

Title: Impact of water, sanitation, and hygiene (WASH) interventions on anemia reduction in LMICs: A rapid review

AUTHORS

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Abstract:

Anemia is a major public health concern and low and middle-income countries bear the greatest burden of it. Although anemia is caused by multiple factors, poor water quality, sanitation, and hygiene are considered to be some of the risk factors leading to anemia, however, the association between anemia and water, sanitation, and hygiene remains unclear. The rapid review aims to evaluate the impact of water, sanitation, and hygiene interventions on anemia reduction in LMICs.

A PubMed search and a hand search of relevant websites and journals were followed by a screening of 781 titles, abstracts, and full text based on the criteria outlined in a population, intervention, comparison, outcome, and study design (PICOS) framework. A total of 3 articles met the criteria for inclusion. The data were extracted from the studies for narrative synthesis.

The studies' interventions consist of WASH interventions and other nutrition and behavior change communication interventions. School-based behavior change communication strategies were implemented, focusing on handwashing and waste management initiatives. Additionally, latrines were constructed and handwashing stations were established in schools. Counseling measures were adopted and implemented in different areas of WASH practices. Furthermore, Capacity building of Community Health Promoters was carried out, focusing on intervention-specific behavior change activities.

The outcomes of the studies mainly focused on changes in hemoglobin levels, reduction in anemia prevalence, and observed behavioral changes related to WASH practices. The review identified significant behavior change among the WASH intervention arm with an increase in the proportion of households with latrines, clean latrines, clean environment, and handwashing before eating and after defecation. However, the significant increase in Hb level and decrease in anemia prevalence was only observed in the comparator arm, i.e., the nutrition arm or both WASH and nutrition intervention arm. WASH intervention alone was not sufficient to reduce the prevalence of anemia.

Overall, the review suggests that the behavior change communication strategies focusing on hand washing, sanitation, and hygiene may have an indirect impact on reducing anemia. Also, WASH interventions, when combined with nutrition interventions, intensify the impact of these interventions in improving behavior and thus resulting in the reduction in anemia levels.

Introduction

Anaemia is a serious global public health problem that particularly affects young children, menstruating adolescent girls and women, and pregnant and postpartum women. WHO estimates that 40% of children 6–59 months of age, 37% of pregnant women, and 30% of women 15–49 years of age worldwide are anaemic. Anemia caused 50 million years of healthy life lost due to disability in 2019 (WHO 2023), and it's a major cause of child and maternal mortality in most LMICs (WHO, UNICEF, USAID 2015). The regions of Africa and South-East Asia are most affected, with an estimated 106 million women and 103 million children affected by anemia in Africa and 244 million women and 83 million children affected in South-East Asia (WHO 2023). In children, anemia is associated with various factors such as poor growth, stunting, cognitive delays and increased susceptibility to infections, and delayed physical and mental development with diminished ability to work (Marn et.al., 2016, Kassebaum et.al., 2014, Ballarajan et.al., 2011).

Existing literature indicates that iron-focused intervention alone does not have an impact in treating anemia and normalising the hemoglobin levels in the vulnerable population (Wirth et.al., 2017, Ngure et.al., 2014, Engle stone et.al., 2017). Therefore, it conveys that there is a huge need to focus beyond nutrition-based intervention and lay emphasis on other hidden contributing factors to anemia.

Universal access to safe drinking water, sanitation, and adequate hygiene (WASH) is essential for overall population health, welfare, and development (WHO). However, globally, 2.2 billion do not have access to safe drinking water, more than half of the global population lack access to safe sanitation, handwashing facilities with soap are accessible to 3 billion people, and 673 million people still practise open defecation. The consequence of unsafe water, sanitation, and hygiene may pose a serious threat on the health and well-being of children worldwide. Over 700 million children under age 5 die of diarrhoeal disease due to a lack of appropriate WASH services, and about 50% of the underweight and malnutrition burden in children is attributed because of recurrent diarrhoea or intestinal helminth infections (UNICEF, 2022).

Demographic and Health surveys revealed that in 40% of countries included in the study, the odds of anemia were higher in children using open defecation or poor sanitation facilities, and in about quarter of countries anemia was identified commonly in those children residing in household that lacked access to an improved water source, although results varied among countries. (Baldi et.al., 2020). Intestinal parasites are responsible for morbidity and mortality globally, especially in low and middle-income countries. (Nyarango et.al., 2008) and are more prevalent in hot and humid environments, with poor sanitation, contaminated water, poor housing, and hygiene conditions (Harhay et.al, 2010, WHO 2018). Iron deficiency anemia has also been associated with intestinal parasitic infections such as *Schistosoma mansoni*, hookworms, *T. trichiura*, and *A. lumbricoides*. (Brito et.al., 2006). In low and middle-income countries, the most common parasitic infections are those caused by helminths and protozoan parasites. The disease caused by helminths is called helminthiasis, and Soil-transmitted helminth (STH) infections are among the most common infections worldwide, with an estimated 1.5 billion infected people or 24% of the world's population. Soil-transmitted helminths impair the nutritional status of the people they infect in multiple ways, leading to chronic intestinal blood loss and anemia. (WHO 2018).

Although there is strong evidence that micronutrient supplementation is an effective intervention to prevent anemia and reduce its prevalence to a certain extent, there is limited evidence on the impact of water, sanitation and hygiene (WASH) practices on anemia. Therefore, this study needs to be conducted to address the existing gap to identify the current available evidence. Hence, this paper aims to evaluate the impact of Water, Sanitation and hygiene interventions on anemia reduction in LMICs.

Theoretical principle explaining aware, agree and act on a positive behavior

The adoption of any positive behavior is the result of the awareness and knowledge regarding the behavior i.e., safe and clean water, sanitation and hygiene practices. The transtheoretical model (TTM) explains the theory of behavior change through stages of change including not ready to change (precontemplation), thinking about change (contemplation), preparing to change (preparation), changing (action), and maintaining the change (maintenance).

The processes of change are experiential and behavioral strategies that people use to change their behavior. In early stages of change, people use experiential strategies while they use behaviorally oriented strategies in later stages of change. Studies indicate that the TTM has been successfully applied to health communication campaigns, and to a larger extent, to computer-tailored interventions to change health behavior. The aware, adapt and agree framework (**Figure 1**) as based on the transtheoretical model describes the causal pathway through which the behavior change strategies function in improving the behavior at first level leading to mitigation of final outcome. For the present review, water, sanitation and hygiene are being studied to understand their role in reducing levels of anemia particularly in low- and middle-income countries (LMICs).

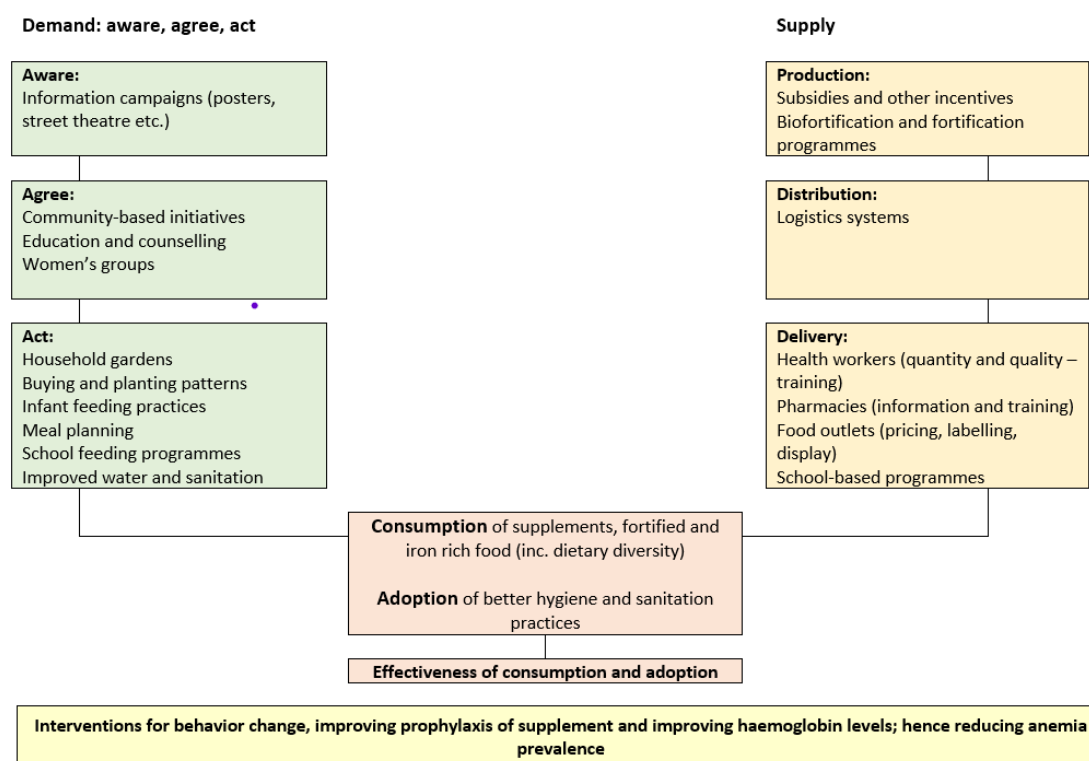


Figure 1: Conceptual framework based on the transtheoretical model describing the aware, agree and act principle

METHODOLOGY

Inclusion criteria for studies

The rapid review assessed the WASH intervention aimed at reducing anemia. Further, the PICOS framework was used to formulate the eligibility criteria for the review.

We used the Population, Intervention, Comparison, Outcomes, Study design (PICOS) framework to formulate the eligibility criteria for the review (**Table 1**).

Population: Population groups could either have been the participants who received the intervention or the stakeholders of interest who were interviewed.

Interventions: We considered water, sanitation, and hygiene interventions aimed at reducing anemia.

Intervention domains	Intervention Sub-domains
Provision of safe drinking water	Constructing or improving water supply systems or services, such as providing piped water on-site, public standpipes, boreholes, protected dug wells, protected springs, and rainwater. Regular household treatment of water that includes boiling, filtration, chemical disinfection (chlorination), pasteurization and ultraviolet radiation, combined flocculant/disinfectant
Improving Sanitation	Provision of flush or pour-flush to piped sewer system, septic tank, pit latrine, ventilation improved pit (VIP) latrine, pit latrine with slab, composting toilet, latrine with manual flush, established wastewater treatment plants.
Promoting Hygiene	Provision of handwashing with soap at all times, availability of handwashing facilities near latrines at households, schools, health care facilities, and public places. Maintaining food hygiene by handling food items with safety measures including safe water, handwashing, cleaning utensils and key surfaces, and protecting foods from insects and pests by covering. Maintain environmental hygiene by improving drainage and garbage disposal system.
Capacity building programmes	Sensitizing community mainly school teachers, students, mothers and other care takers of children regarding the importance of WASH on health, Demonstrating the most cost-effective interventions such as handwashing, Regular training of key personnel involved in the WASH programme, IEC materials on WASH interventions to be made available in all the health facilities and schools.
Strengthening Programmes & policies	Integrating cost effective and sustainable WASH solutions with educational programmes, increasing WASH finances and sector efficiency, strengthening WASH infrastructures at all levels,

Comparison: For impact evaluations, we only considered studies with a valid comparison group. Subsequently, we excluded pre-post intervention studies with no control groups. For the process evaluations, the concept of comparison group was not necessarily relevant.

Outcomes: Reduction in anemia levels

Outcome domain	Outcome Sub domain
Knowledge and awareness	Knowledge about WASH practises and its impact on anemia prevention
Improved biochemical levels	Mean hemoglobin level, prevalence of anemia
Access to improved sanitation and drinking water and hygiene	Proportion of households with latrine, clean latrine, clean environment, handwashing with soap.

Study designs: We included impact evaluations with any evaluative component and completed process evaluations. Process evaluations could have quantitative and qualitative components. We also considered observational studies with qualitative components. We excluded impact evaluation studies which did not have any implementation outcomes of interests, and which did not have a valid comparison group. Additionally, we excluded descriptive studies that did not include any measurement or implementation outcome.

Exclusion criteria comprised impact evaluations lacking implementation outcomes of interest and a valid comparison group. Descriptive studies without measurement or implementation outcomes were also excluded.

Search Methods: A search strategy based on PICOS was developed and executed on the PubMed database in April and May 2023. Articles published between January 2000 and April 2023 were examined. Additional hand searches were conducted in the archives of relevant journals from 2017 to 2023, including Lancet Global Health, WHO Bulletin, BMJ Global Health, American Journal of Clinical Nutrition, Advances in Nutrition, BMC Public Health, Journal of Nutrition, PLOS One, Maternal and Child Nutrition, Public Health Nutrition, and Health Policy and Planning. Websites such as WHO, BMGF, Open Grey, Google Scholar, IFPRI, Nutrition International, Micronutrient Forum, and UNICEF were also explored. S1 lists the detailed search strategy used for the review.

Screening of Studies: The Eppi Reviewer software facilitated the screening, data extraction, and critical appraisal processes. The articles were screened based on title and abstract, followed by full-text screening for those meeting the criteria. The screening was guided by a screening tool [S2]. Two independent reviewers screened each article, with any discrepancies reconciled. If there were any disagreements then they were reviewed and resolved by the third-party reviewer. The PRISMA diagram (Figure 2) illustrates the number of articles at each screening stage.

Data Extraction: The data was extracted from the studies based on PICOS by two independent reviewers. The data extraction was guided by a data extraction tool. The tool was designed and pilot tested to extract the following information study design, geography, study characteristics, intervention details, and outcome characteristics. (The data extraction tool is specified in S2a)

Critical Appraisal: Quality assessment tools specific to process evaluations and effectiveness studies were employed (Ref-Keenan and White) to assess the confidence in the

study findings. Two reviewers independently assessed each study's quality followed by reconciliation of any differences. Process evaluations were assessed for appropriateness of methodology, recruitment and sampling strategy, ethical considerations, rigor of data analysis, relevancy of recommendations, and availability of information on intervention. Effectiveness studies were evaluated for intervention description, baseline balance, study design, validation and definition of outcomes, and blinding of participants. The tools follow the 'weakest in chain principle' whereby if a study scores low in any one of the items on the checklist, the overall study confidence for that study is marked as low. Overall, studies were rated as high, medium, or low quality. S2b details the critical appraisal tools used in the review.

Data Analysis:

The studies were synthesized narratively for the present rapid review. There were only 3 studies which were included in the review.

RESULTS

In this mixed method review, we included in total 3 studies as per our inclusion criteria. All the three included studies were impact evaluation. Description of the PICOS and the critical appraisal of the included studies are available in Tables 1 and 2.

Geographical distribution and Settings:

These studies were conducted in South Asia and Sub-Saharan Africa region spanning in Angola (n=1), Kenya & Bangladesh (n=1) and Nepal (n=1). Two studies were conducted in urban and both rural and urban whereas the setting was not clearly specified in the paper for one of the study. (S4)

Population, Interventions, Outcomes, and Study Designs (PICOS):

The Population included in the studies comprise of children 6-59 months (n=1), School aged children 8-17 years (n=1), Pregnant women and their children upto 2 years (n=1).

The studies used WASH interventions along with other nutrition and behavior change communication interventions. The interventions used BCC strategies to impart various key messages related to WASH behaviors. School based initiatives were introduced such as display of IEC materials in the form of posters, flip charts based on nutrition, handwashing and waste management for children. Demonstration on efficient handwashing with soap by Health personnels in school targeting the children and their caregivers. Distribution of nutrition booklets and handouts. Construction of minimum 3 latrines per school. Counselling measures were adopted and different areas of counselling included prevention of open sky defecation, latrine cleaning, adequate hand washing, maintaining healthy backyard environment and nutrition components such as food safety and hygiene, responsible feeding, food and disease, importance of breast feeding and food adequacy. Apart from the counselling strategies, latrines and handwashing stations were created in communities and households. The provision of soaps was also part of interventions. Additionally, Capacity building of Community Health Promoters were carried out focusing on intervention specific behavior change activities.

The outcomes of studies across 3 studies are the hemoglobin levels or reduced prevalence of anemia.

Fancony (2021) identified significant behaviour change among the WASH arm with increase in proportion of households with latrines, clean latrines, clean environment, and clean nails of the care takers. However, significant increase in Hb level (0.27g/dl) and decrease in anemia prevalence (14.2%) were only observed in the comparator arm i.e., nutrition arm.

The findings from Shreshta (2020) suggested that handwashing with soap before eating and after defecation increased strongly from baseline to endline in the group where WASH interventions were given (74.1 to 96.9%) compared to control arm (78.3 to 84.0%). Also, knowledge about anemia increased significantly in the group (12.4 % to 22.4%) and slight reduction of anemia was seen (33% to 32%) but major increase in the anemia prevalence was observed in the other two arms.

Stewart (2019) suggests that, in Kenya compared to control there was 26% and 44% lower prevalence of anemia in the nutrition and WASH+nutrition groups. Contrast to this finding, in Bangladesh there was an effect of WASH alone in reducing anemia (lowered by 26%) and there was no added benefit of WASH+nutrition. Although the result was not significant in Kenya and therefore study suggests that there may be additional benefit from combining WASH with nutrition package. Therefore, the study concludes that educational measures focusing on WASH practices had no greater beneficial effect on reducing anemia, however, it was successful in changing the behaviour related to WASH practices which may have a positive impact on reducing anemia in the long run.

The studies with small sample sizes have small effects on the outcome (Fancony et al, 2021; Shreshta et al, 2020) (**Table 3**). However, the study conducted by Stewart et al (2019) wherein, the interventions were conducted in Kenya and Bangladesh the reported effects are very large. The effect sizes were adjusted for the direction of outcomes as the increasing levels of both the outcomes are in opposite direction.

Discussion

The study captured information on WASH practices and its effect on anemia reduction. Our results highlight the significant positive effect of educational intervention and counselling measures on improving WASH behaviour as statistically significant increase in the proportion of household with latrines, clean latrines, clean environment and better hand hygiene of the caretakers were observed in the intervention group. However, the intervention did not prove to be of greater benefit in changing the hemoglobin level or reducing the prevalence of anemia (Fancony 2021). Similarly, an analysis of national and sub national data from 21 surveys revealed that improved household sanitation was associated with reduced anemia prevalence in some surveys but the association was not consistent. Access to an improved water source did not show any significant association with anemia in general across surveys (Emma 2020). Although a study by Baranwal et.al identified poor toilet facility as one of the most important environmental variable leading to anemia among children <5 years of age. Association between water, sanitation and anemia through 47 nationally representative demographic and health survey also revealed that in 60% and 65% of countries, women and children exposed to open sanitation facilities had significantly higher odds of being anemic (Kothari 2019). Children living in houses with access to adequate sanitation facility was associated with lower odds of anemia as compared to children in houses with no access to sanitation facility. (Larsen 2017). In one of our study we found that, demonstration of adequate handwashing at schools combined with provision of 6 to 12 handwashing facilities showed strong increase in handwashing with soap before eating and after defecation in the intervention group (Stewart 2019). Comparably, a randomized controlled trial in Kenya on the impact of provision of regular soap and cleaning materials coupled with hygiene education observed that the handwashing

rates following toileting among the students in the intervention school were 32-38% as compared to the control school students which was 2% (Saboori 2013). In another study dedicated handwashing stations were constructed in schools which was effective in improving handwashing after toilet use among students (handwashing with soap increased from 4% to 74% post intervention) (Dreilbelbis 2016). The above discussed WASH interventions and practices may not have a direct impact on reducing anemia but increased enteropathogen exposure due to inadequate WASH may cause acute and chronic intestinal infections, enteric and systemic inflammation elevating hepcidin which is a master regulator of systemic iron homeostasis further resulting in impaired intestinal iron absorption leading to iron deficiency anemia (Korpe 2012; Prentice 2019).

This review also indicates that WASH interventions when combined with nutrition interventions may have a significant impact in changing the behaviour leading to reduction in anemia prevalence, however the finding was not consistent as similar study conducted in Bangladesh ruled out that WASH intervention alone was successful in reducing anemia prevalence to 26% and there was no additional benefit of WASH+Nutrition intervention (Stewart 2019).

Notably, the school meal programme combined with dietary and educational interventions related to health, nutrition and hygiene among school students resulted in increase in hemoglobin level and reduction in the prevalence of anemia from 42.6% to 21.7% respectively (Rimbawan 2023). Very few studies have examined the impact of WASH+Nutrition intervention on reducing anemia prevalence and the findings are inconsistent, therefore, further analysis and comprehensive studies are required to establish the effectiveness of combined WASH and nutrition interventions in improving the hemoglobin level and thereby, reducing anemia prevalence.

CONCLUSION

The summary results show that the causal processes through WASH interventions impact on reducing anemia is through improving the behavior related to hand washing and hygiene and sanitary practices. In addition, WASH interventions when combined with nutrition interventions amplify the impact of these interventions in improving behavior and thus resulting in the reduction in the anemia levels. Therefore, WASH interventions are to be looked as a long term strategy for mitigating anemia across populations.

SUPPLEMENTARY FILES

Figure 1: PRISMA Flowchart

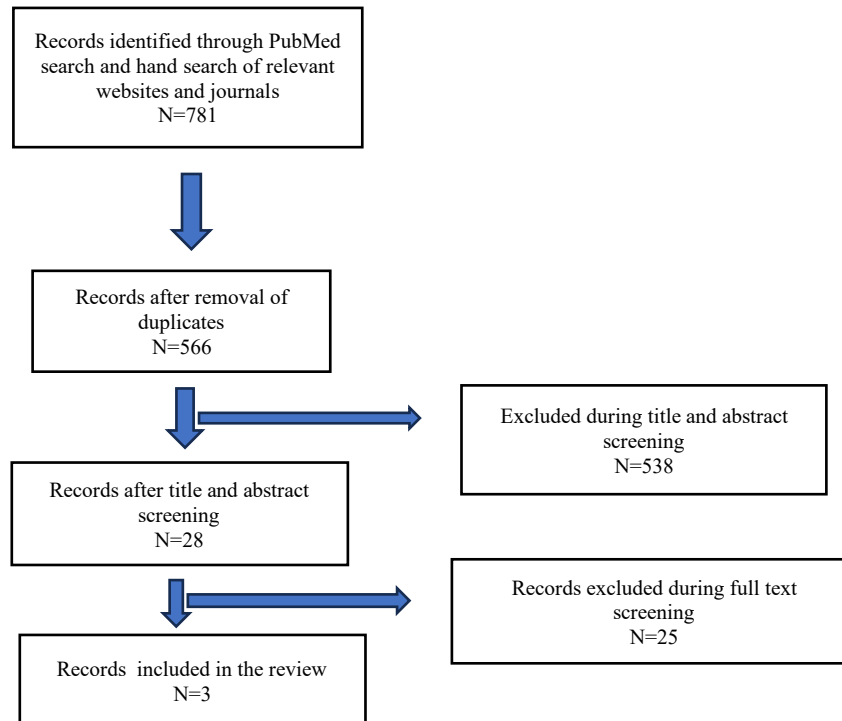


Table 1: Details of the population, intervention, comparator and outcome of the included studies in the review

Study	Population	Intervention type	Comparator	Outcomes	Study design	Location
Fançon y (2021)	Children (6-59 months)	Counselling on prevention of open sky defecation, latrine cleaning, adequate hand washing, healthy backyard	Nutrition counselling	Increase in hemoglobin levels and reduction of anemia prevalence , Proportion of households with	Experimental Impact Evaluation (RCT)	Angola

Study	Population	Intervention type	Comparator	Outcomes	Study design	Location
		environment , adequate water availability, treatment, transportation and storage and adequate personal hygiene		latrines, clean latrines, clean environment		
Shrestha (2020)	School-aged children aged 8–17 years	Development of a poster to display information related to handwashing and waste management , handwashing demonstration, songs, audio visual aids, construction of latrines, handwashing facilities with the weekly provision of soap, weekly health education programmes related to WASH for caregivers	Education on fruits and vegetables	Prevalence of anemia, handwashing with soap, knowledge about anemia	Experimental Impact Evaluation (RCT)	Nepal

Study	Population	Intervention type	Comparator	Outcomes	Study design	Location
		and community stakeholders with the distribution of soap once a week				
Stewart (2019)	Pregnant women and their children upto 2 years	Promotion of treatment of drinking water, upgradation of existing latrines, provision of sani-scoop for removing animal and human fecal material, handwashing stations provision along with soapy water dispensers	IYCF behavior and lipid-based supplementation	Levels of hemoglobin	Experimental Impact Evaluation (RCT)	Kenya & Bangladesh

Table 2: Critical appraisal of the effectiveness studies included in the review

Author Name	1*	2*	3*	4*	5*	6*	7*	8*	Overall*
Fançony (2021)	Medium	Low	Medium	High	High	Low	Low	Medium	Low
Shrestha (2020)	High	Medium	High	High	High	Low	Medium	Medium	Low
Stewart (2019)	High	Low	High	High	Medium	Medium	High	Medium	Low

*1. Intervention-Is the intervention clearly named and described, including all relevant components 2. Baseline balance 3. Evaluation: Are the evaluation questions clearly stated? 4. Study design- Use the study design coding 5. Outcomes-Are the outcomes clearly defined? Where appropriate do they use an existing, validated measurement tool? 6. Sample size (power calculation)-Do the authors report a power calculation as the basis for sample size? 7. Attrition- Reported for endline and longest follow up. Calculate overall attrition and differential attrition It is often necessary to calculate from table of results. If sample size varies by outcome calculate for highest attrition. 8. Blinding Overall (including questions for all studies)-The overall score uses the weakest link in the chain principle i.e., is the lowest score on any item

Table 3: Summary of effects - effectiveness studies included in the review

Author Name	Outcome	d (95% CI)	Absolute reduction	Interpretation
Fançony (2021)	Hemoglobin levels and prevalence of anemia (%)	0.011 (-0.248 to 0.269) 0.011 (-0.168 to 0.190)	0.13 g/dl increase – Hb 5.4% lower anemia prevalence	Small
Shrestha (2020)	Prevalence of anemia	0.222 (0.012 to 0.431)	1.0% lower anemia prevalence	Small
Stewart (2019)	Hemoglobin level (Kenya)*	4.860 (4.422 to 5.298)	26% lower anemia levels	Very Large
	Hemoglobin level (Bangladesh)*	1.940 (1.764 to 2.116)	9% lower anemia levels	Very Large
I² (p-value): 99.4% (0.000)				
*d value is as reported in the study				

ANNEXURES

S1: Search terms- PubMed database

PICOs	Search terms	Number of hits
Population	Women or “pregnant women” or adolescent* or child* or “frontline workers” or “health worker”	5,590,433
Intervention	"sanitation” OR “sanitation” OR “Wastemanagement” OR “Latrine utilization” OR “Water quality” OR “Food hygiene” OR “Personal hygiene” OR “Hand washing” OR “Water, sanitation and hygiene”	70,148
Outcome Anemia Iron deficiency anemia	“Prophylactic IFA” or “iron folic acid” or “anemia” or “anaemia” or “iron deficiency anemia” or “iron deficiency anaemia” OR Deworming OR haemoglobin OR awareness OR knowledge	1,643,583
Study design	“Impact evaluat*” OR “Randomized control trial” OR RCT OR “Intervention studies” OR “Quasi experimental” OR “Difference in Difference” OR “Propensity score matching” OR “Process Evaluat*” or “Implementation Evaluat*” OR Barriers or facilitators	1,143,744
LMICs	afghanistan OR albania OR algeria OR american samoa OR angola OR antigua and barbuda OR antigua OR barbuda OR argentina OR armenia OR armenian OR aruba OR azerbaijan OR bahrain OR bangladesh OR barbados OR belarus OR byelarus OR belORussia OR byelORussian OR belize OR british honduras OR benin OR dahomey OR bhutan OR bolivia OR bosnia OR herzegovina OR botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR burkina faso OR burkina fasso OR upper volta OR burundi OR urundi OR cabo verde OR cape verde OR cambodia OR kampuchea OR khmer republic OR cameroon OR cameron OR cameroun OR central african republic OR ubangi shari OR chad OR chile OR china OR colombia OR comoros OR comoro islands OR iles comores OR mayotte OR congo OR zaire OR costa rica OR cote d ivoire OR cote divoire OR cote d ivoire OR ivory coast OR croatia OR cuba OR cyprus OR czech republic OR czechoslovakia OR djibouti OR french somaliland OR dominica OR dominican republic OR ecuador OR egypt OR united arab republic OR el salvador OR eritrea OR estonia OR eswatini OR swaziland OR ethiopia OR fiji OR gabon OR gabonese republic OR gambia OR georgia republic OR georgian OR ghana OR gold coast OR gibraltar OR greece OR grenada OR guam OR guatemala OR guinea OR guyana OR british guiana OR	9,137,647

	<p> haiti OR hispaniola OR honduras OR hungary OR india OR indonesia OR timor OR iran OR iraq OR isle of man OR jamaica OR jordan OR kazakhstan OR kazakh OR kenya OR korea OR kosovo OR kyrgyzstan OR kirghizia OR kirgizstan OR kyrgyz republic OR kirghiz OR laos OR lao pdr OR lao people's democratic republic OR latvia OR lebanon OR lebanese republic OR lesotho OR basutoland OR liberia OR libya OR libyan arab jamahiriya OR lithuania OR macau OR macao OR macedonia OR madagascar OR malagasy republic OR malawi OR nyasaland OR malaysia OR malay federation OR malaya federation OR maldives OR indian ocean OR mali OR malta OR micronesia OR kiribati OR marshall islands OR nauru OR northern mariana islands OR palau OR tuvalu OR mauritania OR mauritius OR mexico OR moldova OR moldovian OR mongolia OR montenegro OR morocco OR ifni OR mozambique OR portuguese east africa OR myanmar OR burma OR namibia OR nepal OR netherlands antilles OR nicaragua OR niger OR nigeria OR oman OR muscat OR pakistan OR panama OR papua new guinea OR new guinea OR paraguay OR peru OR philippines OR philipines OR phillipines OR philippines OR poland OR polish people's republic OR portugal OR portuguese republic OR puerto rico OR romania OR russia OR russian federation OR ussr OR soviet union OR union of soviet socialist republics OR rwanda OR ruanda OR samoa OR pacific islands OR polynesia OR samoan islands OR navigator island OR navigator islands OR sao tome and principe OR saudi arabia OR senegal OR serbia OR seychelles OR sierra leone OR slovakia OR slovak republic OR slovenia OR melanesia OR solomon island OR solomon islands OR norfolk island OR norfolk islands OR somalia OR south africa OR south sudan OR sri lanka OR ceylon OR saint kitts and nevis OR st. kitts and nevis OR saint lucia OR st. lucia OR saint vincent and the grenadines OR saint vincent OR st. vincent OR grenadines OR sudan OR suriname OR surinam OR dutch guiana OR netherlands guiana OR syria OR syrian arab republic OR tajikistan OR tadjikistan OR tadzhikistan OR tadzhik OR tanzania OR tanganyika OR thailand OR siam OR timor leste OR east timor OR togo OR togolese republic OR tonga OR trinidad and tobago OR trinidad OR tobago OR tunisia OR turkey OR turkmenistan OR turkmen OR uganda OR ukraine OR uruguay OR uzbekistan OR uzbek OR vanuatu </p>	
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	OR new hebrides OR venezuela OR vietnam OR viet nam OR middle east OR west bank OR gaza OR palestine OR yemen OR yugoslavia OR zambia OR zimbabwe OR northern rhodesia	
Region	global south or africa south of the sahara or sub-saharan africa or subsaharan africa or africa central or central africa or africa northern or north africa or northern africa or magreb or maghrib or sahara or africa, southern or southern africa or africa eastern or east africa or eastern africa or africa western or west africa or western africa or west indies or indian ocean islands or caribbean or central america or latin america or south and central america or south america or asia central or central asia or asia northern or north asia or northern asia or asia southeastern or southeastern asia or south eastern asia or southeast asia or south east asia or asia western or western asia or europe eastern or east europe or eastern europe	1,422,541
Developing country	developing country or developing countries or developing nation* or developing population* or developing world or less developed countr* or less developed nation* or less developed population* or less developed world or lesser developed countr* or lesser developed nation* or lesser developed population* or lesser developed world or under developed countr* or under developed nation* or under developed population* or under developed world or underdeveloped countr* or underdeveloped nation* or underdeveloped population* or underdeveloped world or middle income countr* or middle income nation* or middle income population* or low income countr* or low income nation* or low income population* or lower income countr* or lower income nation* or lower income population* or underserved countr* or underserved nation* or underserved population* or underserved world or under served countr* or under served nation* or under served population* or	2,121,743

	under served world or deprived countr* or deprived nation* or deprived population* or deprived world or poor countr* or poor nation* or poor population* or poor world or poorer countr* or poorer nation* or poorer population* or poorer world or developing econom* or less developed econom* or lesser developed econom* or under developed econom* or underdeveloped econom* or middle income econom* or low income econom* or lower income econom* or low gdp or low gnp or low gross domestic or low gross national or lower gdp or lower gnp or lower gross domestic or lower gross national or lmic or lmics or third world or lami countr* or transitional countr* or emerging economies or emerging nation*)	
	Total number of hits – combined terms	781

S2: Screening questions

1. Is the study conducted in Low and Middle Income Countries, as per the latest World Bank Classification?
 - a. Yes, Include and see Q2
 - b. No, exclude
2. Does the study target children, adolescents and women in the reproductive age groups (0-49 years)?
 - a. Yes, include and see Q3
 - b. No, exclude
3. Does the study evaluate demand side (BCC, social marketing, social media) and health system intervention (WASH, IFA supplementation, deworming, Hb testing) for reducing anemia?
 - a. Yes, Include
 - b. No, exclude
4. Is the study an impact evaluation or process evaluation?
 - a. Yes, include
 - b. No, exclude

S2a: Data coding tool

Code	Options	Comments
Year of publication	Info box	
Funding agency	Info box	
Author and title (only for word format)		
Region	<ol style="list-style-type: none"> 1. East Asia and Pacific 2. Europe and Central Asia 3. Latin America and Caribbean 4. Middle East and North Africa 5. South Asia 6. Sub Saharan Africa 7. South America 	
Country Name	Info box (add names of countries in eppi)	
Study Design	<ol style="list-style-type: none"> 1. Experimental Impact Evaluation (Randomised controlled trials) 2. Non-experimental Impact Evaluation 3. Systematic Reviews 4. Process Evaluations 5. Qualitative reports (includes both) 6. Observational qualitative study 	
Settings	<ol style="list-style-type: none"> 1. Rural 2. Urban 3. Rural and Urban (Both) 4. Not Clear 	
Population	<ol style="list-style-type: none"> 1. Children (6-59mo) 2. Children (5y-9y) 3. Adolescent girls 4. Adolescent boys 5. Women of Reproductive Age 6. Pregnant women 7. Lactating women 8. Frontline workers 9. Other program level staff 	
Intervention details		
Intervention name	Mention in info box	
Scale of intervention	<ol style="list-style-type: none"> 1. Regional level 2. National level 3. State level/District level 4. Village/ward/block level 5. Household/individual level 	
Intervention broad category (these levels are based on socio ecological framework-McLeroy)	<ol style="list-style-type: none"> 1. Interpersonal level (individual) 2. Intrapersonal level (household) 3. Community level (schools, ANC clinics, AWC etc.) 4. Public policy level (government, programs) 	Mention the level at which the intervention is conducted

Code	Options	Comments
Intervention type (categories and sub-categories)	<ol style="list-style-type: none"> 1. Deworming 2. IFA supplementation 3. Hemoglobin testing 4. Behavior change communication 5. Social marketing 6. Social media/Digital /M-health/Artificial intelligence 7. WASH interventions 	
Frequency of intervention	<ol style="list-style-type: none"> 1. More than 3 times a week 2. 2-3 times a week 3. Once a week 4. More than once a month (but <weekly) 5. Less than once a month (once in 2 months) 6. Others-info box 7. Not reported 8. Not applicable 	
Channel used to deliver the intervention	<ol style="list-style-type: none"> 1. Home visits 2. Healthy / community facility visit 3. Digital/M-health 4. Others 5. Not reported 6. Not applicable 	
Key personnel delivered the intervention	<ol style="list-style-type: none"> 1. Government 2. Private 3. others, specify (info box) 	
Comparator	<ol style="list-style-type: none"> 1. No intervention 2. Similar intervention 3. Info box 	
Duration of intervention		
Sample size	<ol style="list-style-type: none"> 1. Intervention category 2. Comparator category 3. Total 4. Not reported 	
Attrition	Mention in info box	
Outcome details		
Broad outcome levels	<ol style="list-style-type: none"> 1. Interpersonal level (individual) 2. Intrapersonal level (household) 3. Community level (schools, ANC clinics, AWC etc.) 4. Public policy level (government, programs) 	
Outcome categories	<ol style="list-style-type: none"> 1. IFA supplement adherence 2. Consumption of supplement 3. Knowledge attitudes towards supplement 4. Hemoglobin level 	

Code	Options	Comments
	5. Prevalence of anemia 6. Taboos about anemia 7. Availability of supplies 8. Facility based service provision 9. Frequency of visit by frontline workers 10. Deworming treatment 11. Utilization of services-IFA supplementation 12. Transfer of trained staff 13. Availability of information about anemia 14. Visit to ANC clinics 15. Side effects of IFA supplementation 16. Use of social media 17. Knowledge about WASH practices 18. Access to improved sanitation and drinking water	
Outcome detail	Mention details in Info box <i>(add page no in the info box as reference of text)</i>	
Causal mechanism	Mention details in Info box <i>(add page no in the info box as reference of text)</i>	Any mechanism through which intervention has impacted the outcomes
What stakeholders say? – Quotable quotes		These are the quotes from the different stakeholders as mentioned in qualitative studies
Barriers – Supply-side Supply side interventions are defined as those focused on the quality and reach of services. <i>(add page no in the info box as reference of text)</i>	1. Deworming 2. IFA supplementation 3. Hemoglobin testing 4. Behavior change communication 5. Social marketing 6. Social media/Digital /M-health/Artificial intelligence 7. Other	Examples: Stockout/low supplies, training, resources, affordability, administrative capacity
Facilitators – Supply-side Supply side interventions are defined as those focused on the quality and reach of services.	1. Deworming 2. IFA supplementation 3. Hemoglobin testing 4. Behavior change communication 5. Social marketing 6. Social media/Digital /M-health/Artificial intelligence 7. Other	Examples: counselling on intake, side effects

Code	Options	Comments
<i>(add page no in the info box as reference of text)</i>		
Barriers – Demand-side Demand side interventions focuses on increasing uptake of services through financial incentives that reduce the cost of accessing services or through community mobilization <i>(add page no in the info box as reference of text)</i>	1. Deworming 2. IFA supplementation 3. Hemoglobin testing 4. Behavior change communication 5. Social marketing 6. Social media/Digital /M-health/Artificial intelligence 7. Other	Examples: access to IFA, side effects, No information, No knowledge, access to deworming medication, side effects no information/knowledge, access to testing, lack of access to smart phone, social norms
Facilitators – Demand-side Demand side interventions focuses on increasing uptake of services through financial incentives that reduce the cost of accessing services or through community mobilization <i>(add page no in the info box as reference of text)</i>	1. Deworming 2. IFA supplementation 3. Hemoglobin testing 4. Behavior change communication 5. Social marketing 6. Social media/Digital /M-health/Artificial intelligence	Examples: family support, side effects, management/acceptance, beneficiary knowledge; Women's education; Household wealth
Intervention Implementation related issues	Info box <i>(add page no in the info box as reference of text)</i>	

S2b: Critical appraisal tool (Impact evaluations)

Critical appraisal tool for primary studies: effectiveness			
<i>Item</i>	Description	Key	Notes
<i>Intervention</i>	Is the intervention clearly named and described, including all relevant components	High: full and clear description, so that the main components and how they are delivered are clear. Medium: Partial description Low: Little or no description	High if fully reference source for such information
<i>Baseline balance</i>	A test that the average values of outcomes and confounders are the same in treatment and comparison at baseline. Sampling error means we would expect 5% of tests to appear as significantly different even if no true population difference. Properly done randomization should, with sufficient sample size, ensures balance but not guaranteed.	High confidence: baseline balance on 90% or more of reported indicators Medium confidence: Baseline balance on 80% or more of reported indicators Low: Baseline balance on less than 80% or more of reported indicators or no baseline balance table / results	
<i>Evaluation questions</i>	Are the evaluation questions clearly stated?	High: full and clear description, Medium: Partial description Low: Little or no description	
<i>Study design</i>	Use the study design coding	High: Experimental (RCT and natural), Medium: IV, RDD, ITS, Switching regressions Low: PSM , Other regression, other matching	
<i>Outcomes</i>	Are the outcomes clearly defined? Where appropriate do they use an existing, validated measurement tool?	High: full and clear definition using validated instruments where available (a researcher wishing to use these outcomes would have sufficient information to do so) Medium: Partial definition. May use validated instruments	

		but without sufficient references to source. Low: Little or no definition	
<i>Sample size (power calculation)</i>	Do the authors report a power calculation as the basis for sample size?	High: Power calculation report and sample size meets necessary sample size Medium: Power calculation mentioned and sample size meets necessary sample size Low: No mention of power calculation.	
<i>Attrition</i>	Reported for endline and longest follow up. Calculate overall attrition and differential attrition It is often necessary to calculate from table of results. If sample size varies by outcome calculate for highest attrition.	High: Attrition within IES conservative standard Medium: Attrition within IES liberal standard Low: Attrition outside IES liberal standard	
Blinding		High: Blinding at any stage of the study Medium: No mention of blinding	Non critical item
<i>Overall (including questions for all studies)</i>	The overall score uses the weakest link in the chain principle i.e., is the lowest score on any item	High: High on all critical items Medium: No lower than medium on any critical item Low: At least one low critical item	

S3: List of included studies

1. Fançony Cláudia, Soares Ânia, Lavinha João, Barros Henrique, & Brito Miguel. (2021). Effectiveness of Nutrition and WASH/malaria educational community-based interventions in reducing anemia in children from Angola. *Scientific Reports*, 11(1), 1–12.
2. Shrestha Akina, Schindler Christian, Odermatt Peter, Gerold Jana, Erismann Séverine, Sharma Subodh, Koju Rajendra, Utzinger Jürg, & Cissé Guéladio. (2020). Nutritional and health status of children 15 months after integrated school garden, nutrition, and water, sanitation, and hygiene interventions: A cluster-randomised controlled trial in Nepal. *BMC Public Health*, 20(1), 1–19.
3. Stewart Christine P, Dewey Kathryn G, Lin Audrie, Pickering Amy J, Byrd Kendra A, Jannat Kaniz, Ali Shahjahan, Rao Gouthami, Dentz Holly N, & Kiprotich Marion. (2019). Effects of lipid-based nutrient supplements and infant and young child feeding counseling with or without improved water, sanitation, and hygiene (WASH) on anemia and micronutrient status: Results from 2 cluster-randomized trials in Kenya and Bangladesh. *The American Journal of Clinical Nutrition*, 109(1), 148–164.

S4: Details of the Included studies

Author (Year)	Population	Intervention	Comparator	Outcome	Study design	Region	Country	Study name
Fançony (2021)	Children (6-59 months)	Counselling on prevention of open sky defecation, latrine cleaning, adequate hand washing, healthy backyard environment, adequate water availability, treatment, transportation and storage and adequate personal hygiene	Nutrition counseling	Increase in hemoglobin levels and reduction of anemia prevalence, Proportion of households with latrines, clean latrines, clean environment	Experimental Impact Evaluation (RCT)	Sub-Saharan Africa	Angola	National Child
Shrestha (2020)	School-aged children aged 8–17 years	Development of a poster to display information related to handwashing and waste management, handwashing demonstration, songs, audio visual aids, construction of latrines, handwashing facilities with the weekly provision of soap, weekly health education programmes related to WASH for caregivers and community stakeholders with the distribution of soap once a week	Education on fruits and vegetables	Prevalence of anemia, handwashing with soap, knowledge about anemia	Experimental Impact Evaluation (RCT)	South Asia	Nepal	Un
Stewart (2019)	Pregnant women and their children	Promotion of treatment of drinking water, upgradation of existing latrines, provision of sani-scoop for removing animal and human fecal material, handwashing stations	IYCF behavior and lipid-based	Levels of hemoglobin	Experimental Impact Evaluation (RCT)	Multiregional	Kenya & Bangladesh	Rural urban

Author (Year)	Population	Intervention	Comparator	Outcome	Study design	Region	Country	Study
	upto 2 years	provision along with soapy water dispensers	supplementation					