



# Integrated Approach in Addressing Undernutrition in Developing Countries: A Scoping Review of Integrated Water Access, Sanitation, and Hygiene (WASH) + Nutrition Interventions

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## ABSTRACT

A scoping review of integrated water access, sanitation, and hygiene (WASH) plus nutrition interventions was conducted mainly to describe different components of intervention and examine their effectiveness in improving nutritional outcomes among children. Of the 8 small- to large-scale interventions, 6 were conducted in sub-Saharan Africa and the remaining 2 in South Asia. All the interventions were done in rural settings; the majority involved sanitation and hygiene deliverables along with the nutrition strategies, such as distribution of nutrition supplements. In assessing effectiveness, no significant improvements were seen in growth indicators; reduction in diarrheal rate among children was also not universal across interventions. Further strengthening of WASH, especially an improvement in “W”, or water access, is warranted to ensure uptake of sanitation and hygiene behaviors and prevent the fecal–oral route among children. Improved water access will also enhance the effectiveness of nutrition initiatives, such as promoting vegetable gardening and utilization of child nutrient supplements. *Curr Dev Nutr* 2021;5:nzab087.

**Keywords:** safe water, sanitation, hygiene, WASH, undernutrition, intervention, integrated trials, nutrition

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Supplemental Table 1 is available from the “Supplementary data” link in the online posting of the article and from the same link in the online table of contents at <https://academic.oup.com/cdn/>.

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Abbreviations used: COVID-19, coronavirus disease 2019; SDG, Sustainable Development Goal; SHINE, Sanitation, Hygiene, Infant Nutrition Efficacy; USAID, US Agency for International Development; WASH, water access, sanitation, and hygiene.

## Introduction

The 4 different forms of undernutrition (i.e., wasting, stunting, underweight, and micronutrient deficiencies) remain prevalent global health issues (1). In particular, children in low- and middle-income countries are highly vulnerable to undernutrition and its related lifelong effects (1–3). According to the World Bank Report, the economic burden of undernutrition, measured as the loss of national productivity and economic growth, costs up to 11% of the gross domestic product in certain countries in Africa and Asia (3). This report also emphasized that undernutrition is one of the world’s most serious but least addressed challenges. For the most part, South Asia and sub-Saharan Africa are highly affected, with an above-average prevalence of undernutrition compared with other regions (3). Furthermore, the coronavirus disease 2019 (COVID-19) pandemic has worsened undernutrition in these regions by disrupting food systems, daily income, earning opportunities, and related loss of network.

To address the underlying causes of undernutrition, several approved nutrition-related behavioral and regulatory interventions involve a multisectoral approach. Especially at the country level, a multi-

stakeholder platform is recommended that involves the government, health organizations, and the private sector to address the multifactorial and complex issue of undernutrition (4). At the micro-level, behavioral interventions focusing on the improvement in personal practices and habits are often used to prevent and treat undernutrition among children. For instance, nutrition education and the use of complementary food supplements have been successful in reducing undernutrition among children in resource-poor settings (5). However, it is recognized that the use of a single nutrition intervention is effective only in certain specific conditions. In most settings, a combination of nutrition-specific and nutrition-sensitive approaches is more useful in addressing and preventing undernutrition (6). The UNICEF conceptual framework of the determinants of child undernutrition highlights that inadequate nutrient intake and the occurrence of frequent diarrhea are immediate causes of undernutrition (6). In particular, diarrhea affects the nutritional status in 2 ways: 1) diarrhea causes anorexia, reduces food utilization, and causes nutrient exhaustion at each episode and 2) undernutrition puts children at higher risk for diarrheal diseases (1, 6, 7).

Diarrhea kills ~1400 children every day, making it the second leading cause of death among children under 5 (7). Rotavirus is the most

prevalent pathogen responsible for acute diarrhea; hence, rotavirus vaccination has become one of the leading efforts in addressing diarrhea-related morbidity and mortality among children (8, 9). However, approximately 88% of diarrhea-related mortality is linked to underlying issues of unsafe water, poor sanitation facilities, and insufficient hygiene (9). Occurrence of the fecal–oral route due to poor sanitation and lack of water services is of significant concern in low- and middle-income countries. The current evidence indicates that a lack of water and sanitation services is associated with food insecurity and poor hygiene practices at the household level (10–12), while, specifically among children, it is associated with environmental enteropathy and diarrheal diseases (13, 14). Hence, water access, sanitation, and hygiene (WASH) interventions have been implemented at the community and household levels to reduce diarrheal infections and undernutrition among children. A 2013 Cochrane review of WASH interventions indicated that strategies involving improvement in water quality, quantity, and hygiene were effective in bringing about a small reduction in stunting among children. This review's conclusions demonstrated that more integrated and rigorous trials were needed considering the complexity and interconnection among various WASH components and nutrition (15).

Considering the important role of WASH, the WHO, in collaboration with the US Agency for International Development (USAID) and UNICEF, called for the integration of WASH and nutrition programs to achieve greater health gains and nutrition outcomes among children (6). Under this call for action, 3 major large-scale randomized controlled trials—the WASH-Benefits Bangladesh, WASH-Benefits Kenya, and the Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) in Zimbabwe—sponsored by large, multilateral sources of funding, were implemented, and a summary of the effectiveness of these trials has been published (16). In this summary paper, Pickering et al. (16) provided a clear understanding of the components, coverage, and outcomes of these 3 interventions, with the conclusion that these trials were not effective in improving linear growth among young children. Specifically, it was emphasized that a more rigorous approach was needed to make the living environment free of fecal matter and to reduce the rate of diarrhea among children in low- and middle-income countries. However, to recognize the importance of small- and mid-scale interventions and fully understand the current status of the use of the integrated WASH plus nutrition approach as well as its outcomes, the 3 specific objectives of this scoping review were to 1) describe the WASH and nutrition components of small- to large-scale integrated interventions, 2) examine the effectiveness of the integrated interventions in improving nutritional outcomes, and 3) compare the intervention components to identify vital strategies and approaches needed in advancing the use of an integrated framework to address undernutrition.

## Methods

### Literature search process and steps in shortlisting papers for the review

From August to November 2020, an extensive literature search was conducted using 3e scientific databases: EBSCO, PubMed, and Google Scholar. For each database, the following keywords were used in different combinations: water, water access, time spent, water intervention, nutrition, undernutrition, malnutrition, undernourishment, sani-

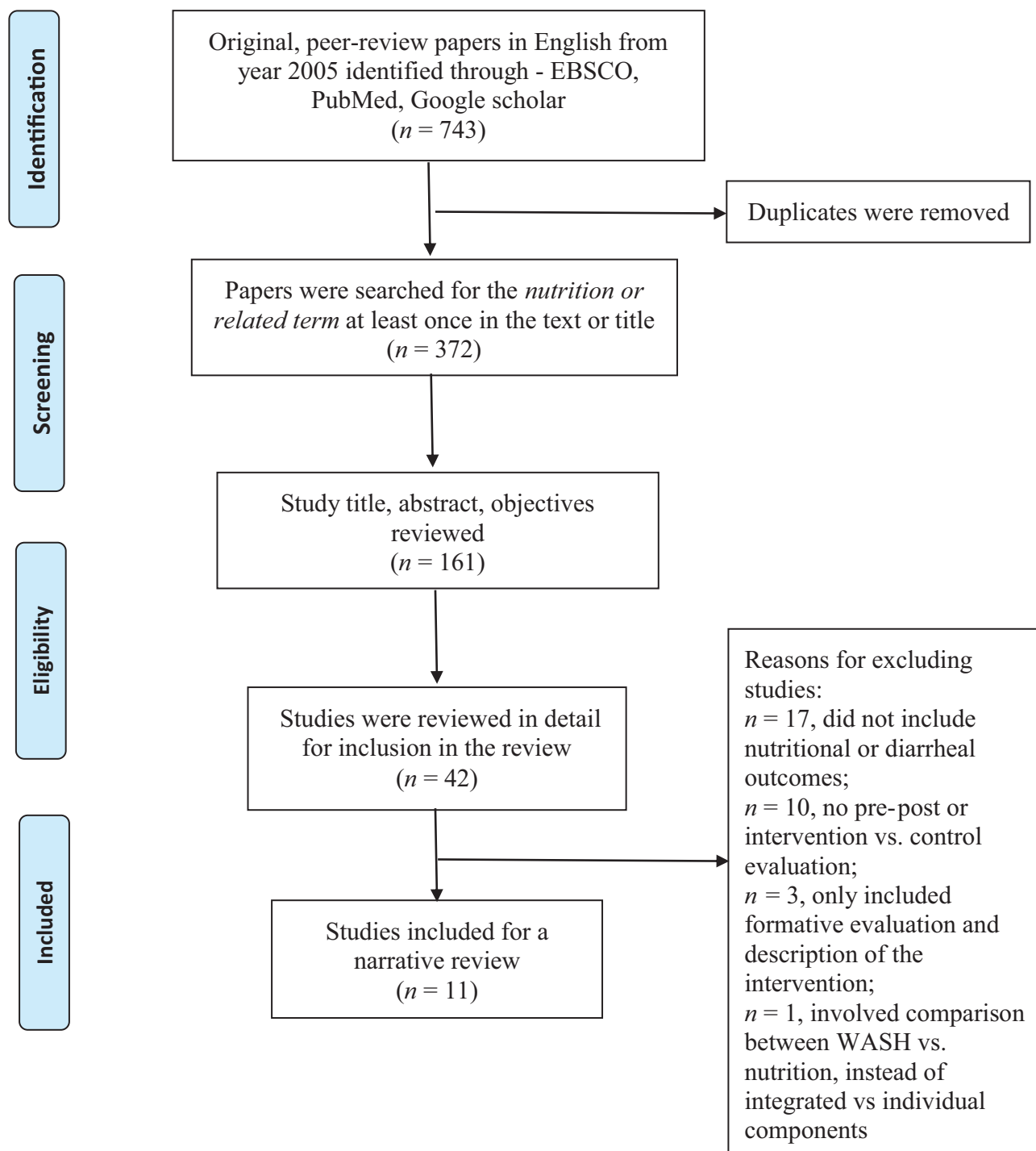
tation, integrated WASH, hand washing, hand hygiene, and growth (see **Supplemental Table 1**). The search results from different combinations were organized in the MS-Excel (version 16.0; Microsoft Corporation) for each database. The following filters were used at this stage 1 of identification: 1) articles published from year 2005 onwards, 2) only peer-reviewed articles, and 3) published in English. Any non-peer-reviewed articles, such as reports, abstracts, and policy briefs, were excluded. Even short communications were filtered out from the search. Then, as a next step, the lists from the 3 databases were compared and duplicates were removed.

Under stage 2 of screening, the peer-reviewed studies were searched for WASH. The articles including WASH were then searched for nutrition or related words in the abstract or title. Then, as shown in **Figure 1**, the studies' title, abstract, and/or objectives were scrutinized in reference to the review paper topic. At this stage, all the articles involving a combination of nutrition and WASH-related outcomes were considered eligible for an in-depth and detailed review.

In the final selection of articles, papers that included the following 1 or more components of WASH were selected: 1) water quantity or supply, 2) water quality (especially in reference to drinking water), 3) sanitation (or safe ways of disposing human excreta), and 4) hygiene (hand-washing at critical stages such as after defecation and disposal of child feces and before eating). Additionally, the other 3 criteria that were used in the final selection of papers were 1) an integrated intervention involving equal or almost equal components of WASH and nutrition; 2) the manuscript involved the measurement of nutrition-related outcomes, such as stunting (length/height-for-age *z* score), wasting (weight-for-length/height *z* score), or diarrhea (defined as at least 3 loose or watery stools within 24 h or at least 1 stool with blood) in measuring the effectiveness of the integrated intervention; and 3) pre- and post- or intergroup comparisons were made to evaluate the effectiveness of the intervention or program. Furthermore, the selection of articles included all types of interventions ranging from just educational to a combination of education and delivery of materials for nutrition and WASH. Intervention or programs that did not include evaluation of direct nutrition-related indicators were excluded. For instance, papers that aimed to measure the effectiveness of integrated intervention on respiratory diseases or cognitive development or parasitic infections without any nutrition outcomes were not included in the review. In addition, interventions or programs without pre-post or intergroup evaluation were excluded, including studies that focused on formative assessment and just implementation of the intervention. In the end, back-referencing was also done to find potential additional studies for the review.

### Coordination between authors in selecting and reviewing papers

After the initial searching in different databases and organization of the unduplicated article list in the Excel sheet, the authors divided the list with 372 papers between them for independent screening. The second round of screening of articles using title and abstract/objectives was also carried out by both authors independently. Later, the results were compared, and minor discrepancies were discussed to come to consensus. Further, using the above-described predefined set of inclusion and exclusion criteria, authors reviewed the articles independently and then together to select a final list of 11 articles for the review (see **Figure 1**).



**FIGURE 1** Description of the search process and election of articles for the review. EBSCO, Elton Bryson Stephens Company; WASH, water access, sanitation, and hygiene.

The selected papers were reviewed and information from each study was extracted independently by each author using a predetermined information-organizing table, including listing key conclusion points, especially in reference to the effectiveness of integrated interventions in improving nutritional outcomes. Disagreements were discussed to come to consensus.

## Results

The study used the recommended Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (17). A summary of the search steps and results is shown in Figure 1. From the initial unduplicated list of 743 articles, 161 were shortlisted using the

initial round of searching and screening for WASH and nutrition-related terms. The titles, abstracts, and texts of these 161 studies were then screened to shortlist 42 for the detailed review using the inclusion and exclusion criteria. Based on this stage 2 selection, 11 peer-reviewed papers were included in the review.

These 11 peer-reviewed papers represented 8 different trials or studies, since the nutrition results of the WASH-Benefits Kenya and Bangladesh trials were presented in 5 different papers (18–22). Of these, 2 papers (21, 22) presented the results of the primary outcomes of growth indicators (stunting, wasting, and underweight) in Kenya and Bangladesh, while 3 others (18–20) presented the secondary outcomes, such as hemoglobin concentrations and diet diversity among intervention children. To ensure a complete understanding of the effectiveness of the trials, all 5 WASH-Benefits trials papers presenting nutrition-related outcomes were included for review. However, the descriptions of the basic characteristics and comparisons of the interventions are presented for 8 different interventions (21–28).

### Characteristics of the studies

All of the peer-reviewed papers selected were full research articles, the publication years of which ranged from 2012 to 2020 (see Table 1). All 8 studies were conducted in rural areas in Asia and sub-Saharan Africa. In particular, the majority of the studies were carried out in sub-Saharan Africa and represented such countries as Malawi (23), Ethiopia (24, 25), Zimbabwe (26), Burkina Faso (27), and Kenya (22). In Asia, the studies specifically took place in Nepal (28) and Bangladesh (21). The average duration of the studies was ~3 y, involving 3 main consecutive stages: the baseline measurements, the intervention, and a follow-up. As shown in Table 1, for all 8 different trials, the nutritional outcomes were measured in children, with 4 of them specifically focusing on infants and toddlers (21, 22, 25, 26). Especially, the WASH-Benefits Kenya, WASH-Benefits Bangladesh, and SHINE trials began with recruiting pregnant women to measure the effect of trials on the growth of their infants and toddlers (21, 22, 26).

Six of the 8 studies represented interventions at the community or household level (21–26); for the remaining 2 studies (27, 28), the intervention was implemented at the school level, targeting older children (aged 8–17 y old). All of the studies involved comparisons between groups encompassing different intervention and control arms. Existing partnerships and ongoing nutrition or related programs were often used to define interventions or study areas. Then, as a next step, a randomization was carried out to group clusters of households or villages as intervention and control groups. For instance, in the study by Head et al. (24) in Ethiopia, as a first step, 2 districts with an ongoing food aid program and the presence of a partner agency were selected as the study area. Then, as a second step, the villages in these districts were randomized for the intervention.

### Description of integrated WASH and nutrition-intervention strategies

As shown in Table 2, 2 interventions were primarily educational (23, 25), while the remaining trials involved deliverables or the distribution of hardware in the treatment groups. Overall, community health workers familiar with the study area and the population were utilized to recruit, outreach, and collect data for evaluation.

### Educational integrated intervention.

In the intervention conducted by Morse et al. (23) in Malawi, the nutrition component comprised education on food hygiene and covered the following topics: washing utensils with soap and keeping them in an elevated place, reheating leftover food, and the importance of finding time to feed the children. In the case of the WASH components, the topics included handwashing with soap at critical times, safe removal of feces from the household compound, and how to keep the water clean during storage. The educational messages were delivered in a repetitive format, including several door-to-door individual and group sessions, as well as the promotion of messages at community events. As for sampling, a cluster of villages referred to as “Traditional Authorities” were randomized into treatment and control groups. Households in these villages were then selected in groups for the convenience of the intervention delivery, which was conducted by trained community workers under the supervision of local program officers.

The second integrated educational intervention took place in 11 villages in the Amhara region in Ethiopia (25) and mainly supplemented an ongoing safety net program involving health care delivery, food aid, and therapeutic feeding initiatives. Under WASH education, topics such as soap use, handwashing, and keeping surroundings clean were covered. In the case of nutrition education intervention, the focus was on prenatal nutrition and feeding practices covering the first 1000 d as well as information on causes, symptoms, and treatment of diarrhea. The integrated intervention villages involved the delivery of messages for 10 d/mo.

### Intervention involving hardware delivery along with the educational component.

The majority of the integrated interventions involved hardware delivery, such as the construction and/or distribution of WASH and nutrition-related items. Among WASH-related interventions, 2 components—improving sanitation and handwashing facilities—were very common as deliverable strategies.

### Water quantity and quality components of WASH.

Three studies involved strategies to improve water access (24, 25, 27). Among them, a school-based intervention in Burkina Faso (27) included the rehabilitation of water pumps and the installation of drinking water stations in the classrooms. Similarly, in another intervention in Ethiopia (24), the water quantity aspect of WASH was covered by repairing and/or construction of water sources in the intervention area. In this specific study area, the construction of water sources was critical, since the intervention site was a drought-prone area and involved a government-based food aid program due to a severe food shortage.

For water quality, intervention households in the WASH-Benefits trial in Bangladesh (21) received a 10-L container with a tap and a lid to store drinking water. In addition, households received a supply of a water-purifying agent (dichloroisocyanurate tablets) with instructions on how to use it. In the educational component, it was emphasized that household members, especially children, should drink treated water stored in this safe container (21). Similarly, in the WASH-Benefits trial in Kenya (22), the water-purifying agent was distributed at the community and household levels. Moreover, households were given a 6-mo supply of purifying agent to utilize during the rainy season, when rainwater use was more common, versus communal water sources. In

**TABLE 1** Description of basic characteristics of the integrated WASH and nutrition interventions implemented between 2005 and 2020<sup>1</sup>

Study, year (reference)	Study location	Study period	Study design	Target population and total sample size <sup>2</sup>
Morse et al., 2020 (23)	Southern region, Malawi (Rural)	March 2017–November 2018	Intervention 1 vs. 2 vs. control; each group 1 TA	<5-y-old children, n = 1000
Shrestha et al., 2020 (28)	Northeastern region, Nepal (Rural)	March 2015–June 2016	Intervention 1 vs. 2 vs. control, each group 4 schools	8–17-y-old children, n = 682
Head et al., 2019 (24)	One zone in the largest region, Ethiopia (rural)	2011–July 2015 <sup>3</sup>	Intervention 1 vs. 2, each 6 villages	<5-y-old children, n = 1007
Humphrey et al., 2019 (26)	Midland Province, Zimbabwe (rural)	November 2012–March 2015	Intervention 1 vs. 2 vs. 3 vs. control, each group 52 or 53 villages	Infants and toddlers, <sup>6</sup> n = 3686
Luby et al., 2018 (21) <sup>4</sup>	Central Division, Bangladesh (rural)	May 2012–November 2015	Intervention 1 vs. 2 vs. 3 vs. 4 vs. 5 vs. 6 vs. control; 90 in intervention and 180 household clusters in control group <sup>5</sup>	Infants and toddlers, <sup>6</sup> n = 7094
Null et al., 2018 (22) <sup>4</sup>	Western region, Kenya (rural)	November 2012–July 2016	Intervention 1 vs. 2 vs. 3 vs. 4 vs. 5 vs. 6 vs. active control vs. passive control; 77 to 80 in intervention and 158 household clusters in control groups <sup>5</sup>	Infants and toddlers, <sup>6</sup> n = 6494
Erismann et al., 2017 (27)	Western region, Burkina Faso (rural)	February 2015–March 2016	Intervention vs. control, each group 4 schools	8- to 15-y-old children, n = 360
Fenn et al., 2012 (25)	Regional state in northern Ethiopia (rural)	October 2004–September 2009	Intervention 1 vs. 2 vs. 3 vs. 4 vs. control, 11 villages in 4 intervention and 3 villages in control groups	Infants and toddlers 6–36 mo, <sup>6</sup> n = 3758

<sup>1</sup>TA, Traditional Authorities, a subdivision of a district representing a cluster of villages in the area; WASH, water access, sanitation, and hygiene.

<sup>2</sup>Total sample size specifically represents the follow-up numbers after dropouts, and were represented as households or individuals.

<sup>3</sup>Information on starting month was not provided.

<sup>4</sup>These 2 papers represent the primary papers of the WASH-Benefits trial conducted in Bangladesh and Kenya; the other 3 papers focused on secondary nutrition outcomes (i.e., references 18, 19, 20) not listed here since the study characteristics remain the same.

<sup>5</sup>Household clusters refer to ~6 to 8 pregnant women living in a nearby area with a cluster diameter of 1 km, on average.

<sup>6</sup>Originally, pregnant mothers were recruited and outcomes were measured among children

**TABLE 2** Summary of intervention components in the integrated WASH plus nutrition interventions or programs that occurred from 2005 to 2020<sup>1</sup>

Study, year (reference)	WASH				Nutrition components	Type and other details: educational only (1) vs. hardware only (2) vs. both (3) <sup>2</sup>
	Water quantity	Water quality	Sanitation	Hygiene		
Educational only Morse et al., 2020 (23)	Water use	Water storage techniques	Feces management	Handwashing with soap	Food safety during meal preparation	1: Individual- and group-level sessions for 31 wk 1: Home-based and center-based education sessions for 5 d each
Fenn et al., 2012 (25)	NC	Water protection	Importance of sanitation; importance of separate housing for animals	Importance of hygiene	Nutrition during pregnancy and lactation; importance of diet diversity; optimal feeding practices	
Distribution of hardware/technology Shrestha et al., 2020 (28)	NC	NC	Construction of latrines in schools	Weekly provision of soaps in schools	School gardens; nutrition education in classes; distribution of educational materials	3: Implementation was affected by major earthquake in the area
Head et al., 2019 (24)	Repair of old/construction of new water pumps	NC	Promotion on building/fixing household toilets	Education on hand hygiene	Screening and treatment of severe malnutrition; distribution of vegetable seed + education on feeding practices	3: Study area was drought prone and was affected severely by drought during the study
Humphrey et al., 2019 (26)	NC	Chlorine water treatment product for infant's water	Ventilated improved pit latrines constructed; playing mat and yard provided	"Tippy Tap" handwashing stations built; liquid soap	Lipid-based nutrient supplement (20 g/d); nutrition education	3: Study was conducted in HIV-endemic area, but participants selected were HIV-negative
Luby et al., 2018 (21)	NC	Distribution of insulated container to store drinking water and water-purification tablets	Distribution of potty and scoop; construction of improved latrine	Installation of handwashing station, storage bottle, soap sachet to prepare soapy water	Lipid-based nutrient supplement (20 g/d)	3: This is the main paper evaluating WASH-Benefits trial in Bangladesh

(Continued)



TABLE 2 (Continued)

Study, year (reference)	WASH				Nutrition components	Type and other details: educational only (1) vs. hardware only (2) vs. both (3) <sup>2</sup>
	Water quantity	Water quality	Sanitation	Hygiene		
Null et al., 2018 (22)	NC	Installation of chlorine dispensers at communal water sources	Distribution of potty and scoop; new or upgrading improved latrines in each family compound, education on sanitation	Installations of "dual Tippy Tap" stations in each family compound	Lipid-based nutrient supplement (20 g/d) + education on optimal feeding practices	3: This is the main paper evaluating WASH-Benefits trial in Kenya
Erismann et al., 2017 (27)	Rehabilitation of water pumps	Installation of drinking water stations in classrooms	Installation of latrines at school	Installation of handwashing stations; materials to make soap	Provision of seeds and tools for school gardening	3: School teachers and directors were trained to deliver WASH and nutrition messages in classrooms; antiparasitic treatments were also provided to children

<sup>1</sup>NC, not covered (references 18, 19, 20 representing secondary papers of WASH-Benefits in Bangladesh and Kenya are not listed in the table since the intervention's information remained the same compared with primary papers of references 21 and 22; WASH, water access, sanitation, and hygiene.

<sup>2</sup>In case of hardware/education (type 3) only the hardware component is listed.

addition to that, at the common water sources, chlorine dispensers were installed for the community to use.

#### **Sanitation component of WASH.**

Improvement in sanitation systems to prevent fecal contamination was the most common strategy in the 6 studies that involved deliverables (21, 22, 24–26, 28). The sanitation component mainly involved strategies such as building improved sanitation facilities or latrines at the household or community levels. Even the school interventions in Burkina Faso (27) and Nepal (28) included the building of latrines in the vicinity. For example, in the Nepal study (28), at least 3 latrines were built per intervention school. The WASH-Benefits (21, 22) and SHINE (26) trials also involved the distribution of materials such as play-pan and toilet potties to prevent open defecation for children. Since the use of these materials involved behavior change, all the interventions had sanitation education components covering the importance of latrine use and keeping the household area or environment free of fecal matter.

#### **Hygiene component of WASH.**

The hygiene component of handwashing with soap and water at key steps was promoted both through providing supplies and delivering educational lessons. In the case of deliverables, the distribution of soap bars or liquids was very common among the intervention groups to ensure the uptake of handwashing behavior. Both the SHINE trial in Zimbabwe (26) and the WASH-Benefits trial in Kenya and Bangladesh (21, 22) involved the installation of 2 handwashing stands in the intervention households. The locations chosen were near the latrines and the cooking area. However, the technology used differed in these 3 locations based on the formative assessment, which was adapted to the local household setting and culture. The school interventions also involved the installation of handwashing and soap stations (27, 28). For all the interventions, handwashing education involved providing information on the key stages for washing hands. For instance, Head et al. (24) in Ethiopia used USAID's Essential Hygiene Actions framework to promote handwashing among mothers in 5 key steps: after defecation, after cleaning a child who has defecated, before preparing food, before eating, and before feeding a child.

#### **Nutrition component of the integrated intervention.**

Among the interventions involving both nutrition- and WASH-related deliverables, the distribution of ready-to-use nutrient-rich therapeutic foods among infants and toddlers and vegetable gardening was very common. In particular, the SHINE trial in Zimbabwe (26) and the WASH-Benefits trial (21, 22) comprised the distribution of lipid-based nutrient supplements for infants and toddlers aged 6 mo and older. The delivery of this supplement was generally done on a monthly basis. Each household was provided with a supply so that the indexed child could receive 20 g of supplement/d, corresponding to a daily intake of ~120 kcal. In the intervention in Ethiopia by Head et al. (24), the nutrition component comprised screening and treating children with severe malnutrition, along with the long-term strategies of providing vegetable seeds and promoting backyard gardening.

In the Nepal study (28), the nutrition component involved vegetable gardening in the intervention schools. Schoolteachers were trained to establish and manage school gardens and teach children how to do gardening. It was noted that each school garden produced ~150 kg of veg-

etables/y, part of which was distributed to the children. As a secondary aspect, the children also received small packets of seeds to grow vegetables at home. Similarly, in Burkina Faso (27), the nutrition component of the intervention comprised school gardening. The teachers and school directors were provided with agricultural training, seeds, and gardening tools. The intervention also included nutrition education for schoolchildren on a weekly basis.

#### **Effectiveness of the integrated intervention on nutritional outcomes**

**Table 3** summarizes the effectiveness of the WASH plus nutrition interventions in improving nutritional outcomes among children, and **Figure 2** presents a conceptual framework diagram and a synthesis of our findings. Overall, all of the studies included process evaluations to measure the fidelity of the intervention. For instance, in Malawi, the delivery of educational messages at the individual and group levels was recorded by community health workers and confirmed by field supervisors (23). In the SHINE trial in Zimbabwe (26), the intervention fidelity rate encompassing the distribution and use of deliverables was >80%. However, even with the high intervention fidelity, no significant joint effect of WASH plus nutrition was seen on anthropometrics and the incidence of diarrhea among children in the SHINE trial.

Similarly, as shown in **Table 3**, the WASH-Benefits trials in Kenya and Bangladesh showed no improvement in the length and weight of enrolled children. For the other primary outcome, diarrhea among children, a significant reduction was seen in Bangladesh, but not in Kenya, among the WASH plus nutrition group. In examining the secondary outcomes of the WASH-Benefits trials, it was noted that nutrition supplementation with nutrition education reduced the risk of anemia and other vitamin/mineral deficiencies among children. However, a specific WASH effect was not observed.

The results of the intervention in Ethiopia by Head et al. (24) showed a significantly lower level of stunting among children in the integrated group, but there was no difference in the rate of diarrheal diseases between groups. The study location was a drought-prone area that had ongoing food aid and other health services programs at the time of the intervention. Hence, the improvement in stunting, a chronic malnutrition indicator, might have been the joint effect of the current intervention plus other ongoing food aid and health programs. In an education-only intervention by Fenn et al. (25) in Ethiopia, the primary outcome measured was length for age among children up to 3 y old. In comparison, no significant difference in improvement was seen between the integrated and control children.

Among the school-based interventions in Nepal, it was found in measuring effectiveness that the prevalence of anemia decreased in the integrated group. However, for the anthropometric measurements, the incidence of stunting remained the same as the control group. In addition, in the school-based intervention in Burkina Faso (26), no significant changes in anthropometrics were found among children from the integrated intervention schools. The intervention also involved giving antiparasitic drugs to children, which was achieved, and there was a significant reduction in intestinal infection for intervention children. For education-only interventions, Morse et al. (23) found a significant reduction in diarrhea rates among intervention children. In the second educational intervention that took place in Ethiopia, there was a significant increase in knowledge among mothers related to WASH and



**TABLE 3** Effectiveness of the integrated WASH plus nutrition intervention on different primary and secondary nutritional outcomes among children<sup>1</sup>

Study, year (reference)	Anthropometric measurements			Diarrhea <sup>2</sup>	Other nutritional outcomes (if any)
	Stunting	Wasting	Underweight		
Morse et al., 2020 (23)	NM	NM	NM	↓	—
Shrestha et al., 2020 (28)	NSE	NM	↑	NM	Increase in knowledge and intake of fruits and vegetables; decrease in anemia mainly attributed antiparasitic drugs
Head et al., 2019 (24)	↓	NSE	NSE	NSE	—
Humphrey et al., 2019 (26)	NSE	NSE	NSE	NSE	Head circumference
Jannat et al., 2020 (18)	—	—	—	—	Decrease in consumption of soft drinks, canned fruit juice, sweets/candy, savory snacks, and pickles
Stewart et al., 2019 (19)	—	—	—	—	Decrease in prevalence of iron deficiency and anemia
Jannat et al., 2018 (20)	—	—	—	—	Increase in diet diversity and intake of animal-based foods
Luby et al., 2018 (21)	NSE	NSE	NSE	↓	—
Null et al., 2018 (22)	NSE	NSE	NSE	NSE	—
Erismann et al., 2017 (27)	NSE	NSE	NSE	NM	Prevalence of anemia remained same
Fenn et al., 2012 (25)	NSE	NM	NM	NSE	Increase breastfeeding knowledge and practice; increased knowledge in complementary feeding practices, causes of diarrhea and what to feed during it

<sup>1</sup>All of the up (↑) or down (↓) arrows represent a significant increase or decrease in that particular outcome (i.e.,  $P \leq 0.005$  at the endpoint measurement). NM, not measured; NSE, no significant effect; WASH, water access, sanitation, and hygiene.

<sup>2</sup>Diarrhea referred to as the passage of  $\geq 3$  loose stools or 1 bloody stool in 24 h in reference to the past 7 d.

nutrition, such as causes of diarrhea and the importance of diet diversity (25).

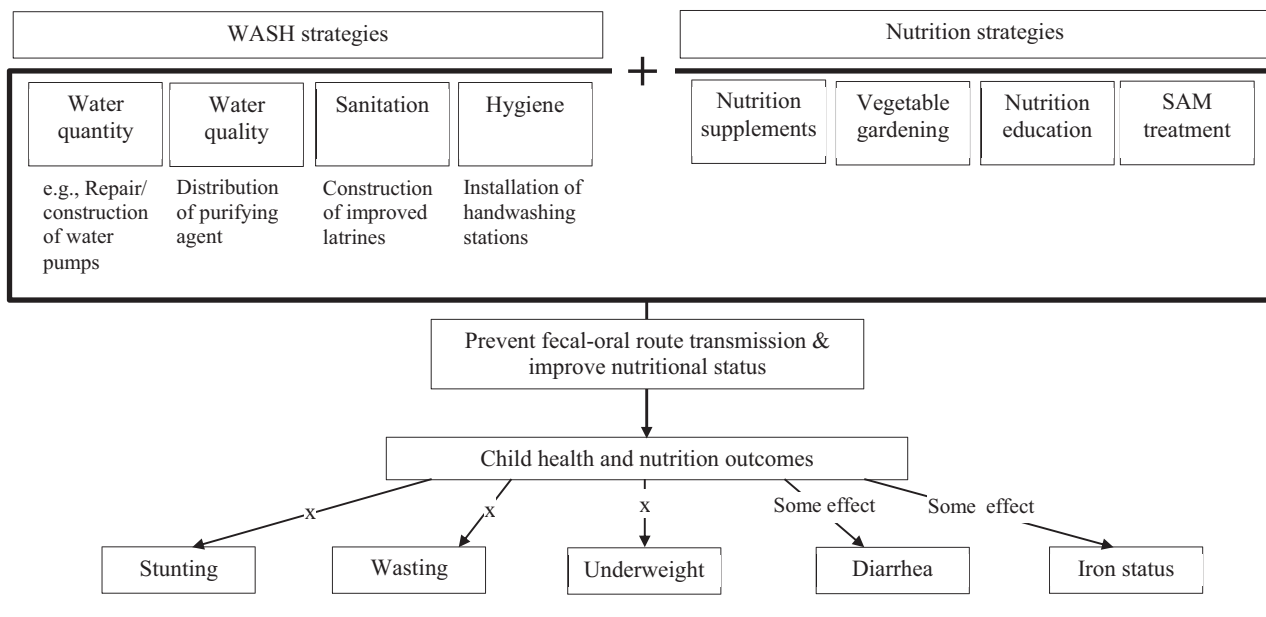
## Discussion

This review of several integrated trials shows that integrated interventions to address undernutrition have been recognized, and efforts are underway to implement joint-effect interventions. As shown in Figure 2, the review indicates that the integrated interventions were not effective in addressing stunting, wasting, or underweight among young children. In the case of another critical undernutrition indicator, that of diarrhea, mixed results were seen. Of the 6 interventions, 2 showed a significant reduction in diarrheal rate among children. Due to significant variability between interventions, it was not possible to conclude which aspects of interventions or settings were critical in reducing diarrhea. However, high intervention fidelity and community-level changes can be concluded as critical components of successful integrated interventions. Similarly, in some interventions, improvement in iron status was noted and can be attributed to the distribution of nutrient-rich supplements and antiparasitic treatment.

All of the interventions included in our review were carried out in rural areas, representing a setting where households generally spend a significant amount of time and energy fetching and managing water for drinking and other household activities. Specific information on wa-

ter access was not provided, but based on the settings, it could be concluded that access to improved water services was not universal among intervention households. For instance, in the WASH-Benefits trial in Kenya, it was noted that household members had to walk for at least 10 min to get to a water source (22). Improved access involving water that is available when needed and free from fecal contamination is not common in rural areas where interventions were conducted (i.e., sub-Saharan Africa and South Asia). Previous research has shown that long distances to water sources and hours spent fetching water are associated with low breastfeeding (29), poor hygiene (13), and low compliance with HIV treatment (30). Water access is the main component, and it should be addressed adequately for the sanitation and hygiene components of WASH to occur effectively. Without good access to water, the uptake of hygiene and sanitation practices, as well as optimal caretaking behaviors, will not be feasible for mothers. In a recent opinion paper on why WASH was not effective in SHINE and WASH-Benefits trials, it was recognized that water services ensuring easy access to clean, safe drinking water are critical and must not be ignored (31).

In a longitudinal study in Bangladesh among 1157 infants, no positive association was found between household-level WASH practices, such as availability of handwashing soap and treating water before use, and linear growth among infants. Based on the results, it was concluded that robust water and sanitation infrastructure at the community level is critical to improving WASH and preventing the fecal–oral route at the household level (32). Several studies have shown that poor water



**FIGURE 2** Summary on effect of integrated WASH + nutrition interventions targeting children in developing countries. WASH strategies involved distribution of hardware/technology delivery and/or education only. SAM, severe acute malnutrition; Some effect, some interventions involved reduction in diarrheal infections or improved iron status among children; x, no significant effect; WASH, water access, sanitation, and hygiene.

access is associated with water insecurity and coping mechanisms that increase the risk for fecal–oral transmission (14, 33–35). For instance, in a qualitative study involving in-depth interviews with women in rural Cameroon, when water fetching took long distances and several trips per day, women used water sparingly and prioritized its use (14). First, water was saved for drinking and cooking. For household activities, recycling or use/reuse of water was common. For example, the water used for washing clothes was then used for washing floors. It was also noted that, due to limited water, the use of toilet facilities was avoided, since cleaning them required water. A positive correlation has also been found between limited water access in water insecurity and handwashing (13, 36). In the interventions, information on the use of handwashing stations or the frequency of handwashing among intervention households was not collected to determine whether water access is associated with the use of handwashing stations among caretakers. During the COVID-19 pandemic, the importance of handwashing has been highlighted and the use of alcohol-based hand sanitizers has been vital. However, due to cost and other issues, such as the need for heavy cleaning due to dirt and grease, the use of hand sanitizers might not be a realistic option in rural settings.

Nutrition strategies ranged from nutrition education on infant feeding practices to the distribution of lipid-based nutrient supplements for children. A sustainable approach including the promotion of vegetable gardening was also a common strategy in the interventions (Figure 2). In the future, the integrated approach of WASH plus nutrition should be continued, with special consideration given to addressing all 3 pillars of food security: food production, access, and utilization. Considering the link between water and food security, it is critical that the nutrition strategies utilized are water and environmentally sensitive, includ-

ing strengthening agricultural water-management practices. It is also important to recognize that water is an essential nutrient, and hence its clean, safe access, and availability, or the “water access” aspect of WASH, can also be counted as a nutrition strategy. In a prospective paper, Young et al. (37) highlighted the importance of accounting for water security in planning food and nutrition programs and policies. It was concluded that consistent availability and access to water should be a goal since they will help to achieve not only SDG no. 6 (universal access to water and sanitation), but also other SDGs, such as no. 2 (zero hunger) and no. 10 (reduced inequalities).

### Strengths and limitations of the review

In this scoping review, each article was reviewed on its own without direct comparison due to differences in methods, intervention period, and strategies. Hence, despite a very thorough review and the systematic process used in the selection of the articles, this paper is not a systematic review. The interventions involved self-reported assessment of diarrheal infections; hence, there is a possibility of recall bias in the original results, and therefore potential understanding of the effect size of integrated interventions on infection rate. Parasitic infections also contribute to poor food utilization and faltering growth, but our review was restricted to diarrhea and did not cover the assessment of an integrated approach from the enteric infections point of view.

### Implications of key findings and next steps

Even though a significant improvement in growth and nutrition was not noted among the integrated interventions, the importance of WASH and addressing it in reducing undernutrition is of the utmost importance. Moving forward, the measurement of water access and strategies

to improve it should be considered when designing integrated interventions. Concurring with Young et al. (37), we propose an interdisciplinary approach to improve water and food security to achieve equity, sustainability, and health at the global level. Based on the review of integrated interventions, we concluded that interventions improving sanitation and hygiene at the household level will be more effective with improved water access and bringing about community-level changes to successfully address the ubiquitous nature of fecal and bacterial contamination of the environment.

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