted according to the type of evidence included. Empirical studies were assessed using the Mixed Methods Appraisal Tool (MMAT), Version 2018 (Hong *et al.*, 2018), while policy and guideline documents were assessed using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument (Hoffmann-Eßer *et al.*, 2017).

The MMAT was selected because the empirical evidence included diverse study designs requiring design-specific appraisal criteria. Assessment domains included study design appropriateness, sampling, outcome measurement, risk of bias and analytical methods. Policy and guideline documents were evaluated using AGREE II across six domains: scope and purpose, stakeholder involvement, rigour of development, clarity of presentation, applicability and editorial independence.

Quality assessments were conducted separately for each evidence category. Disagreements between reviewers during quality assessment were resolved through discussion until agreement was reached. Detailed appraisal results are provided in the Supplementary File. The appraisal findings were considered when interpreting the strengths and limitations of the evidence informing the GROW-WELL Integrated Nutrition and WASH Model.

3.8. Data Synthesis

A narrative synthesis approach was adopted due to heterogeneity in study designs, interventions, populations and outcome measures. Findings were organised thematically around biological and social pathways of the malnutrition-infection cycle, intervention effectiveness, implementation barriers and enabling factors. Evidence from empirical studies and policy documents was integrated to develop the GROW-WELL Integrated Nutrition and WASH Model.

4. RESULTS AND DISCUSSION

4.1. Overview of Included Studies

A total of 16 publications met the review's eligibility criteria, comprising 11 empirical studies and five policy and guideline documents. The empirical evidence included cluster randomised controlled trials, observational research, mixed-methods studies, quasi-experimental research and an environmental exposure assessment. The included studies examined childhood nutritional outcomes, infectious disease risks, household water, sanitation and hygiene (WASH) conditions, caregiver practices, and approaches to delivering nutrition and WASH interventions. Table 1 summarises the characteristics of the empirical studies, while Table 2 presents the included policy and guideline documents.

The empirical studies were conducted in Bangladesh, Kenya, Zimbabwe, Uganda and Sri Lanka, predominantly in low- and middle-income settings. Their populations and units of analysis varied, ranging from large population-based samples to children, pregnant women, caregivers and households participating in community interventions. Hasan *et al.* (2023), for example, analysed data from 30,514 children under five years in Bangladesh to investigate associations between household WASH conditions and nutritional outcomes. The WASH Benefits studies in Bangladesh and Kenya examined nutrition and WASH intervention packages in relation to child health and development outcomes (Luby *et al.*, 2018; Null *et al.*, 2018; Stewart *et al.*, 2018; Tofail *et al.*, 2018). Other studies investigated intervention implementation and environmental exposure (Pickering *et al.*, 2018; Rahman *et al.*, 2018), agriculture, nutrition and WASH integration (Wegmüller *et al.*, 2022), community-based nutrition and WASH promotion (Matsungo *et al.*, 2023), care group-based nutrition education in refugee settlements in Uganda (Komakech *et al.*, 2024), and community nutrition education in Sri Lanka (Wijesinghe *et al.*, 2025).

Intervention components and delivery platforms differed across studies. These included feeding and nutrition education, growth monitoring, household hygiene promotion, water safety, sanitation-related activities, community support groups and programme monitoring. The variation in study designs, populations, intervention components and outcomes provided evidence relevant to several dimensions of the malnutrition–infection cycle, but also limited direct comparability across studies.

The five policy and guideline documents provided complementary guidance on the epidemiology, prevention and management of childhood malnutrition and on integrated child health programming. These comprised the global estimates of child malnutrition published by UNICEF, WHO and the World Bank Group (2023); WHO guidance on early childhood development (WHO, 2020), essential nutrition actions (WHO, 2019), and the prevention and management of wasting and nutritional oedema (WHO, 2023); and the Global Action Plan on Child Wasting developed by WHO (2020). Together, these documents informed the review's consideration of nutrition services, responsive caregiving, early identification and management of nutritional risk, and coordination across health and WASH systems. They were treated as policy and implementation evidence rather than as primary empirical evaluations of intervention effectiveness.

Table 1. Characteristics of Included Empirical Studies.

Study ID	Country/Setting	Study Design	Population/Sample Size	Intervention/Exposure	Comparator	Main Outcomes
Hasan *et al.* (2023)	Bangladesh	Cross-sectional secondary analysis	Children aged 0–59 months (n=30,514)	Household WASH access	Children with adequate WASH access	Stunting, wasting, underweight
Matsungo *et al.* (2023)	Rural Zimbabwe	Mixed-methods retrospective cohort	Infants and young children participating in care groups	Care group nutrition and WASH promotion	Non-participating households	Feeding practices, dietary diversity, WASH behaviours, nutrition outcomes
Rahman *et al.* (2018)	Rural Bangladesh	Intervention implementation study within cluster RCT	4,169 households	WASH and nutrition intervention monitoring	Different intervention arms	Coverage, adoption and implementation fidelity
Pickering *et al.* (2018)	Rural Bangladesh	Prospective environmental exposure study	1,843 households with children 0–60 months	Environmental contamination assessment	Comparison of exposure levels	Diarrhoea occurrence and contamination pathways
Wegmüller *et al.* (2022)	Western Kenya	Cluster randomised controlled trial	Children aged 6–35 months (n=1,927)	Agriculture, nutrition and WASH package	Agriculture programme without integrated components	Growth, dietary diversity, morbidity
Wijesinghe *et al.* (2025)	Sri Lanka	Mixed-methods quasi-experimental study	Mothers participating in nutrition support groups (n=208)	Community nutrition education	Pre-intervention assessment	Nutrition knowledge, attitudes and practices
Tofail *et al.* (2018)	Rural Bangladesh	Cluster randomised controlled trial	Pregnant women and children from 720 clusters	WASH and nutrition interventions	Control group	Child development and growth outcomes
Stewart *et al.* (2018)	Rural Kenya	Cluster randomised controlled trial	Children from 702 clusters	WASH and nutrition interventions	Control groups	Child development outcomes
Null *et al.* (2018)	Rural Kenya	Cluster randomised controlled trial	Pregnant women (n=8,246) and children	WASH and nutrition interventions	Control groups	Diarrhoea and length-for-age z-score
Luby *et al.* (2018)	Rural Bangladesh	Cluster randomised controlled trial	Children from rural households	WASH and nutrition interventions	Control groups	Diarrhoea and growth outcomes
Komakech *et al.* (2024)	Uganda refugee settlements	Cluster randomised controlled trial	Pregnant women and infants (n=390)	Care group-based nutrition education	Alternative education groups/control	Infant anthropometric outcomes

Table 2. Characteristics of Contextual Policy and Guideline Documents Included.

Document	Issuing Organisation (Year)	Geographical Scope	Purpose and Target Population	Major Recommendations and Implementation Priorities	Contribution to GROW-WELL Model Development
Levels and trends in child malnutrition	UNICEF, WHO and World Bank Group (2023)	Global	Provides estimates of childhood stunting, wasting and overweight among children under five years and monitors global nutrition targets.	Strengthen nutrition surveillance, prioritise high-burden populations and improve coordination of nutrition services.	Provides the epidemiological basis for including growth monitoring and early identification of nutritional risk within GROW-WELL.
Improving early childhood development: WHO guideline	WHO (2020)	Global	Provides recommendations for improving early childhood development among children from birth to five years through health, nutrition and responsive caregiving approaches.	Integrate responsive caregiving, nutrition support and early childhood interventions into primary healthcare systems.	Supports the Education and Empowerment component by emphasising caregiver support and integrated child development approaches.
Essential nutrition actions: Mainstreaming nutrition through the life-course	WHO (2019)	Global	Provides evidence-based nutrition actions targeting mothers, infants, young children and vulnerable populations.	Promote breastfeeding, complementary feeding, micronutrient interventions and integration of nutrition services into routine healthcare.	Provides the foundation for Growth Monitoring and Responsive Feeding components of GROW-WELL.
WHO Guideline on Prevention and Management of Wasting and Nutritional Oedema in Children Under Five Years	WHO (2023)	Global	Provides recommendations for prevention, identification and management of acute malnutrition among children under five years.	Strengthen screening, community-based management, referral pathways and continuity of care.	Informs Growth Monitoring, Oral Rehydration and Infection Management, and Linkage to Services components.
Global Action Plan on Child Wasting	WHO *et al.* (2020)	Global, with emphasis on LMICs and humanitarian settings	Provides a multisectoral framework for preventing and managing child wasting.	Integrate nutrition, health, WASH, food security and social protection strategies through coordinated systems.	Provides the multisectoral foundation of GROW-WELL by supporting integration of nutrition, infection prevention, WASH and health-system coordination.

4.2. Quality Appraisal of Included Evidence Sources

4.2.1. Quality Appraisal of Empirical Studies

The methodological quality of the 11 empirical studies was assessed using the Mixed Methods Appraisal Tool (MMAT), Version 2018. Overall, 9 studies were assessed as having high methodological quality, while Matsungo *et al.* (2023) was rated moderate–high and Wijesinghe *et al.* (2025) moderate.

All 11 studies were judged to have clear research questions or objectives, appropriate study designs, suitable sampling strategies, appropriate measurement of outcomes or exposures, and appropriate statistical analyses. However, some uncertainty remained regarding the representativeness of the target population and the completeness of outcome data in Matsungo *et al.* (2023) and Wijesinghe *et al.* (2025). Risk of bias was also recorded as indeterminate for these two studies, as well as for Hasan *et al.* (2023). These assessments indicate that, although the included empirical studies generally met the reported methodological criteria, some limitations or reporting gaps remained in specific studies.

For the mixed-methods studies, Matsungo *et al.* (2023) and Wijesinghe *et al.* (2025), the integration of qualitative and quantitative components was assessed as satisfactory. The remaining studies were marked as not applicable for this criterion. The detailed study-level MMAT assessments are provided in the Supplementary File.

4.2.2. Quality Appraisal of Policy and Guideline Documents

The five policy and guideline documents were assessed using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument. All five documents received an overall quality judgement of high. Scope and purpose and clarity of presentation received scores of 7 across all documents, indicating strong appraisal ratings in these domains.

Scores for stakeholder involvement and applicability were generally 6, with the WHO guideline on the prevention and management of wasting and nutritional oedema (2023) receiving a score of 7 in both domains. Rigour of development was rated 7 for the WHO early childhood development guideline (2020) and the WHO wasting and nutritional oedema guideline (2023), and 6 for the remaining documents. Editorial independence received a score of 7 for the UNICEF, WHO and World Bank Group child malnutrition estimates (2023), the WHO early childhood development guideline (2020), and the WHO essential nutrition actions framework (2019); the Global Action Plan on Child Wasting (2020) received a score of 6.

Overall, the AGREE II assessments indicated strong appraisal ratings across the five policy and guideline documents, although some domains received scores below the maximum. These documents were used as policy and implementation evidence to inform the synthesis, rather than being treated as empirical evaluations of intervention effectiveness.

Taken together, the appraisals suggest that the included evidence was generally methodologically strong according to the assessments reported, while uncertainties in selected empirical studies and variation in policy-document domain scores warrant consideration when interpreting the findings. The appraisal results informed the synthesis but do not, by themselves, establish the effectiveness of integrated nutrition and WASH interventions.

4.3. Biological and Social Pathways of the Malnutrition-Infection Cycle

The included evidence indicates that the malnutrition–infection cycle involves interacting biological, household and environmental pathways. Inadequate nutritional intake can increase children's vulnerability to infection, while illness can worsen nutritional status through reduced food intake, nutrient losses and impaired recovery. The reviewed studies examined different parts of this relationship, including environmental pathogen exposure, household WASH conditions, caregiver practices and community-based nutrition support. However, the studies differed in design and outcomes, so the pathways should be interpreted as complementary rather than as a single causal sequence established by every study.

4.3.1. Biological and Environmental Pathways

Diarrhoeal disease and exposure to faecal contamination were important links between household environments and child health. Pickering *et al.* (2018) assessed environmental contamination across multiple exposure pathways in rural Bangladesh, including children's hands, water, food and household environments, and examined their relationship with diarrhoeal illness. Hasan *et al.* (2023) also reported associations between inadequate household water, sanitation and handwashing facilities and higher prevalence of stunting, wasting and underweight among children under five in Bangladesh. As Hasan *et al.* used a cross-sectional analysis, these associations do not establish that inadequate WASH conditions directly caused the observed nutritional outcomes. The WASH Benefits trials in Bangladesh and Kenya further examined nutrition and WASH interventions in relation to child health and development outcomes (Luby *et al.*, 2018; Null *et al.*, 2018; Stewart *et al.*, 2018; Tofail *et al.*, 2018). Collectively, these studies illustrate the importance of considering infectious exposure and nutritional vulnerability together, while recognising that individual outcomes varied across interventions and study settings.

4.3.2. Caregiver Practices and Social Pathways

Caregiver knowledge, feeding behaviours and access to community support also featured in the evidence. Matsungo *et al.* (2023) reported improvements in infant and young child feeding practices, dietary diversity and WASH-related behaviours associated with participation in community care groups in rural Zimbabwe. In refugee settlements in Uganda, Komakech *et al.* (2024) examined care group-based nutrition education and infant anthropometric outcomes. Wijesinghe *et al.* (2025) reported improved awareness of balanced diets and childcare practices through mothers' support groups, although quantitative improvements in nutrition-related practices were modest. These findings suggest that community-based platforms can support nutrition-related knowledge and behaviours, but changes in awareness or reported practices should not automatically be interpreted as evidence of sustained behavioural change or reduced infection.

Household livelihoods and programme delivery.

Nutritional vulnerability was also linked to broader household circumstances and the practical delivery of interventions. Wegmüller *et al.* (2022) examined an agriculture, nutrition and WASH package in Western Kenya, highlighting the relevance of food production and dietary quality alongside other determinants of child health. Rahman *et al.* (2018) investigated implementation of WASH and nutrition interventions, providing evidence relevant to intervention coverage, adoption and fidelity. The Global Action Plan on Child Wasting similarly frames inadequate diets, recurrent infections, poor sanitation, food insecurity and limited access to essential services as interconnected challenges (WHO *et al.*, 2020).

4.4. Burden, Distribution, and Health Inequities

The included evidence situated childhood malnutrition and infection within broader socioeconomic and environmental inequalities. The empirical studies covered Bangladesh, Kenya, Zimbabwe, Uganda and Sri Lanka, with several focusing on rural communities and one examining refugee settlements. This geographical distribution provides insight into settings where nutritional vulnerability, inadequate WASH conditions and barriers to essential services may overlap, but it does not represent the full global distribution of the malnutrition–infection cycle.

4.4.1. Global Burden and Overlapping Risks

The 2023 UNICEF, WHO and World Bank Group estimates reported that approximately 148.1 million children under five experienced stunting and 45 million experienced wasting globally in 2022 (UNICEF, World Health Organization, & World Bank Group, 2023). These figures illustrate the scale of childhood malnutrition, although they should not be interpreted as estimates of the number of children experiencing both malnutrition and infection. The Global Action Plan on Child Wasting identifies inadequate diets, recurrent infections, poor sanitation, food insecurity and limited access to essential services as interconnected challenges in preventing and managing wasting (WHO *et al.*, 2020).

4.4.2. Household and Environmental Inequalities

Evidence from Bangladesh linked household WASH conditions with child nutritional outcomes. Hasan *et al.* (2023) reported higher levels of stunting, wasting and underweight among children living in households without adequate water, sanitation and handwashing facilities. Because the study used cross-sectional data, these findings demonstrate associations rather than establishing a direct causal effect of WASH access on nutritional status. Pickering *et al.* (2018) also examined environmental contamination pathways associated with diarrhoeal illness among children in rural Bangladesh. Considered together, these studies highlight how household environments can expose children to infectious risks while also reflecting inequalities in access to basic services.

4.4.3. Geographical and Social Vulnerability

The WASH Benefits studies in Bangladesh and Kenya examined nutrition and WASH interventions in rural settings where sanitation, hygiene and nutritional risks could coexist (Stewart *et al.*, 2018; Tofail *et al.*, 2018). The included evidence also covered populations facing particular social and livelihood challenges. Komakech *et al.* (2024) examined care group-based nutrition education among South Sudanese refugee communities in Uganda, while Wegmüller *et al.* (2022) evaluated an agriculture and nutrition-sensitive intervention among farming households in Western Kenya. These studies broadened the review beyond household hygiene alone, drawing attention to the relevance of community support, food production and context-specific programme delivery.

4.4.4. Implications for Equity-focused Services

The WHO Essential Nutrition Actions Framework and the WHO guideline on the prevention and management of wasting and nutritional oedema emphasise nutrition services, early identification of nutritional risk and appropriate management for vulnerable children (WHO, 2019; WHO, 2023). In light of the reviewed evidence, these policy documents support prioritising populations facing overlapping nutritional, environmental and service-access disadvantages. However, the review did not establish a single ranking of the most disadvantaged groups or quantify how much each inequality contributed to malnutrition.

4.5. Effectiveness of Nutrition, WASH, and Integrated Interventions

The included studies evaluated nutrition-focused, WASH-focused and integrated interventions targeting different components of the malnutrition–infection cycle. Findings varied by intervention design and outcome, indicating that although integrated approaches address a wider range of determinants, their benefits were not uniform across settings or health indicators.

4.5.1. Nutrition-focused Interventions

Community-based nutrition interventions reported improvements in dietary practices and selected child growth outcomes. Wegmüller *et al.* (2022) evaluated an agriculture and nutrition-sensitive intervention in Western Kenya that combined micronutrient powders, poultry production, vegetable cultivation and behaviour change education. The intervention improved dietary diversity, consumption of nutrient-rich foods and selected growth indicators. In rural Zimbabwe, Matsungo *et al.* (2023) reported improvements in infant and young child feeding practices, dietary diversity and WASH-related behaviours following participation in care groups. Similarly, Komakech *et al.* (2024) reported improved infant growth indicators following peer-led nutrition education among South Sudanese refugee communities in Uganda. However, these findings do not establish that nutrition-focused interventions alone can address the environmental and infectious risks associated with childhood malnutrition. The Global Action Plan on Child Wasting identifies poor diets, recurrent infections, inadequate sanitation and food insecurity as interconnected challenges requiring coordinated responses (WHO *et al.*, 2020).

4.5.2. WASH-focused Interventions

WASH interventions sought to reduce exposure to contaminated water, unsafe sanitation and inadequate hygiene. In rural Bangladesh, Pickering *et al.* (2018) identified associations between environmental contamination across multiple exposure pathways and childhood diarrhoeal illness. Hasan *et al.* (2023) likewise reported associations between inadequate household water, sanitation and handwashing facilities and higher prevalence of stunting, wasting and underweight. These observational findings highlight the relationship between household environmental conditions and child health but do not, by themselves, establish causation. Evidence from the WASH Benefits Kenya trial also illustrates the limitations of relying on WASH interventions alone. Null *et al.* (2018) reported growth benefits from nutrition and combined WASH–nutrition interventions, whereas WASH-only interventions did not produce comparable improvements in linear growth or significantly reduce diarrhoea prevalence. Thus, improvements in WASH conditions should not automatically be assumed to translate into measurable nutritional or infection-related benefits.

4.5.3. Integrated Nutrition and WASH Interventions

The WASH Benefits trials examined nutrition and WASH components delivered separately and in combination. In Bangladesh, Luby *et al.* (2018) evaluated interventions addressing water quality, sanitation, handwashing and nutrition, while Tofail *et al.* (2018) examined child developmental outcomes in relation to these intervention approaches. In Kenya, Stewart *et al.* (2018) assessed child development outcomes following combined WASH and nutrition interventions. Together with the growth findings reported by Null *et al.* (2018), these studies provide evidence that intervention effects can differ according to the outcome measured and the components delivered. They do not establish that every combined package is superior for all outcomes or that combining components necessarily produces additional benefits.

Implementation quality also influenced the interpretation of intervention results. Rahman *et al.* (2018), examining the WASH Benefits Bangladesh trial, highlighted the importance of monitoring intervention coverage and implementation fidelity. Community health workers, household engagement and ongoing monitoring were relevant to maintaining delivery quality. Policy documents similarly support coordinated service delivery: the WHO Essential Nutrition Actions Framework emphasises integrating nutrition interventions into routine health systems and community platforms (WHO, 2019); the WHO guideline on wasting addresses prevention, early identification and treatment (WHO, 2023); and the Global Action Plan on Child Wasting calls for coordination across nutrition, health, WASH and social support (WHO *et al.*, 2020).

4.6. Health System and Implementation Factors Influencing Integration

The included evidence showed that the potential effectiveness of integrated nutrition and WASH interventions depended not only on intervention content but also on how consistently services were delivered, monitored and connected across households, communities and health facilities. Recurring implementation factors included programme coordination, intervention fidelity, community-based delivery, caregiver engagement and continuity between community and facility services.

4.6.1. Programme Coordination and Fragmented Delivery

Fragmented delivery represented an important health-system challenge. The Global Action Plan on Child Wasting identified inadequate coordination across nutrition, health, food and social support systems as a constraint to comprehensive prevention and management of childhood wasting (WHO *et al.*, 2020). Similarly, the WHO Essential

Nutrition Actions Framework supports incorporating nutrition interventions into routine health services and community platforms rather than delivering them as isolated activities (WHO, 2019). Wegmüller *et al.* (2022) also illustrated the operational demands of combining agriculture, nutrition-specific and nutrition-sensitive components within a single intervention.

4.6.2. Implementation Fidelity and Monitoring

Continuous monitoring was another important implementation consideration. Rahman *et al.* (2018) examined intervention coverage and implementation fidelity within the WASH Benefits Bangladesh trial, demonstrating the value of monitoring delivery quality and identifying implementation gaps. This suggests that integrated programmes require monitoring systems capable of assessing whether intended intervention components reach participating households as planned. However, evidence on implementation fidelity does not itself establish that improved programme delivery produces better long-term nutritional or infection outcomes.

4.6.3. Community-based Delivery and Caregiver Engagement

Community-based delivery provided an important mechanism for reaching households beyond health facilities. The WASH Benefits trials used community promoters and repeated household contact to deliver nutrition, water, sanitation and hygiene interventions (Stewart *et al.*, 2018; Null *et al.*, 2018). Care-group approaches provided similar evidence. Matsungo *et al.* (2023) reported improvements in feeding practices, dietary diversity and WASH-related behaviours among households participating in community care groups, while Komakech *et al.* (2024) reported improved infant growth following peer-led nutrition education among South Sudanese refugee communities in Uganda. Wijesinghe *et al.* (2025) also highlighted the role of mothers' support groups in strengthening nutrition awareness and peer support. These findings suggest that community workers and peer-support structures can serve as practical channels for extending child health interventions beyond health facilities.

4.6.4. Service Coordination and Continuity

The policy evidence further emphasised the need for continuity between community-based prevention, routine health services and management of children with nutritional problems. The WHO Essential Nutrition Actions Framework promotes integration of nutrition interventions within routine health systems and community platforms (WHO, 2019), while the WHO guideline on wasting prevention and management emphasises prevention, early identification and treatment (WHO, 2023). The Global Action Plan on Child Wasting similarly calls for coordinated action across nutrition, health, WASH and social support systems (WHO *et al.*, 2020). Together, these recommendations support stronger referral pathways, communication and follow-up between community and facility-based services.

4.7. The GROW-WELL Integrated Nutrition and WASH Model

The findings from the systematic review were synthesised into the GROW-WELL Integrated Nutrition and WASH Model, a conceptual framework intended to organise complementary actions for preventing and managing childhood malnutrition and infection. The model was derived from recurring intervention components, implementation factors and recommendations identified across the empirical studies and policy documents. It should be interpreted as an evidence-informed framework rather than a validated intervention, as the model itself has not yet undergone prospective implementation or empirical effectiveness evaluation.

GROW-WELL comprises six linked components: G – Growth monitoring; R – Responsive feeding; O – Oral rehydration and infection management; W – Water safety and sanitation; E – Education and empowerment; and L – Linkage to services. These components reflect the major intervention areas identified across the reviewed evidence, including growth assessment, improved feeding, infection prevention and management, WASH improvement, caregiver support and health-system coordination (Matsungo *et al.*, 2023; Tofail *et al.*, 2018).

As illustrated in Figure 2, GROW-WELL is structured as a cyclical framework in which child growth, nutritional care, infection prevention and caregiver support interact continuously. Growth monitoring provides an entry point for identifying nutritional risk and growth faltering, while responsive feeding addresses inadequate dietary intake and supports healthy growth. Oral rehydration and infection management are intended to reduce illness-related nutritional losses, while water safety, sanitation and hygiene measures address environmental exposure to infectious pathogens. Education and empowerment strengthen caregiver knowledge and practices, and linkage to services connects household and community-level activities with primary healthcare and referral systems.

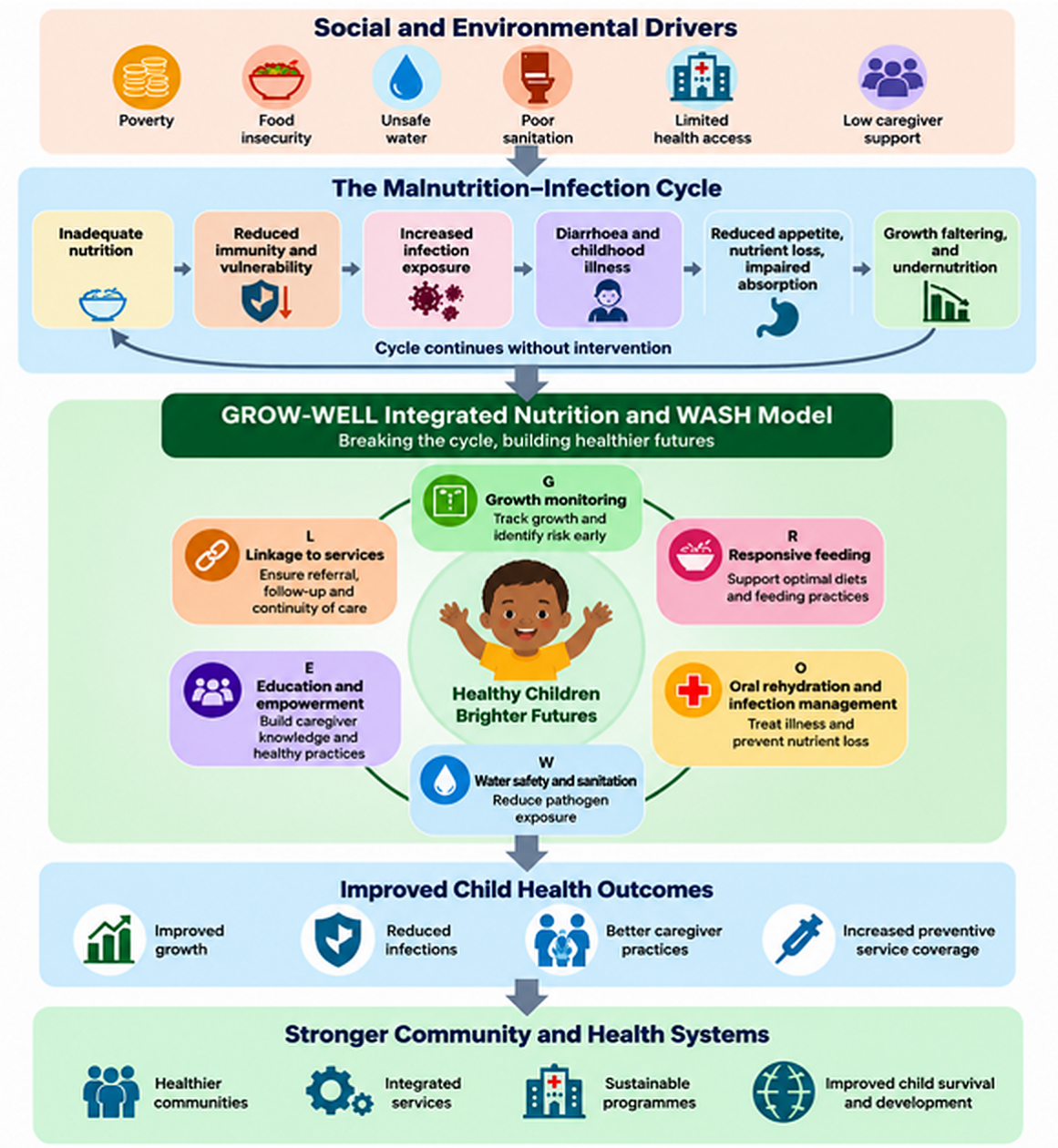


Figure 2. Conceptual Framework of the GROW-WELL Integrated Nutrition and WASH Model.

The practical structure of each component is presented in Table 3, which specifies the principal activities, delivery actors, anticipated clinical contribution and corresponding public health delivery mechanism. This table is intended to clarify how the conceptual model could potentially be translated into coordinated programme activities.

Table 3. Structure and Implementation Components of the GROW-WELL Integrated Nutrition and WASH Model.

GROW-WELL Component	Key Activities	Delivery Actors	Clinical Contribution	Public Health Delivery Mechanism
G – Growth monitoring	Weight assessment, MUAC measurement, growth tracking and early identification of nutritional risk	CHWs, nurses and primary healthcare providers	Early detection of growth faltering and timely intervention	Immunisation sessions, child welfare clinics and outreach services

R – Responsive feeding	Infant and young child feeding counselling, dietary diversity promotion and food demonstrations	Nutrition workers, CHWs and caregivers	Improves dietary intake and supports healthy growth	Community nutrition programmes and caregiver groups
O – Oral rehydration and infection management	ORS, zinc, infection screening, treatment and referral pathways	CHWs, clinicians and PHC teams	Reduces nutritional losses associated with infection	Community case management and referral systems
W – Water safety and sanitation	Safe water practices, sanitation improvement and hygiene promotion	WASH personnel, CHWs and community groups	Reduces pathogen exposure and recurrent infection risk	Household and community WASH programmes
E – Education and empowerment	Caregiver education, behaviour change communication and peer support	CHWs, social workers and community leaders	Improves caregiver knowledge and health practices	Community support groups and communication platforms
L – Linkage to services	Referral systems, follow-up visits and coordination between community and facilities	Health workers, CHWs and programme managers	Promotes continuity of care	Primary healthcare integration and monitoring systems

The components in Figure 2 and Table 3 are complementary rather than sequential requirements. Their proposed value lies in connecting interventions that are frequently delivered through separate programme areas. For example, growth monitoring may identify a child requiring nutritional support, while infection screening, WASH risk assessment and referral mechanisms can address additional factors that may influence recovery. Similarly, caregiver education and community support may reinforce recommended feeding and hygiene practices. The framework therefore reflects the interconnected pathways identified in the review rather than assuming that any individual component is sufficient to prevent malnutrition or infection.

The model also aligns with the policy evidence included in the review. The WHO Essential Nutrition Actions Framework promotes delivery of evidence-based nutrition interventions through health systems and community platforms (WHO, 2019). The WHO guideline on prevention and management of wasting supports prevention, early identification, treatment and continuity of care for children under five years (WHO, 2023). The Global Action Plan on Child Wasting similarly emphasises coordinated action across nutrition, health, WASH, food security and social support systems (WHO *et al.*, 2020). These documents therefore provide policy support for the domains represented in GROW-WELL, although they do not constitute evidence that the specific GROW-WELL configuration is effective.

Taken together, Figure 2 provides the conceptual overview of the model, whereas Table 3 provides its operational structure. The framework translates the principal themes emerging from the systematic review into a potentially implementable structure while recognising the heterogeneity of the underlying evidence. Future research should therefore assess the feasibility, acceptability, implementation fidelity, resource requirements, cost-effectiveness and clinical effectiveness of GROW-WELL before conclusions can be drawn about its effectiveness across different populations and health-system settings.

4.8. Translational Implications of the GROW-WELL Model

The findings of this review have implications for translating evidence on childhood malnutrition, infection and WASH into coordinated actions at household, community and primary healthcare levels. The GROW-WELL model provides an organising framework for connecting these levels rather than proposing a separate or independently validated programme. Its potential application should therefore be understood as a translation of the reviewed evidence and policy guidance that requires prospective evaluation.

4.8.1. Household and Community Level

The reviewed studies highlighted the importance of caregiver practices in influencing child nutrition and infection risk. Care-group, mothers' support-group and community education approaches were associated with improvements in feeding practices, dietary diversity, hygiene-related behaviours and caregiver knowledge (Matsungo *et al.*, 2023;

Komakech *et al.*, 2024; Wijesinghe *et al.*, 2025). Within GROW-WELL, these findings support providing caregivers with practical guidance on responsive feeding, dietary diversity, safe water use, hygiene, recognition of childhood illness and appropriate healthcare seeking. Community platforms could also support growth monitoring and follow-up, particularly where access to facility-based services is limited.

4.8.2. Primary Healthcare Delivery

For healthcare professionals, GROW-WELL proposes greater coordination between assessment and management of nutritional and infectious conditions. Routine child health contacts could incorporate nutritional assessment, growth monitoring, infection screening, feeding counselling, identification of WASH-related risks and appropriate referral. Evidence from the WASH Benefits studies indicates that delivery quality, household engagement and monitoring are important considerations when implementing integrated interventions (Tofail *et al.*, 2018; Rahman *et al.*, 2018). The proposed model therefore places community health workers, nurses and primary healthcare teams within a connected system rather than treating nutrition and infection services as independent activities.

4.8.3. Health-system and Public Health Level

The policy documents included in this review consistently support multisectoral responses involving nutrition, health, WASH, food security and community systems (WHO, 2019; WHO, 2023; WHO *et al.*, 2020). At the health-system level, GROW-WELL could therefore provide an organising structure for linking existing child nutrition, WASH and primary healthcare activities. Potential implementation priorities include strengthening referral pathways, improving communication between community and facility providers, incorporating relevant nutrition-WASH indicators into monitoring systems, and providing appropriate training and supervision for community health workers.

4.8.4. Equity and Contextual Adaptation

Translation into practice would also need to account for differences in household resources, WASH infrastructure, health-system capacity and population vulnerability. The reviewed evidence included rural communities, farming households, refugee populations and other settings with differing implementation contexts. Consequently, the individual GROW-WELL components should not be assumed to have identical feasibility or effects across settings. Adaptation to local service structures, available resources, community preferences and existing programmes would be necessary before implementation.

Overall, GROW-WELL provides a structured pathway for translating the review findings into coordinated child health programming. Its principal contribution at this stage is conceptual: it brings together growth monitoring, responsive feeding, infection management, WASH, caregiver empowerment and linkage to services within one framework. The model should not, however, be interpreted as evidence of intervention effectiveness. Future implementation research should assess its feasibility, acceptability, fidelity, resource requirements and cost-effectiveness, followed by appropriately designed evaluations of child health outcomes across diverse health-system settings.

4.9. Discussion

4.9.1. Main Findings

This systematic review synthesised evidence showing that childhood malnutrition and infection are interconnected through nutritional, biological, environmental and social pathways. The included studies indicate that inadequate dietary intake, recurrent infection, pathogen exposure, caregiver practices and service-delivery constraints can interact to increase risks of poor growth and illness. Nutrition and WASH interventions addressed different components of these pathways, but effects varied across interventions, populations and outcomes. Therefore, the findings support coordinated approaches without establishing that integrated interventions are universally superior to single-sector approaches.

The review also identified community health workers, caregiver engagement, implementation fidelity, monitoring and referral systems as important implementation considerations. These findings informed the development of GROW-WELL, which organises recurring intervention and implementation elements into a single conceptual framework. The model should be regarded as evidence-informed rather than validated, as it has not yet undergone prospective implementation or empirical effectiveness evaluation.

4.9.2. Comparison With Existing Literature

The findings are broadly consistent with Dulal *et al.* (2021), whose systematic review and meta-analysis found benefits from integrated nutrition and stimulation interventions while highlighting the importance of personnel, intervention intensity and community engagement. Similarly, Wolf *et al.* (2022) demonstrated the relevance of WASH interventions for reducing childhood diarrhoeal disease. However, Patlán-Hernández *et al.* (2022) found that evidence linking WASH interventions directly to acute malnutrition remained inconsistent, supporting the present review's caution against assuming that WASH improvements alone will produce nutritional recovery. Waddington *et al.* (2023) further demonstrated potential population-level benefits of improved WASH for childhood mortality. Collectively, these studies

support addressing multiple determinants while also demonstrating that effects depend on the outcome and intervention context.

4.9.3. Relevance and Implementation of Study Findings for Intervention Purposes

The findings have practical relevance for caregivers, healthcare providers and public health planners because they demonstrate that preventing childhood malnutrition requires coordinated action across multiple levels. For caregivers, the review highlights the importance of combining appropriate feeding practices with safe water use, hygiene behaviours, early illness recognition and participation in growth monitoring activities. For healthcare professionals, the findings support integrated child assessments that consider nutritional status, infection history, household risks and caregiver practices during routine services.

At health-system level, the review suggests that integrated programmes should be embedded into existing primary healthcare and community platforms. The evidence indicates that community health workers can provide an effective connection between households and formal healthcare services by delivering nutrition counselling, supporting behaviour change, identifying growth problems and facilitating referrals. This interpretation aligns with the findings of Dulal *et al.* (2021), who identified intervention personnel and delivery strategies as important factors influencing the success of integrated child health programmes.

The GROW-WELL model therefore offers a structured approach that policymakers and programme managers can adapt when designing child health strategies. Rather than creating a separate programme, the model can support coordination between nutrition services, WASH programmes and primary healthcare activities. Such integration may improve programme efficiency by reducing duplication and ensuring that children receive preventive and therapeutic support through connected systems.

4.9.4. Strengths and Limitations

This review has several strengths. First, it combined empirical research with international policy documents, allowing interpretation of both intervention effectiveness and implementation requirements. Second, the inclusion of diverse study designs provided evidence from controlled trials, observational studies and mixed-methods research, allowing examination of both outcomes and delivery processes. Third, the development of the GROW-WELL model provides a practical translation of research findings into an organised framework that connects clinical care, household actions and public health programming.

However, some limitations should be considered. The heterogeneity of included studies in terms of interventions, populations, settings and outcomes limited direct comparison between studies and prevented stronger quantitative conclusions. In addition, many interventions were conducted in specific low- and middle-income country contexts, which may limit transferability to settings with different health-system structures. The review also included policy documents that provide implementation guidance but do not generate primary outcome data. Finally, although the GROW-WELL model was developed from existing evidence, it requires future evaluation through implementation studies to determine its effectiveness, feasibility and sustainability in real-world health systems.

Overall, this review contributes to the growing evidence that childhood malnutrition and infection require integrated solutions. By connecting nutrition, WASH, caregiver support and health-service delivery, the GROW-WELL model provides an evidence-informed pathway for strengthening child health interventions.

5. CONCLUSION

Childhood malnutrition and infection are interconnected public health challenges shaped by nutritional, environmental, behavioural and health-system factors. This systematic review found that nutrition and WASH interventions address complementary determinants of child health, but the effects of integrated approaches varied across interventions, settings and outcomes. The evidence therefore supports coordinated, context-sensitive approaches rather than a universal assumption that integration will produce superior outcomes.

The synthesis informed the development of the GROW-WELL Integrated Nutrition and WASH Model, which brings together growth monitoring, responsive feeding, oral rehydration and infection management, water safety and sanitation, education and empowerment, and linkage to services. GROW-WELL is an evidence-informed conceptual framework, not a validated intervention, and its effectiveness cannot be inferred from the evidence included in this review.

The findings support greater coordination between nutrition, WASH and primary healthcare services, particularly through community-based platforms, caregiver engagement and strengthened referral pathways. However, implementation should be adapted to local health-system capacity, population needs and available resources.

Future research should prospectively evaluate the feasibility, acceptability, implementation fidelity, resource requirements, cost-effectiveness and clinical effectiveness of GROW-WELL across diverse settings. Such evaluation is necessary to determine whether the proposed integrated framework can improve child health outcomes and contribute to reducing the malnutrition–infection cycle in practice.

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