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SYSTEMATIC REVIEW

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The role of nutrition-sensitive interventions in improving nutritional outcomes: findings from a systematic review and meta-analysis

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Abstract

Background Maternal and child undernutrition remains a major global health concern despite modest progress. Accelerating reductions in stunting and wasting will require increased investments in nutrition-sensitive interventions, which target nutrition impacts outside of the healthcare setting. This review examines the effects of four types of nutrition-sensitive interventions —cash/food transfers, nutrition-sensitive agriculture, water/sanitation/hygiene, and school nutrition— on maternal and child nutrition outcomes and dietary diversity.

Methods We synthesized the evidence using an initial broad search and synthesis for nutrition-sensitive interventions, followed by targeted searches and syntheses for specific interventions and nutrition outcomes. Meta-analyses were performed to evaluate the impacts of cash transfers and agricultural interventions, while a narrative synthesis was produced for additional nutrition-sensitive interventions. Additionally, qualitative synthesis was incorporated to provide insights into the relationship between implementation context and program effectiveness.

Results Our initial evidence synthesis included 260 quantitative studies, and additional targeted searches produced 72 eligible articles. Meta-analyses reveal positive impacts on dietary diversity for cash transfers without nutrition-specific components (0.14 SMD; 95% CI: 0.06–0.22), and some nutrition-sensitive agricultural interventions (0.24 SMD; 95% CI: 0.11–0.37). Cash transfers have larger effects on dietary diversity when they include behavior change communication or other nutrition-specific elements (0.41 SMD; 95% CI; 0.15–0.66), whereas agriculture programs with nutrition-specific elements do not show larger effects on dietary diversity than those without. Narrative syntheses indicate that homestead food production interventions may reduce anemia, school feeding interventions may improve anthropometric outcomes, and WASH interventions are most effective when combined with other nutrition initiatives.

Conclusions We find consistent evidence that nutrition-sensitive programs contribute to dietary diversity and may have small but positive effects on nutrition outcomes, such as anthropometric outcomes and anemia. Integrating nutrition into social protection, agriculture, and education sectors is essential for addressing the underlying causes of malnutrition, such as dietary diversity.

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Registration Our review protocols were pre-registered at AIR.org [https://www.air.org/sites/default/files/2024-01/Synthesis-of-evidence-nutrition-sensitive-interventions-maternal-childrens-nutrition-outcomes-research-protocol-Nov-2023.pdf] and PROSPERO [https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42024552449].

Keywords Nutrition-sensitive interventions, Maternal and child nutrition outcomes, Nutrition, Stunting, Dietary diversity, Anemia

Background

Despite progress and concerted efforts, maternal and child undernutrition remains a major global health concern, as 45 million children under age 5 suffer from wasting, and 148.1 million children are affected by stunting [92]. Further, anemia is the most common micronutrient-related deficiency worldwide, with women and children under 5 years of age being the most affected groups [32].

Accelerating multisectoral actions is critical because to date progress is lagging in fulfilling the maternal and child nutrition Sustainable Development Goal (SDG) targets (SDG 2.2), including stunting, wasting, maternal and child anemia, low birthweight, and obesity. While exclusive breastfeeding has seen larger improvements, pending work remains on this target as well. Existing literature increasingly suggests that nutrition interventions delivered through the health sector, such as complementary feeding, acute treatment of malnutrition, and micronutrient supplementation, are necessary but not sufficient to achieve sizeable improvements in nutrition outcomes such as stunting and wasting.

Achieving accelerations in improvements in such outcomes requires additional investments in large-scale nutrition programs beyond the health sector, often referred to as nutrition-sensitive interventions. Nutrition-sensitive interventions address key underlying determinants of nutrition and enhance the coverage and effectiveness of nutrition interventions; [16, 49, 55, 79, 93]. Examples of promising nutrition interventions outside the health sector include social protection and safety net programs, such as cash transfers, food transfers, graduation programs, water, sanitation, and hygiene (WASH) services. Other examples of promising initiatives include nutrition-sensitive agriculture programs, school nutrition programs, and early childhood development interventions [7, 49]. Multiple studies highlight how nutrition-sensitive interventions can create synergies across sectors to generate larger impacts on nutrition outcomes, such as stunting and wasting [16, 49, 54, 61, 79, 90]. Annex A provides more details on the implementation models of these intervention types.

To support the investment case of nutrition-specific actions to achieve the SDG 2.2 targets, in 2017, the World Bank introduced an investment framework for nutrition for the first time, providing an overview of the investments required to reach global targets for stunting, maternal anemia, exclusive breastfeeding, and wasting [86]. Since then, rigorous evidence on the impact of interventions outside the health sector on nutrition outcomes and dietary diversity has increased considerably [16, 49]. To inform an update to the World Bank's investment framework for nutrition [87], the authors investigated the following research questions using an evidence synthesis:

I. What are the effects of interventions outside the health sector, or nutrition-sensitive interventions, on maternal and child nutrition outcomes in low- and middle-income countries (LMICs)?
II. What types of interventions outside the health sector contribute to improvements in nutrition outcomes and dietary diversity for children, adolescent girls, mothers, and women of reproductive age? What is the magnitude of the effect(s)?
III. Through what mechanisms do interventions outside the health sector generate nutrition outcomes and dietary diversity?

The conceptual framework (Fig. 1) illustrates the complementary pathways toward improved nutrition outcomes stemming from interventions delivered within and outside the health sector.

This systematic review focused on nutrition-sensitive interventions delivered through social protection policies and programs, WASH interventions, agricultural initiatives, and the education sector. Detailed descriptions of the types of interventions included can be found in Annex A. Among these interventions, we present more in-depth meta-analyses on cash transfer and agriculture interventions, which were the two most common interventions in the initial round of abstracts retrieved from our search. We also examined barriers and facilitators toward the effectiveness of cash transfer and agriculture interventions by incorporating qualitative studies.

Methods

This section presents a summary of the synthesis methods, including inclusion criteria for the systematic review, and the synthesis of quantitative and qualitative studies.

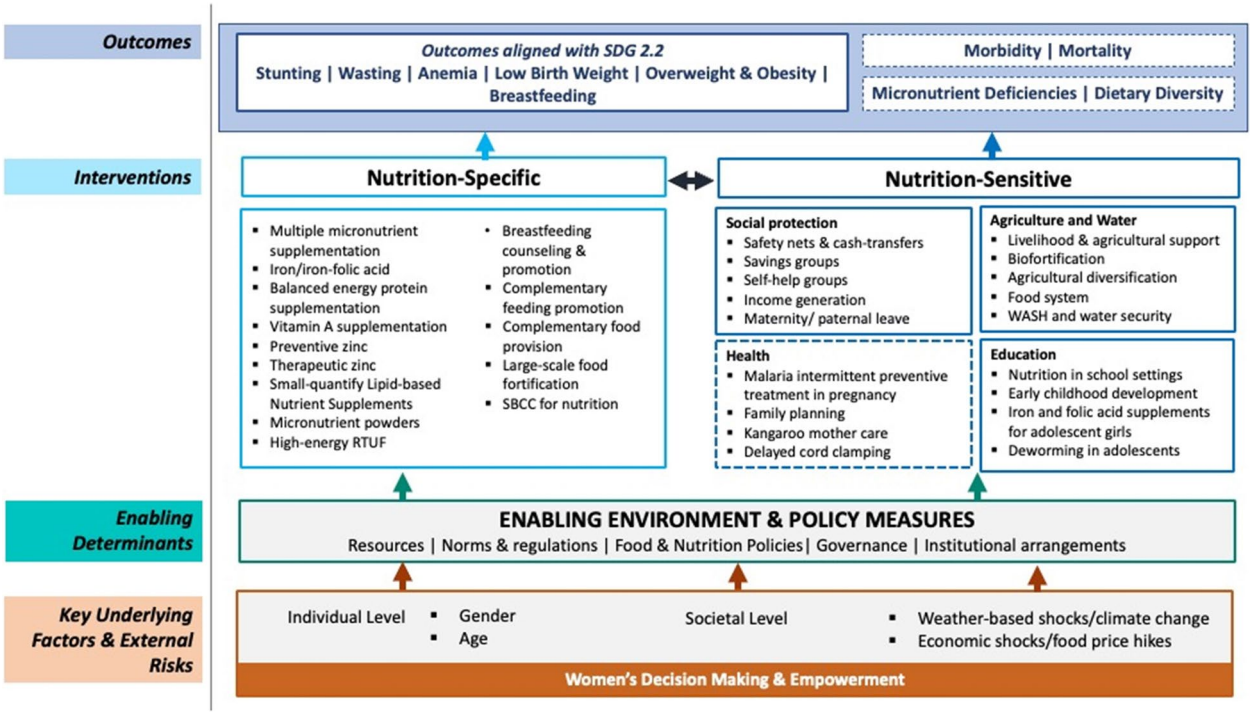

Fig. 1 Framework of the pathways to improve nutrition through nutrition-specific and nutrition-sensitive interventions. Some nutrition-sensitive interventions are delivered through the health sector (dashed box); these interventions were not included in the review

We conducted the review in two parts: 1) we conducted an initial search to comprehensively synthesize evidence on the effectiveness of nutrition interventions outside the health sector; 2) to deepen our contribution to specific evidence gaps, we did targeted searches and syntheses for specific interventions and nutrition outcomes, such as anemia, low birthweight (LBW), and breastfeeding. The protocols for this review provide more details on the methodology [23, 66].

Inclusion criteria for evidence synthesis

We derived a Boolean search string consisting of population-, intervention-, comparison-, and outcome-related keywords ('PICO'). Table 1 reports a summary of the inclusion criteria. Further details, including search terms, can be found in the protocols [23, 66].

Study screening and coding

The first round of screening consisted of a title and abstract review. After manually screening a subset of the identified studies, we optimized efficiency by incorporating the artificial intelligence algorithms embedded in the Evidence for Policy and Practice Information and Coordinating Centre (EPPI)Reviewer software [91] to continuously rank unscreened documents according to their probability of inclusion followed by the exclusion based on a combination of artificial intelligence and human screening. We manually screened articles until the probability of inclusion was 10 percent based on artificial intelligence algorithms analyzing titles and abstracts. After the probability of inclusion for remaining studies fell below 10 percent (and reviewers were rejecting more than 100 consecutive studies or including an equivalent of less than 1 percent of the studies), we conducted key word searches across the remaining unscreened documents to ensure that no eligible studies remained before excluding them. In this way, we finalized the screening of titles and abstracts using a combination of human and artificial intelligence screening.

The second round of screening included a full text review for study inclusion as well as coding whether the study was an impact evaluation, a review, or a process evaluation sibling study.[1] Additional rounds of coding were conducted for included impact evaluations focusing on cash transfer programs and nutrition-sensitive agriculture interventions [22].

Risk of bias assessment

For all impact evaluations focusing on cash transfers or agriculture interventions, we conducted risk of bias

[1] We defined sibling studies as studies that focused on process evaluations of the nutrition sensitive program/intervention or on the fidelity of the implementation of the program or intervention presented in an impact evaluation study included in our review.

Table 1 Inclusion criteria

Domain	Initial Search Criteria	Targeted Search Criteria
Publication dates	2013–2023	2013–2024
Publication accessibility	Published in English Publicly available or shared with the synthesis team	Published in English or Spanish Available in PubMed database
Population of interest	Focuses on population(s) in low- and middle-income countries (LMICs)	Low- and middle-income countries Young children (0–5 years); School-aged children attending public schools; Pregnant and lactating women
Intervention focus	Studies nutrition-sensitive interventions, including those that fall within the purview of agriculture, WASH, social protection (including women's economic empowerment), education, and health programs	Agriculture programs WASH services Early childhood development programs Cash transfers Food transfers and vouchers School feeding programs Maternity leave
Methods	Impact evaluations (randomized controlled trials (RCTs) or quasi-experimental studies with a comparison group); evidence syntheses (e.g., systematic reviews, scoping reviews, meta-analyses); costing studies (e.g., cost–benefit analyses, cost-effectiveness studies, costing studies); qualitative sibling studies that are directly linked to the randomized controlled trial or quasi-experimental study (e.g., process evaluations or implementation science linked to the intervention)	Meta-analysis, Systematic Reviews, Randomized-Controlled trials
Outcomes	Outcomes related to nutritional status and/or dietary diversity	Stunting, wasting, anemia, breastfeeding, low-birth weight, dietary diversity

assessments to appraise the quality of the studies. The risk of bias assessment focused on selection bias and confounding using an adapted version of the tool developed by Waddington et al. [95]. Using these criteria, studies were ranked as either having a low, medium, or high risk of selection and performance bias.[2] Annex B presents the risk of bias assessment tool.

Meta-analyses

After identifying and coding impact evaluations, we extracted data from the studies of cash transfers and agricultural interventions to estimate standardized mean differences (SMDs) and their 95% confidence intervals for nutrition outcomes across treatment and comparison groups. The protocol describes how we first extracted effect sizes from existing meta-analyses followed by the extraction of effect sizes for additional included studies, as well as specifics on how we calculated SMDs and their 95% confidence intervals for the impact evaluations [22].

We conducted separate meta-analyses for cash transfers and nutrition-sensitive agriculture programs and further disaggregated our analyses by outcome (i.e., dietary diversity versus anthropometric outcomes). For our meta-analyses of cash transfer programs, we conducted analyses to examine the pooled effect of all cash transfer programs on nutrition outcomes, as well as analyses of the effects of cash transfer programs with and without nutrition-specific components and the effects of cash transfers with and without conditionalities. For agricultural interventions, we distinguished between the effects of agriculture programs that include nutrition-specific information, agriculture programs that focus on increasing commodity sales using livelihoods interventions, agriculture programs that aim to improve food access through homestead food production and vegetable gardens, agriculture programs that include small animals, livestock and fisheries, and agriculture programs that aim to improve dietary diversity and nutrition through improvements in women's agency. The meta-analyses were conducted using SMDs and standard errors from the impact evaluations.[3]

Systematic review synthesis

For studies categorized as reviews during full-text screening, we conducted an additional round of coding to sort studies based on year, intervention type, reported outcomes, geography (global, regional, or country-specific) and review type (meta-analysis, systematic review, or other review type) – and to verify that each review

[2] We slightly simplified the tool because of the large number of included studies. Specifically, we did not examine risk of outcome and analysis reporting bias.

[3] Following the meta-analyses, we transformed SMDs to odds ratios (OR) using the following formula; $\text{Ln(OR)} = \frac{\pi}{\sqrt{3}} * \text{SMD}$ from (Deeks, Bossuyt, Leeflang, & Takwoingi, 2023). This article only presents the SMDs for space reasons. The report describing the results presents SMDs and ORs (de Hoop, et al., Synthesis of Evidence on the Impacts of Nutrition-Sensitive Interventions on Maternal and Children's Nutrition Outcomes, 2024).

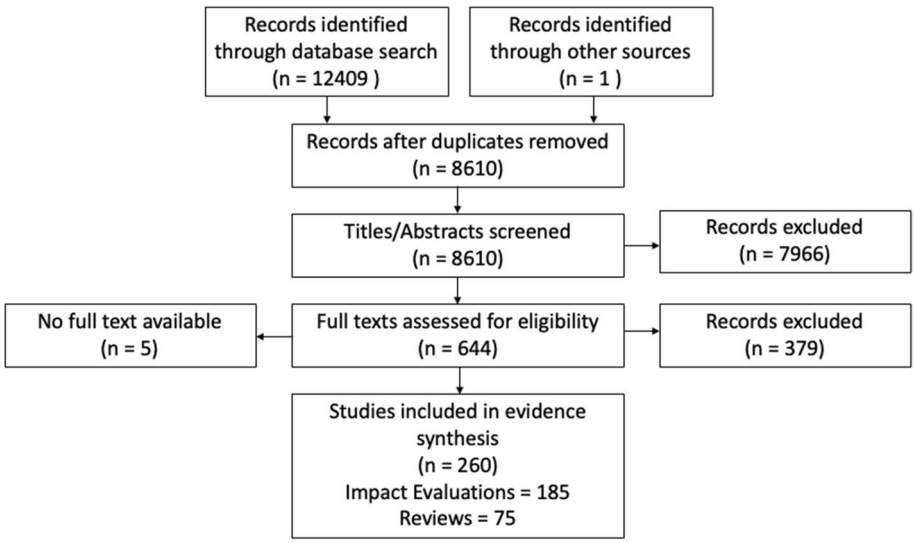

Fig. 2 PRISMA diagram of initial search: impact evaluations and systematic reviews

contained evidence for an eligible pairing between a nutrition intervention outside the health sector and a nutrition outcome related to the Sustainable Development Goals (SDGs). The updated investment framework for nutrition presents a strength of evidence assessment for each intervention category [87].

Qualitative synthesis

To synthesize the qualitative studies, we used a critical appraisal tool and a thematic synthesis of the studies. Annex C provides the codebook used for the thematic synthesis. The protocol presents more details [22].

Results

Characteristics of the included studies

This section describes the characteristics of the included studies. We start with a description of the included impact evaluations and systematic reviews followed by a discussion of the qualitative studies.

Included impact evaluations and systematic reviews

Our initial search produced a total of 8,610 unique articles for review (see Fig. 2). Of these, we manually screened 4,519 titles/abstracts and used artificial intelligence techniques developed as part of EPPI reviewer to exclude an additional 4,091. Of the 644 articles eligible for full text screening, we had full text access to 639 and initially excluded 266. The most common reasons for exclusion were: i) not containing a nutrition-sensitive intervention; ii) not meeting the methodological criteria; and iii) not evaluating a nutrition outcome. During the coding stage, we excluded an additional 113 studies that did not meet the inclusion criteria, for a total of 379 excluded studies. Thus, our initial evidence synthesis included 260 quantitative studies, of which 185 were impact evaluations and 75 were review articles. Within the impact evaluations, 118 focused on either cash transfer or agriculture interventions.[4]

For the initial search, approximately 70% of the 260 included studies were impact evaluations while the remaining 30% were reviews. Figure 3 illustrates the methodological focus of the included studies. Many studies incorporated more than one approach, so the bars in the graph do not sum to 100 percent. Approximately 48% of all studies (68% of impact evaluations) used RCTs, and 28% of all studies (41% of impact evaluations) used a quasi-experimental approach, such as instrumental variable regression analysis, regression discontinuity design, differences-in-differences analysis, propensity score matching, or other panel data method. Approximately one-third of the included reviews contained a meta-analysis. About half of all the impact evaluations included were from sub-Saharan Africa, and another 28% focused on South Asia (Fig. 4). Nearly 70% of the included reviews contained a multi-regional or global focus.

An overview of the outcomes included in the initial search suggests that most of the 260 included studies focused on dietary diversity and stunting with a smaller number of studies focused on wasting. Additional relevant outcomes included food security, anemia, and breastfeeding outcomes (Fig. 5). Many studies included various additional anthropometric outcome measures,

[4] Some of these impact evaluations examined effects of the same intervention (e.g., in different years or on different outcomes or evaluations conducted by different teams).

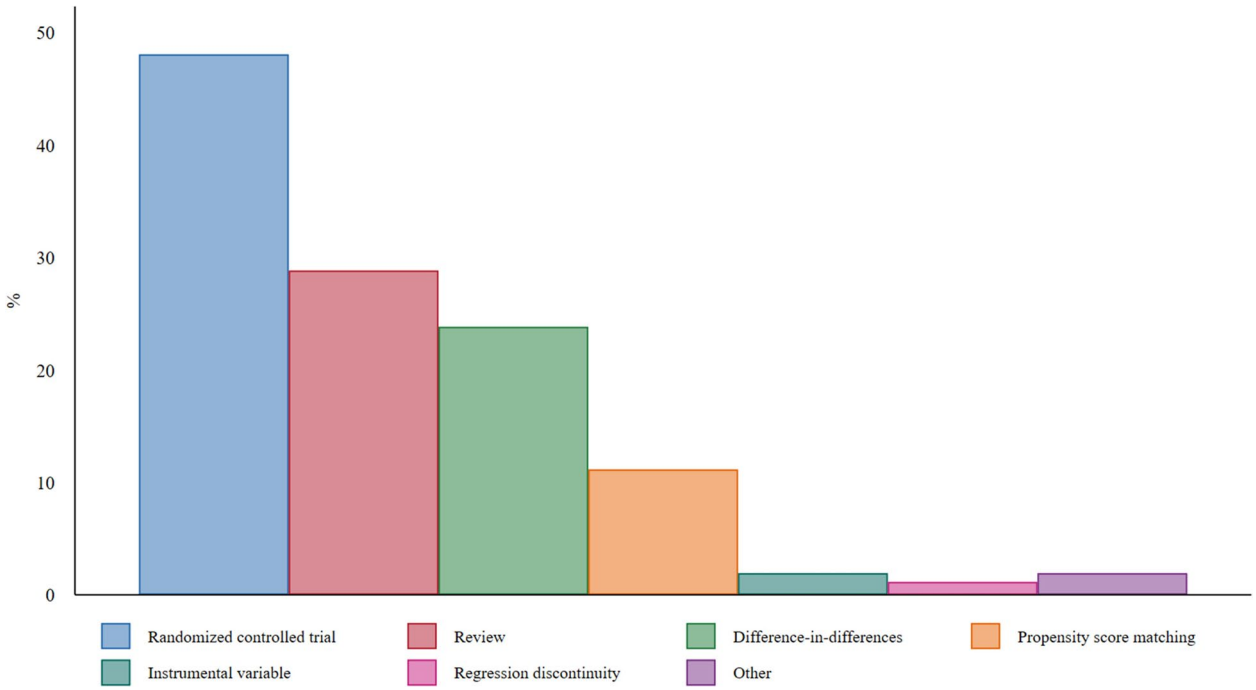

Fig. 3 Methodological focus of studies

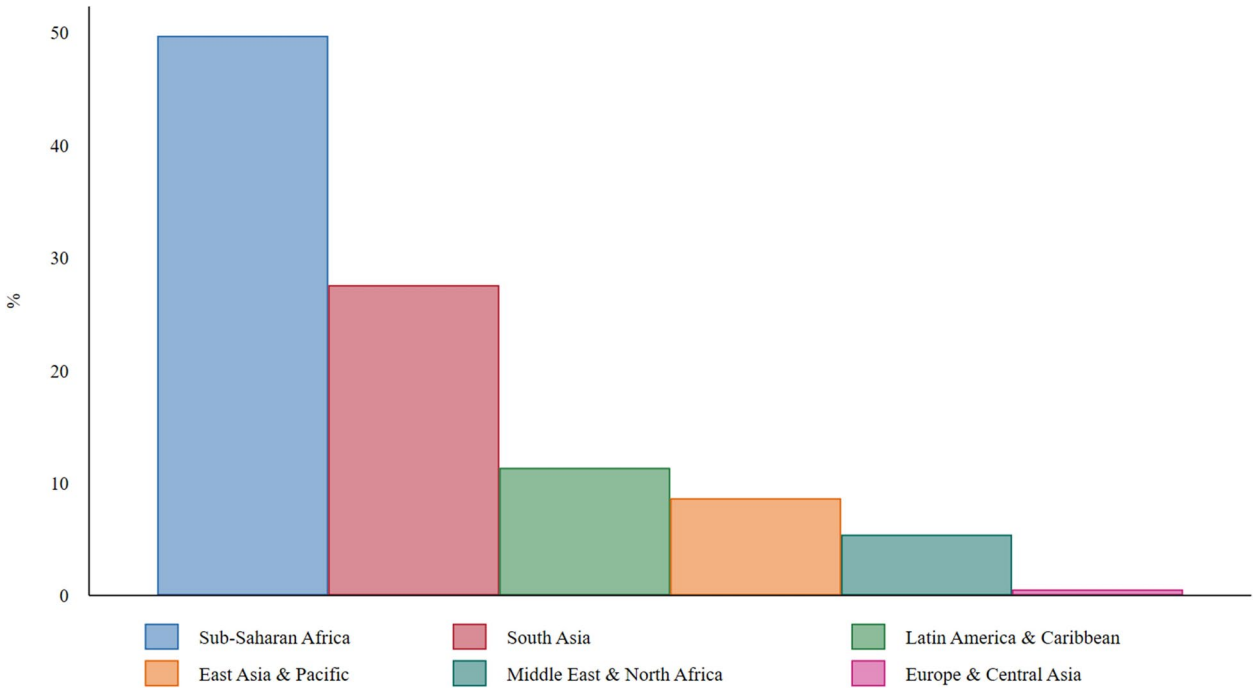

Fig. 4 Regional focus of included impact evaluations

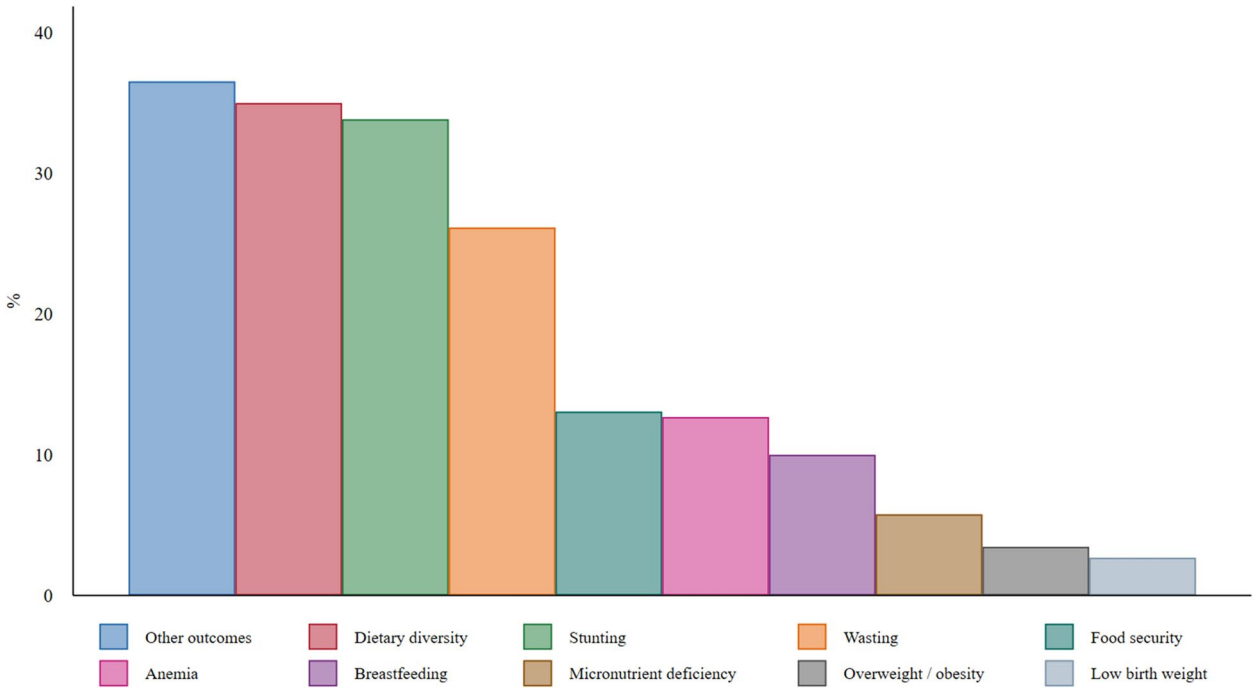

Fig. 5 Outcomes included in the synthesis

such as BMI, height-for-age, weight-for-height, weight-for-age, categorization as underweight, and arm circumference, which we categorized as "Other".[5]

The risk of bias assessment for studies eligible for the meta-analysis[6] suggests that evaluations of cash transfer programs had a lower risk of bias than evaluations of nutrition-sensitive agriculture programs. The majority of agriculture studies had a medium or high risk of selection bias (57% and 27%, respectively). Conversely, 49% of the cash transfer studies in our sample had a low risk of selection bias. Figure 6 presents the results of the risk of bias assessment for the included impact evaluations.[7]

We conducted additional targeted searches for seven types of interventions, and we include the findings for five of these intervention types in the results section.[8] Our targeted searches produced a total of 769 unique articles for review from databases and registers, which were manually screened for title/abstract. Of these articles, 231 were eligible for full text screening. During the initial review, we excluded 126 articles for reasons listed in the PRISMA diagrams of each intervention (i.e., protocol articles, interventions, or outcomes outside of the scope of this review). After full text review, an additional 33 were excluded. Thus, the synthesis of our targeted searches included 72 articles, of which 54 were randomized-controlled trials (RCTs) and 18 were review articles. Table 2 describes the number of articles reviewed for each type of intervention studied, and Annex D contains PRISMA diagrams for the meta-analyses and systematic reviews of the interventions studied.

In the targeted searches (72 studies included), many studies took place in Africa (45.2%), followed by Asia (28.2%) and then globally (16.4%), with Latin America contributing the fewest studies (9.6%). While Africa provided the most evidence across all types of nutrition sensitive interventions, more studies on food transfers and vouchers ($n=11$) came from Asia (45.6%).

Included qualitative studies

Our initial systematic evidence search identified 47 studies that contained some qualitative information about implementation of the interventions. After full-text screening, we excluded 14 studies because they did not

[5] We did not combine stunting and height-for-age measures or wasting and weight-for-height measures in one meta-analysis, which is consistent with the protocol.

[6] The meta-analysis ultimately includes fewer studies because some studies focused on different outcome measures and because some studies examined the effects of the same program.

[7] As discussed in the protocol, we only conducted risk of bias assessments for impact evaluations of cash transfers and nutrition-sensitive agriculture programs.

[8] We do not include results for early childhood development interventions or maternity leave policies, as our findings highlighted the need for broader search terms and methods.

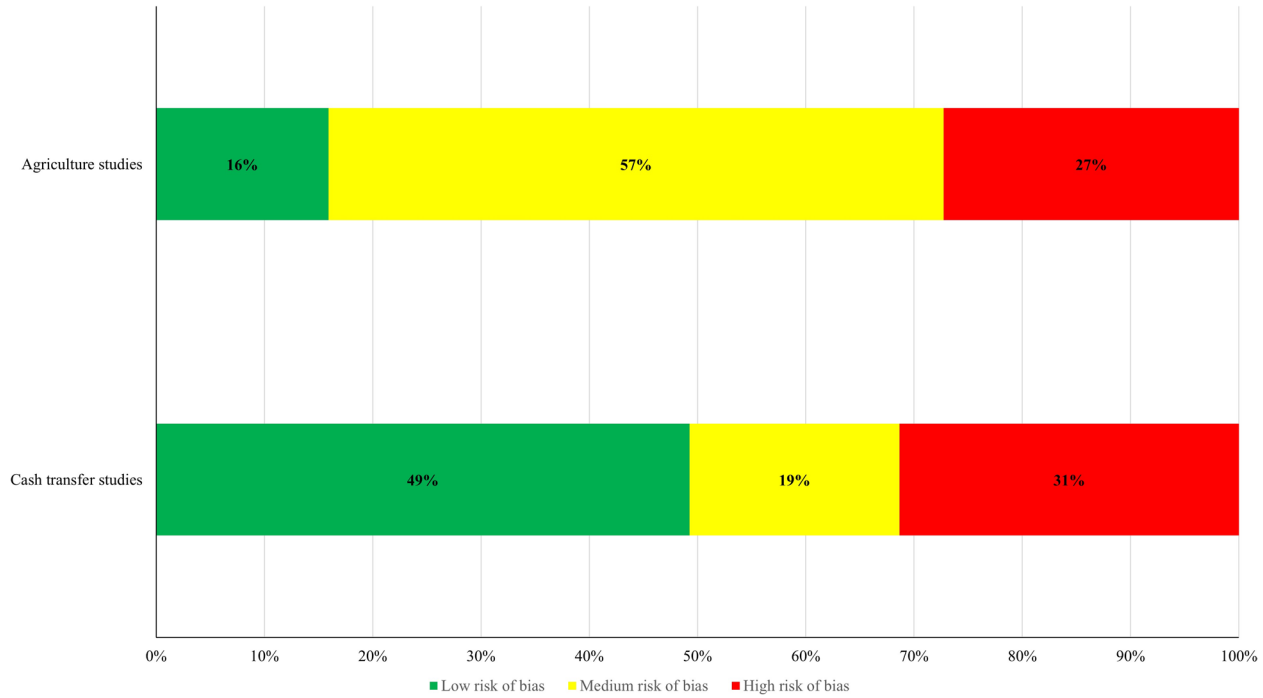

Fig. 6 Risk of selection bias for studies evaluating cash transfers ($n=67$) and agricultural interventions ($n=44$)

Table 2 Screening and reviewing process for targeted searches

Intervention	Abstract review	Full-text review	Articles included
Agriculture	136	37	17
WASH	117	38	6
Cash transfers	165	57	38
Food transfers and vouchers	54	21	11
School feeding	118	34	19
Maternity leave	66	22	5
Early childhood development	113	22	9

We did not include results for early childhood development interventions or maternity leave policies, as our findings highlighted the need for broader search terms and methods

meet the inclusion criteria (see PRISMA in Annex D) and another 24 studies because of low quality (based on the quality appraisal tools). We coded a total of 15 mixed-methods studies, qualitative studies, and process evaluations. We also coded a selection of systematic reviews ($n=14$) focused on nutrition-sensitive agriculture, WASH services, and nutrition-sensitive interventions in school settings (i.e., early childhood development programs) due to the limited number of qualitative studies for these interventions.

Evidence from meta-analyses and narrative syntheses

This section presents the results of the meta-analyses and narrative syntheses related to the different interventions. We start with a description of the impact of cash transfers, followed by discussion around the impact of food transfers and vouchers, nutrition-sensitive agriculture programs, WASH interventions, and school nutrition programs (e.g., school feeding). In each section we present results on the impact of these programs on dietary diversity, and anthropometric outcomes. Where evidence is available, we also discuss implementation challenges and impacts on LWB, breastfeeding practices, and anemia.

Impact of cash transfers

This section summarizes our meta-analysis results on the impact of cash transfers on dietary diversity and anthropometric outcomes, as well as our systematic review on the impact of cash transfers on the likelihood of low birthweight (LBW), breastfeeding practices, and anemia incidence. A more extensive review and synthesis can be found in de Hoop et al., [23]. Annex E presents additional forest plots with the results of the meta-analyses.

Evidence on dietary diversity

The meta-analysis suggests stronger evidence for positive effects of programs that combine cash transfers with

nutrition-specific elements (e.g., behavior change communication) on dietary diversity than for programs that provide cash transfers without nutrition-specific elements though both interventions show positive effects (see Figs. 7 and 8). Cash transfers with nutrition-specific components have an average effect of 0.41 standard deviations on dietary diversity (95% CI: 0.15, 0.66).[9] The meta-analysis suggests that cash transfers without additional nutrition-specific components may, on average, increase dietary diversity by 0.14 standard deviations (95% CI: 0.06, 0.22). Annex E includes additional meta-analyses examining regional trends and differences in the effects of conditional and unconditional transfers.

Evidence on anthropometric outcomes

Cash transfer programs with and without nutrition-specific elements may reduce stunting and wasting incidence, but the average effects are small in magnitude. Cash transfers without nutrition-specific interventions, on average, result in statistically significant reductions of 0.08 standard deviations in stunting (95% CI: −0.15, 0.00) and 0.07 standard deviations in wasting (95% CI: −0.12, −0.01) (see Figs. 9 and 10). Cash transfers with nutrition-specific elements do not seem to have larger effects than cash transfers without nutrition-specific elements on either stunting or wasting, on average (see Annex E).

Table 3 summarizes the studies included from the targeted searches, which assessed the impacts or associations of cash transfers on LBW ($n=4$), breastfeeding ($n=3$), and anemia ($n=5$). Next, we present results for each of these categories.

Evidence on LBW

Studies consistently show a significant, albeit small, reduction in LBW incidence for cash transfer recipients. A systematic review highlighted a 1.5% decrease in LBW cases among mothers who benefited from cash transfers [38]. Another review observed that approximately two-thirds of the included studies confirmed a significant link between conditional cash transfers and a lower probability of LBW [59]. Recent RCTs have echoed these findings, reporting comparable decreases in LBW when cash transfers are coupled with participatory elements and behavior change initiatives [18, 82].

Evidence on breastfeeding

Three recent RCTs evaluated the effect of cash transfers on breastfeeding practices [29, 41, 76]. Two of these trials, which incorporated behavior change communication (BCC) strategies, reported small, but positive effects. Research in Myanmar revealed an increase of 0.7 percentage points (SE = 0.3, $p<0.1$) [29, 76]. However, a study conducted in a humanitarian context in Somalia found no significant effects [41], which may indicate deeper structural challenges. The robustness of the evidence remains modest, given the limited number of studies that have examined this particular outcome.

Evidence on anemia

The evidence on the impact of cash transfers on anemia is mixed. While two systematic reviews reported that a majority of studies found significant improvements in hemoglobin concentrations and reductions in anemia prevalence among children and/or women [67, 83], a recent meta-analysis did not observe a significant effect of unconditional cash transfers on such outcomes [25]. In contrast, the meta-analysis reported a significant association between income generation programs and improvements in both hemoglobin levels and anemia.

How does implementation influence the effectiveness of cash transfers?

The qualitative analysis suggests that factors such as low opportunity costs (cost of participation, cost of transportation), local ownership (by the government or involvement of key community stakeholders), presence of technical assistance from international organizations (e.g., United Nations Children's Fund or World Food Program), and adaptability of implementation strategies were facilitators for implementation. Accessibility of distribution points was a common facilitator of cash transfer implementation [4, 8, 42], and insufficient transfer amounts combined with inflation were the most commonly perceived hindrance to program impacts [1, 4, 14, 39]. The qualitative analysis also stressed the importance of matching the cash transfer mechanism with the implementation context; for example, a program with digital components in Nigeria suffered due to lack of existing digital infrastructure [85], and a voucher program in Pakistan was hindered by lack of access to redeemable items [28].

Impact of food transfers and vouchers

This section focuses on the targeted search to assess the impact of food transfers and vouchers on nutrition outcomes. We first describe the characteristics of the interventions, followed by the main results, challenges in evaluating their impact, and issues related to their implementation. Table 4 summarizes the 11 studies included in the review. The results are presented in two categories: (1) comparisons between food transfers or

[9] However, this effect size reduces to 0.31 standard deviations (95% CI: 0.12, 0.49) when we exclude a study from the Democratic Republic of Congo with a medium risk of selection-bias that targets children with severe acute malnutrition [40].

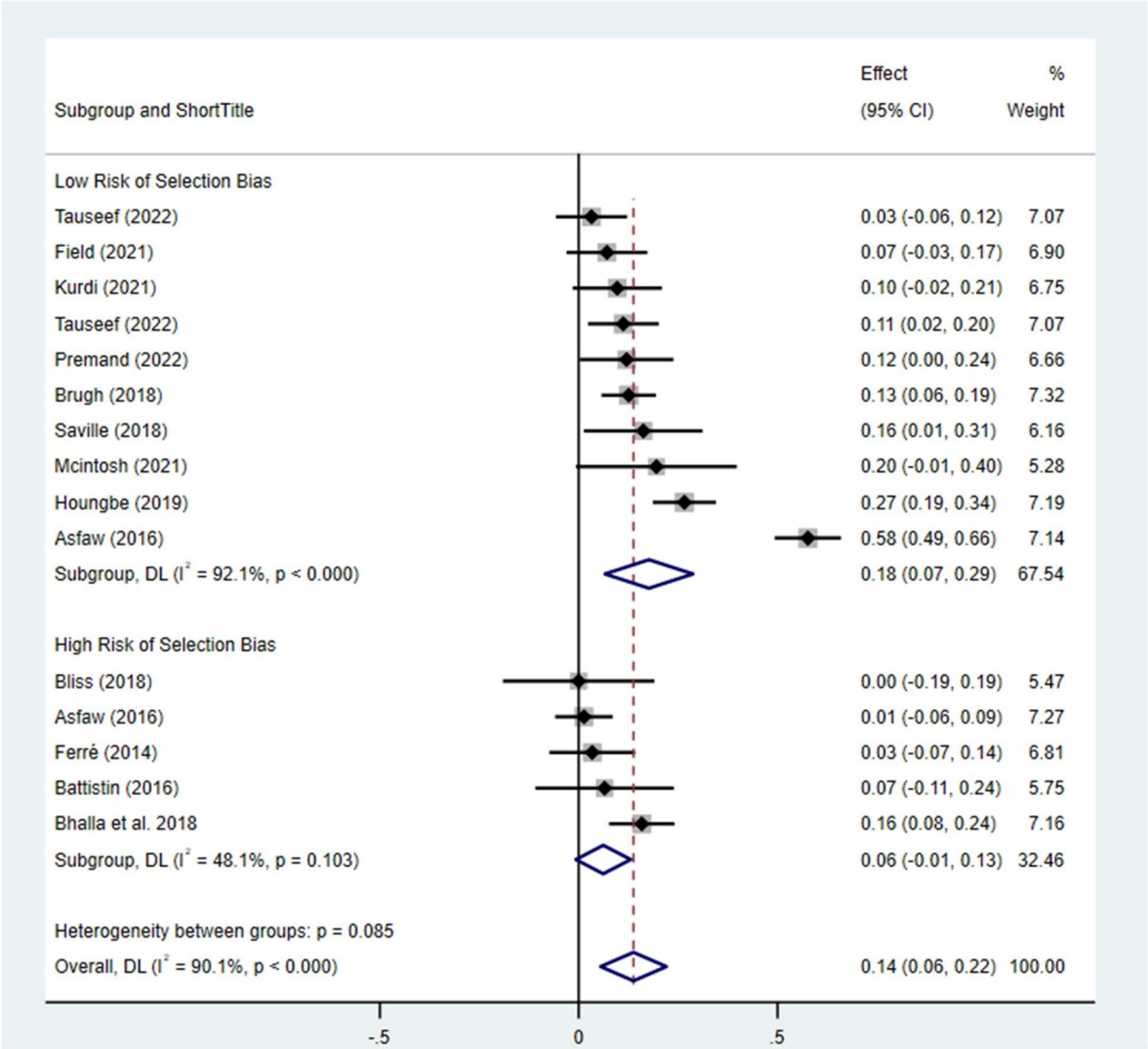

Fig. 7 Effects of cash transfers without additional nutrition-specific interventions on dietary diversity. Weights and between-subgroup heterogeneity test from random effects model. Only includes Effects of Cash Transfer Programs without additional Nutrition-Specific Components

vouchers ($n=3$ studies, $n=5$ papers), and (2) comparisons between food transfers and/or cash transfers ($n=7$ studies, $n=8$ papers). In both cases, interventions are compared against a control group.

Evidence on nutrition outcomes

All studies comparing food transfer or voucher interventions to controls had other components such as behavior change or counseling, delivery of nutrition supplements, and promotion of health service use. Food transfers (plus other components) were linked to significant reductions in stunting [25, 57] and improvements in dietary diversity [25, 58]. One study and one systematic review examined anemia protective effects in children and mothers and found significant positive impacts [67]. Similar effects were reported for food vouchers (plus other components). Food transfers and vouchers were also linked to improvements in height-for-age [10, 25].

Studies comparing food transfers or cash transfers to controls suggest that both interventions can be effective in improving nutrition outcomes and dietary diversity, and context should be carefully considered [5, 43, 67, 77]. For example, the relative effectiveness of cash and food transfers depends on the availability and accessibility of food markets. Such markets are often missing or non-functioning in humanitarian contexts, which may render

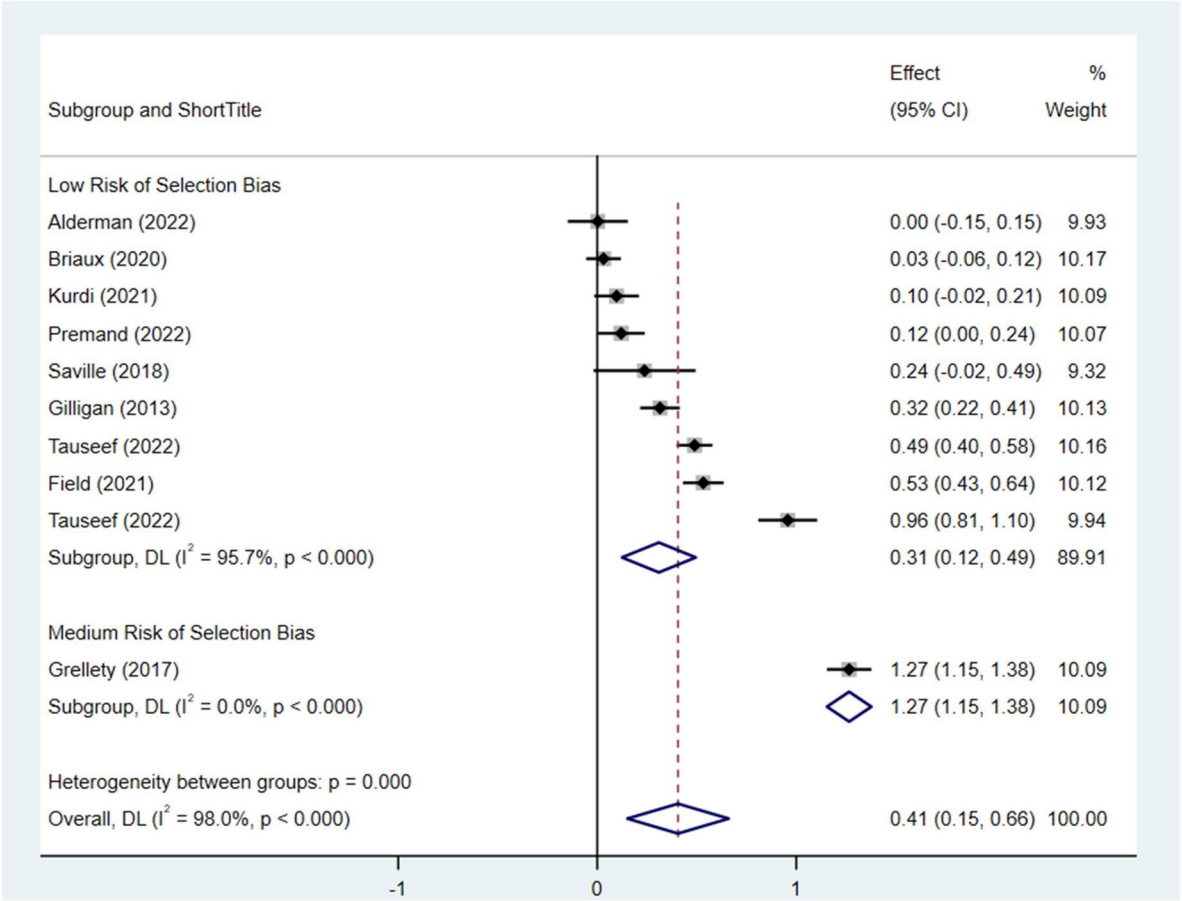

Fig. 8 Effects of cash programs with nutrition-specific elements on dietary diversity. Weights and between-subgroup heterogeneity test from random effects model. Only includes Effects of Cash Transfer Programs with additional Nutrition-Specific Components

cash transfers less effective than food transfers for nutrition outcomes in humanitarian contexts [45].

Implementation challenges related to food transfers and vouchers

The implementation of food transfers and vouchers can face several key challenges, including the definition and adequate targeting of the beneficiaries. These programs may also face distribution challenges in ensuring that the transfers or vouchers reach beneficiaries in a timely manner [28]. In addition, ensuring that the food provided or purchased with vouchers is of adequate nutritional quality and is culturally accepted by the intended beneficiaries requires careful planning and monitoring. Another aspect that emerged in the literature is the fragility of food transfers and vouchers during crises such as ethnic conflicts and climate shocks [34, 35]. Careful planning, strong governance, and community involvement could minimize these challenges.

Impact of nutrition-sensitive agriculture programs

This section summarizes our meta-analysis results on the impact of nutrition-sensitive agricultural programs on dietary diversity and anthropometric outcomes, as well as systematic review results for the impact of nutrition-sensitive agricultural programs on anemia (lack of eligible studies preclude a review on LBW and breastfeeding outcomes). The meta-analysis distinguishes between agriculture programs that do and do not include nutrition-specific information, agriculture programs that focus on increasing commodity sales using livelihoods interventions, agriculture programs that aim to improve food access through homestead food production and vegetable gardens, agriculture programs that include small animals, livestock and fisheries, agriculture programs that aim to improve dietary diversity and nutrition through improvements in women's agency, and programs that provide agricultural inputs, such as fertilizers and seeds. The available impact evaluations tend to study

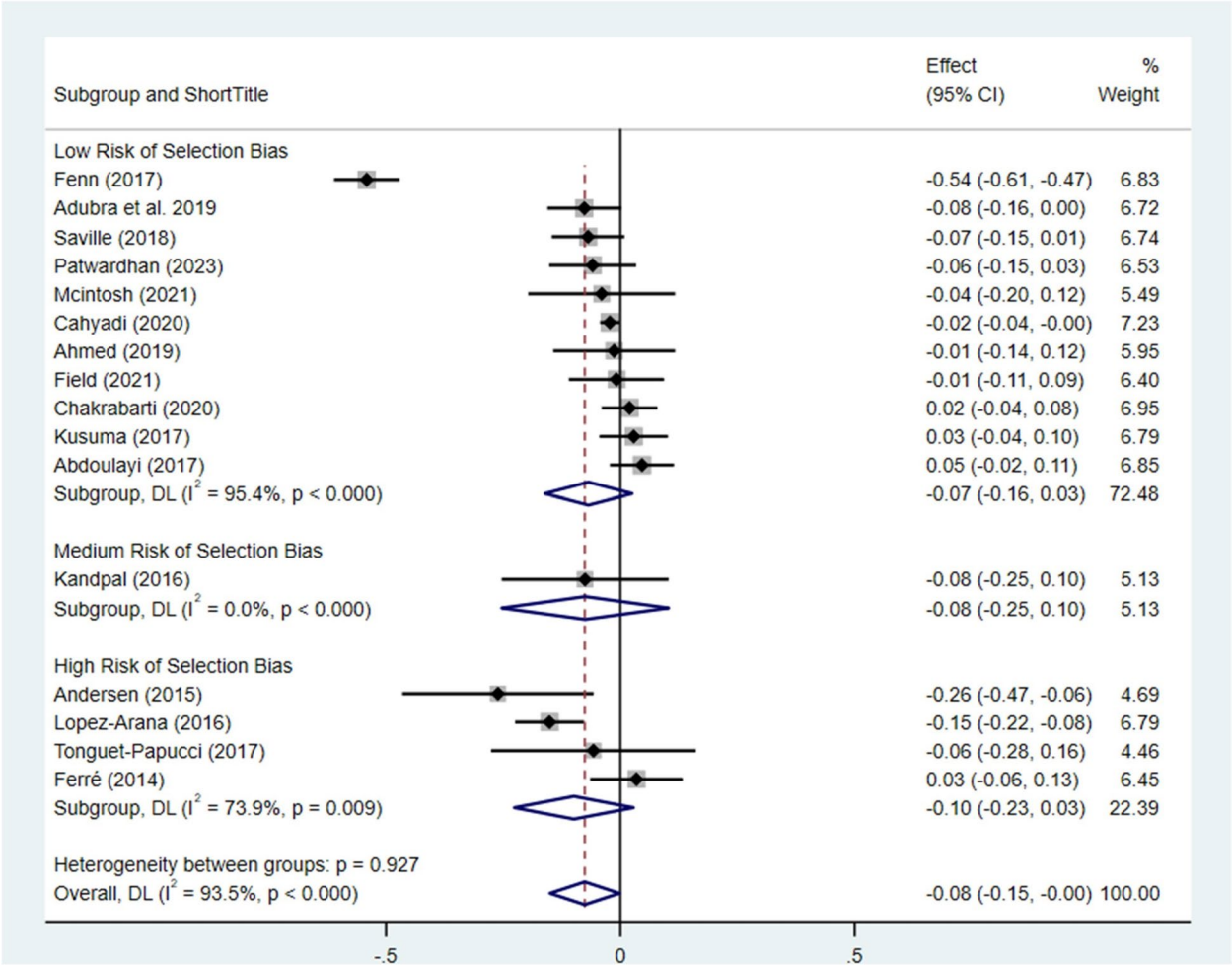

Fig. 9 Effects of cash programs without nutrition-specific elements on the incidence of stunting. Weights and between-subgroup heterogeneity test from random effects model. Only includes Effects of Cash Transfer Programs without additional Nutrition-Specific Components

programs that package together multiple intervention components, which creates challenges in distinguishing between the effects of individual agriculture program components. Some agriculture programs fall into more than one category (e.g., vegetable gardening programs sometimes also focus on improving livelihoods through access to markets). A more extensive review and synthesis can be found in de Hoop et al. [23].

Evidence on dietary diversity

The meta-analysis indicates that nutrition-sensitive agricultural programs may produce moderate positive effects on dietary diversity. The meta-analysis suggests positive effects of agricultural livelihoods programs, such as livelihoods training and value chain interventions (an effect of 0.24 standard deviations (95% CI: 0.11, 0.37)), homestead food production or vegetable garden programs (a statistically significant effect of 0.24 standard deviations (95% CI: 0.09, 0.40), and programs that focus on small animals, livestock, and fisheries (a statistically significant effect of 0.14 standard deviations (95% CI, 0.02, 0.26)). Figures 11, 12, and 13 present these results.

The meta-analysis does not find clear evidence that agriculture programs with nutrition-specific elements have larger effects on dietary diversity than agriculture programs without nutrition-specific elements. As shown in Annex E, integrated agriculture and nutrition programs have a statistically significant average effect of 0.15 standard deviations on dietary diversity (95% CI: 0.07, 0.23), which is lower than the effect size found in other program types without nutrition-specific elements (e.g., homestead food production or agricultural livelihoods programs). Integrated agriculture, nutrition and gender programs may have somewhat larger effects (0.23 standard deviations, 95% CI: 0.12, 0.33), but the number of studies is small, and the effect size is not larger than

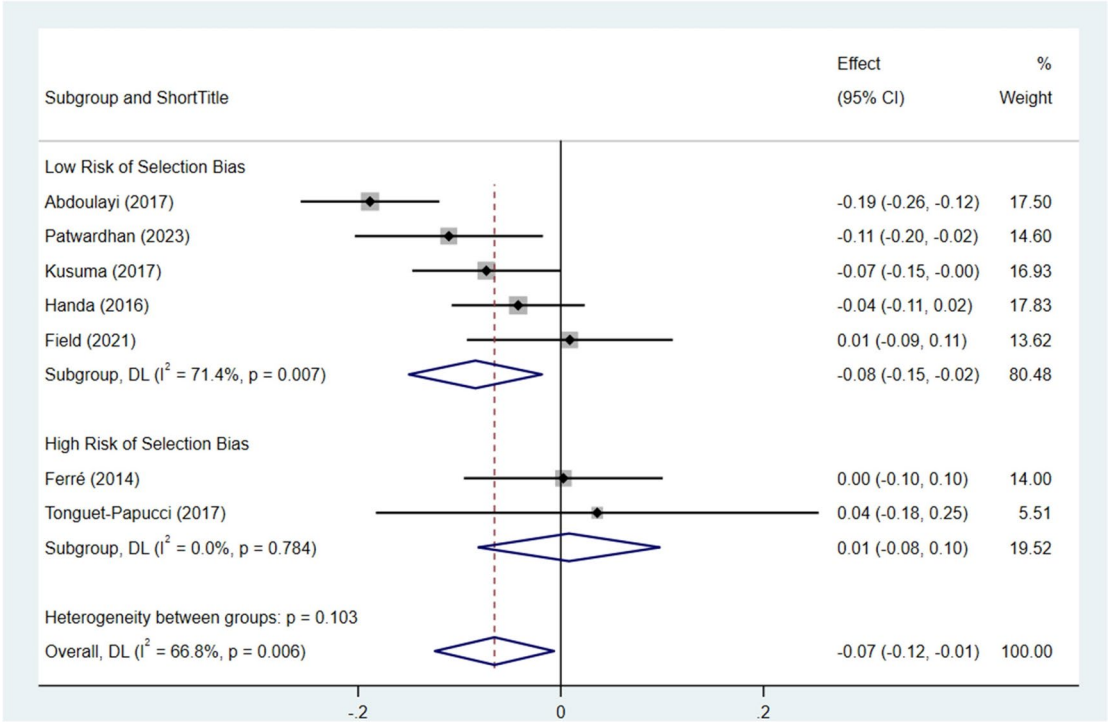

Fig. 10 Effects of cash programs without nutrition-specific elements on the incidence of wasting. Weights and between-subgroup heterogeneity test from random effects model. Only includes Effects of Cash Transfer Programs with additional Nutrition-Specific Components

the effects of standalone nutrition-sensitive agriculture programs.

Evidence on anthropometric outcomes

The meta-analyses suggest that nutrition-sensitive agriculture programs may generate reductions in stunting and wasting, but the effect sizes are small.

Stunting Agricultural livelihoods programs lead to reductions in stunting of 0.04 standard deviations (95% CI: −0.07, 0.00) (see Fig. 14), and homestead food production or vegetable garden programs result in reductions in stunting incidence of 0.05 standard deviations (95% CI: −0.10, −0.01) (see Fig. 15). Programs that focus on small animals, livestock, and fisheries, on average, do not have statistically significant effects on stunting (0.03 standard deviations (95% CI: −0.07, 0.01) (see Fig. 16). Integrated agriculture and nutrition programs (e.g., programs that combine training on vegetable gardens with training on child feeding practices) and integrated agriculture, nutrition, and gender programs (e.g., programs that combine agriculture and nutrition training with women's group programming) lead to reductions in stunting of 0.04 standard deviations (integrated agriculture and nutrition—95% CI: −0.07, 0.00; integrated agriculture, nutrition and gender—95% CI: −0.09, 0.00), on average (see Annex E).

Wasting Agricultural livelihoods programs generate reductions of wasting of 0.06 standard deviations (95% CI: −0.12, −0.01), on average (see Annex E), while homestead food production and vegetable garden programs, on average, lead to reductions of 0.08 standard deviations in wasting (95% CI: −0.16, −0.01) (see Annex E). The analysis does not suggest statistically significant effects of other nutrition-sensitive agriculture programs on the incidence of wasting.

Evidence on anemia Table 5 summarizes the 12 studies examining nutrition-sensitive agriculture programs included in the targeted searches, which include 10 RCTs and 2 systematic reviews (3 other reviews were excluded from the analysis as they mainly synthesized evidence from RCTs that were included in other places). One study addressed agriculture and nutrition [17], another agricultural livelihood programs [53], two focused on agriculture livestock [69, 71], and six examined homestead food production and vegetable gardens [11, 24, 44, 62, 68, 70] (although 3 of these 6 papers were part of the same study [24, 44, 68]). Nine studies were from sub-Saharan Africa, two from South Asia, and one from East Asia and the Pacific region.

Table 3 Summary of the Evidence of Cash Transfers on Birthweight, Breastfeeding, and Anemia Outcomes

Authors (year), region	Features of the study	Outcome	Evidence
Birthweight outcomes			
Glassman et al. [38], global	Systematic review	Low birthweight	*Cash transfer vs no intervention* ↓ 1.5% in low birthweight (2/2 studies in LAC finding positive outcomes)
Saville et al. [82], Nepal	RCT, three treatment arms, participatory learn and action (PLA) for women, PLA plus food transfer, PLA plus cash transfer	Birthweight	*Participatory learn and action plus cash transfer vs control* ↑ 68.8 gr birthweight within 10 days No significant effects on birthweight within 72 h
Briaux et al. [18], Togo	RCT, treatment unconditional cash transfer plus package of community activities, control only package of community activities	Low birthweight	*Unconditional cash transfer plus package of community activities vs only package* ↓ odds of having a low birth child relative (OR = 0.29)
Lisboa et al. [59], global	Systematic review	Low birthweight	*Conditional cash transfer vs control* ↓ 2/3 studies reported reductions in the likelihood of low birthweight among women receiving cash transfer *Unconditional cash transfer vs control* ↓ 1/1 study reported reductions in the likelihood of low birthweight among women receiving cash transfer
Breastfeeding related outcomes			
Field & Maffioli [29], Myanmar	RCT, two treatment arms, unconditional cash transfer, or unconditional cash transfer plus social behavior change communication	Ever breastfed	*Unconditional cash transfer plus BCC vs no intervention* ↑ 0.7 percentage points in children being ever breastfed *Unconditional cash transfer vs no intervention* No significant effect on breastfeeding
Premand et al. (2022), Niger [76]	RCT, two treatment arms cash transfer, cash transfer plus behavior change promotion (including promotion of exclusive and diversity in children's diet)	Index of nutrition practices for children aged 12–23 months (breastfed until 6 months, foods started to consume between 6–9 months)	*Cash transfer plus BCC (BCC value added) vs control* ↑ 0.287 SD nutrition practice index for children aged 12–23 months ↑ 0.240 SD dietary diversity among all children aged 6–59 months old (higher score ↑ variety of food consumed
Grijalva-Eternod et al. [41], Somalia (humanitarian context)	RCT, two treatment arms, conditional cash transfer, mHealth BCC intervention	Exclusive breastfeeding	*Conditional cash transfer vs no intervention* No significant effect on exclusive breastfeeding *mHealth BCC vs no intervention* No significant effect on exclusive breastfeeding
Anemia related outcomes			
Gilligan et al. (2013), Uganda [36]	RCT, two treatment arms, food transfer, and unconditional cash transfer	Anemia	*Unconditional cash transfers versus no intervention* ↓10 percentage points in anemia prevalence moderate/severe among children (54–83 months)

Table 3 (continued)

Authors (year), region	Features of the study	Outcome	Evidence
Segura-Perez et al. [83], Latin America	Systematic review conditional cash transfers (Mexico, Brazil, Colombia)	Anemia Hemoglobin	*Conditional cash transfers vs no intervention* ↑ Hb levels among children > 12 months in 1/2 studies ↓ likelihood of children being anemic in 1/1 studies
Fenn et al. [28], Pakistan	RCT, three treatment arms, standard unconditional cash transfer, double unconditional cash transfer, voucher for fresh fruits and vegetables	Anemia Hemoglobin	*Unconditional cash transfers versus no intervention* No significant effect on anemia or hemoglobin concentration for either of the treatment arms
Durao et al. [25], global	Meta-analysis	Hemoglobin Anemia	*Unconditional cash transfers versus no intervention* No significant effect on hemoglobin concentrations *Income generation vs no intervention*** ↑ 3.49 MD hemoglobin concentration in children ↓ prevalence of anemia in children OR 0.73 No significant effects in anemia for women
Olney et al. [67], global	Systematic review	Hemoglobin Anemia	*Cash transfers vs control* ↑ Hb concentrations in women 1/3 of the studies ↓ anemia in women 1/3 of the studies No significant effects on anemia or hemoglobin concentration among children

Table 4 Summary of the evidence of food transfers/vouchers on nutrition outcomes

Authors (year), region	Features of the study	Outcome	Evidence
Food transfers or vouchers vs control			
Leroy et al. [56], Burundi	RCT, intervention included: food rations, use of health services strengthening and promotion, BCC	Hemoglobin levels Anemia	*Intervention vs control* Protective effect of the program in: -hemoglobin (0.4 g/dL for the overall sample and 0.4 g/dL in children aged 6–23.9 mo), -anemia (6.1 percentage points in children aged 6–23.9 mo and 34.9 percentage points in mothers who had given birth in the previous 3 mo),
Leroy et al. [57], Burundi		Stunting HAZ	*Intervention 1,000 days vs control* ↓ stunting 7.4 percentage points *Intervention pregnancy to18 mo vs control* ↓ stunting 5.7 percentage points *Intervention child reaching to24 mo vs control* ↓ stunting 4.6 percentage points No effects on HAZ
Leroy et al. [58], Burundi		Dietary diversity	*Intervention vs control* ↑ maternal dietary diversity (+0.4 food groups) ↑ proportion of children aged 6–23.9 mo who consumed 4 food groups (impact 8.0 to 9.6 percentage points)
Durao et al. [25], global	Systematic review, community intervention to increase access to food	Stunting Wasting Dietary diversity	*Food vouchers vs No intervention:* ↓ stunting at 12 months (1 RCT, OR 0.48) ↓ severe stunting (1 RCT, OR 0.51) ↑ 0.29 MD HAZ at 12 months (1 RCT) ↑ dietary diversity (2 RCTs) No significant effect on wasting (1 RCT) *Food/nutrition subsidies vs No intervention:* ↑ 0.96 MD dietary diversity score (1 RCT)
Ara et al. [10], Bangladesh	RCT, treatment included food vouchers for egg/milk-based snacks, MNP, counseling (feeding, handwashing)	LAZ Stunting Dietary diversity	*Intervention vs control* ↑ 0.37 LAZ score and 0.44 WAZ score at 12 months ↓ 73 percent risk of stunting decreased at 12 months (AOR: 0.27) ↑ 25.2 percent minimum dietary diversity at 12 months
Food transfers or cash-transfers vs control			
Ramirez-Luzuriaga et al. (2016), Mexico [77]	RCT, three arms include food basket with education, food basket without education, cash transfer with education	Dietary diversity	*Intervention vs control* ↑ 21.6 percentage points minimum dietary diversity food basket without education vs control (no significant effects in other arms)
Fenn et al. [28], Pakistan	RCT, three arms include standard cash, double cash, fresh food voucher	Wasting WHZ Stunting HAZ	*Intervention (at 6 mo) vs control* ↓ odds of wasting (OR 0.52) in double cash (no effect in other arms) ↑ mean WHZ 0.16 in food voucher and 0.11 in double cash ↓ odds of stunting in all arms (OR 0.36–0.41) ↓ odds of severe stunting in all arms (OR 0.38–0.47) ↑ mean HAZ in all arms (0.24–0.27

Table 4 (continued)

Authors (year), region	Features of the study	Outcome	Evidence
Saville et al. [82], Nepal	RCT, arms include a participatory program for women, the same program plus food (fortified super cereal), same program plus cash	Birthweight WAZ	*Intervention vs control* ↑ 78 gr in birthweight (after 72 h) in the program plus food (no significant effects in other arms) No effect in WAZ (average 9 mo)
Harris-Fry et al. [43], Nepal		Dietary diversity	*Intervention vs control* Dietary diversity was 0.4 food groups higher in the PLA plus cash arm than in the control arm ↑ odds of pregnant women consuming more animal-source foods than the household head (OR 1.7–2.4) in all arms
Ahmed et al. [3], Bangladesh (Ahmed, Hoddinott, & Roy, Food transfers, cash transfers, behavior change communication and child nutrition Evidence from Bangladesh, 2019)	RCT, treatment arms include cash transfers, food ration, food ration and cash transfer, cash transfer and nutrition BCC, food ration and nutrition BCC	HAZ WHZ Dietary diversity	*Intervention vs control* ↑ HAZ by 0.25 SD but only among cash plus BCC ↑ diets (intake of animal source foods) in the cash plus BCC treatment arm No effect on WHZ
Olney et al. [67], global	Systematic literature review social assistance programs (cash transfers, in kind, vouchers)	Stunting Wasting Anemia	*In-kind transfers (with fortified foods) vs cash transfer* more likely to significantly: ↑ children's WHZ ↑ women's and children's hemoglobin concentration ↓ anemia prevalence ↑ women's BMI (not always desirable)

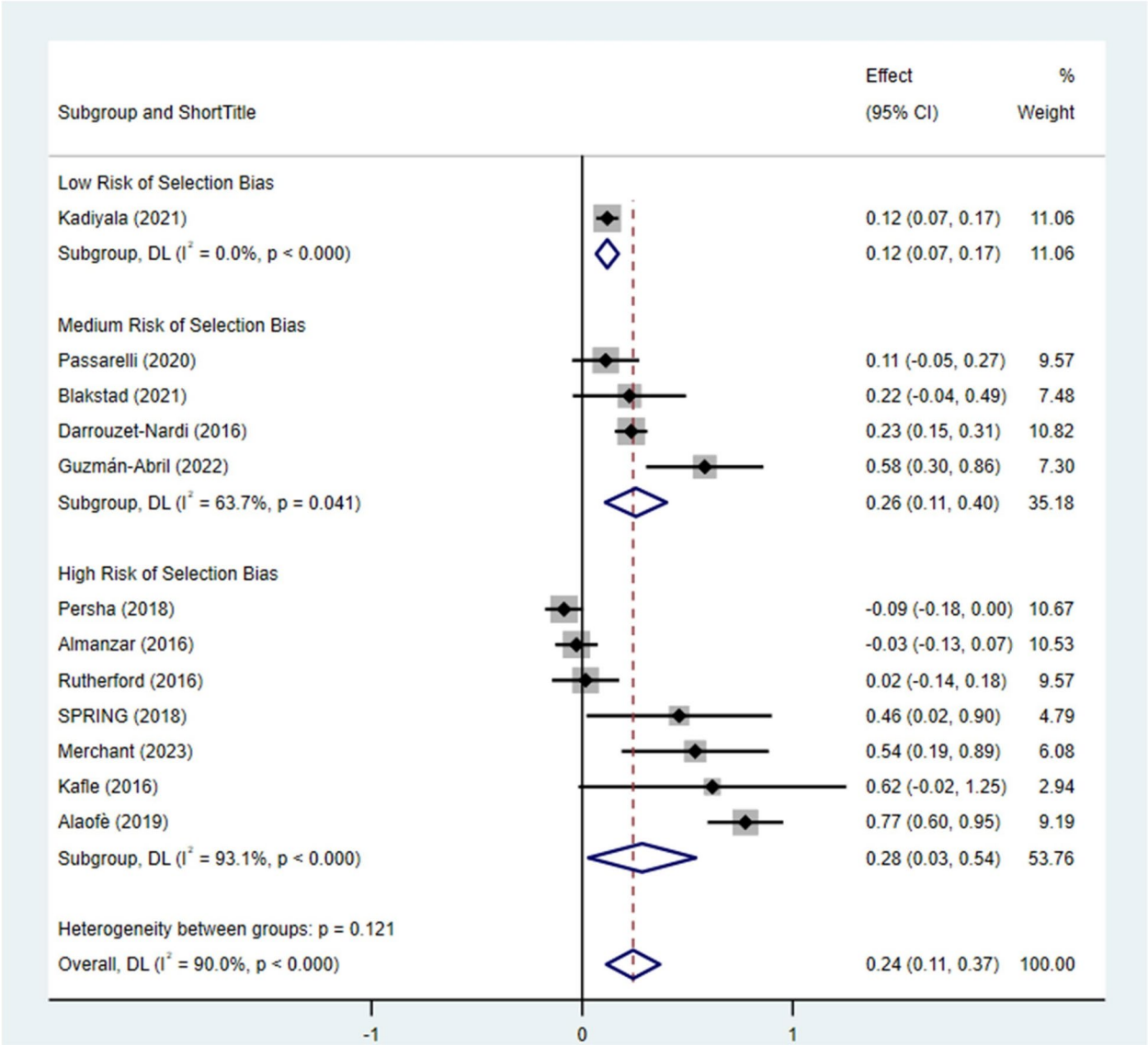

Fig. 11 Effects of agriculture and livelihoods programs on dietary diversity. Weights and between-subgroup heterogeneity test from random effects model

There is mixed evidence on the impact of nutrition-sensitive agricultural programs on anemia. One RCT in Tanzania in which interventions had components of integrated agriculture and nutrition, as well as home food production and vegetable gardens, did not find significant effects on anemia prevalence or hemoglobin concentration either for children or women [17]. One study with components of agriculture and livelihoods (Senegal), which involved milk production in return for money and fortified yogurt, reported improvements in hemoglobin levels (MD = 0.55 g/dL, 95% CI: 0.27, 0.84), but no significant effects on anemia [53].

Most studies included in the targeted review focused on homestead food production and vegetable gardens, and about two-thirds of them reported significant reductions in anemia prevalence and/or hemoglobin concentration. For example, a plant-based enhanced homestead food production intervention in Cambodia reported reductions of 14 percentage points in anemia (MD = −0.14 pp; $p < 0.05$) [62]. A study involving an enhanced homestead food production intervention plus behavior change communication components in Nepal found improvements in hemoglobin levels and a 24-percentage-point reduction in the odds of children being anemic (OR 0.76, 95% CI: 0.59, 0.98) [70]. Two studies linked to agriculture

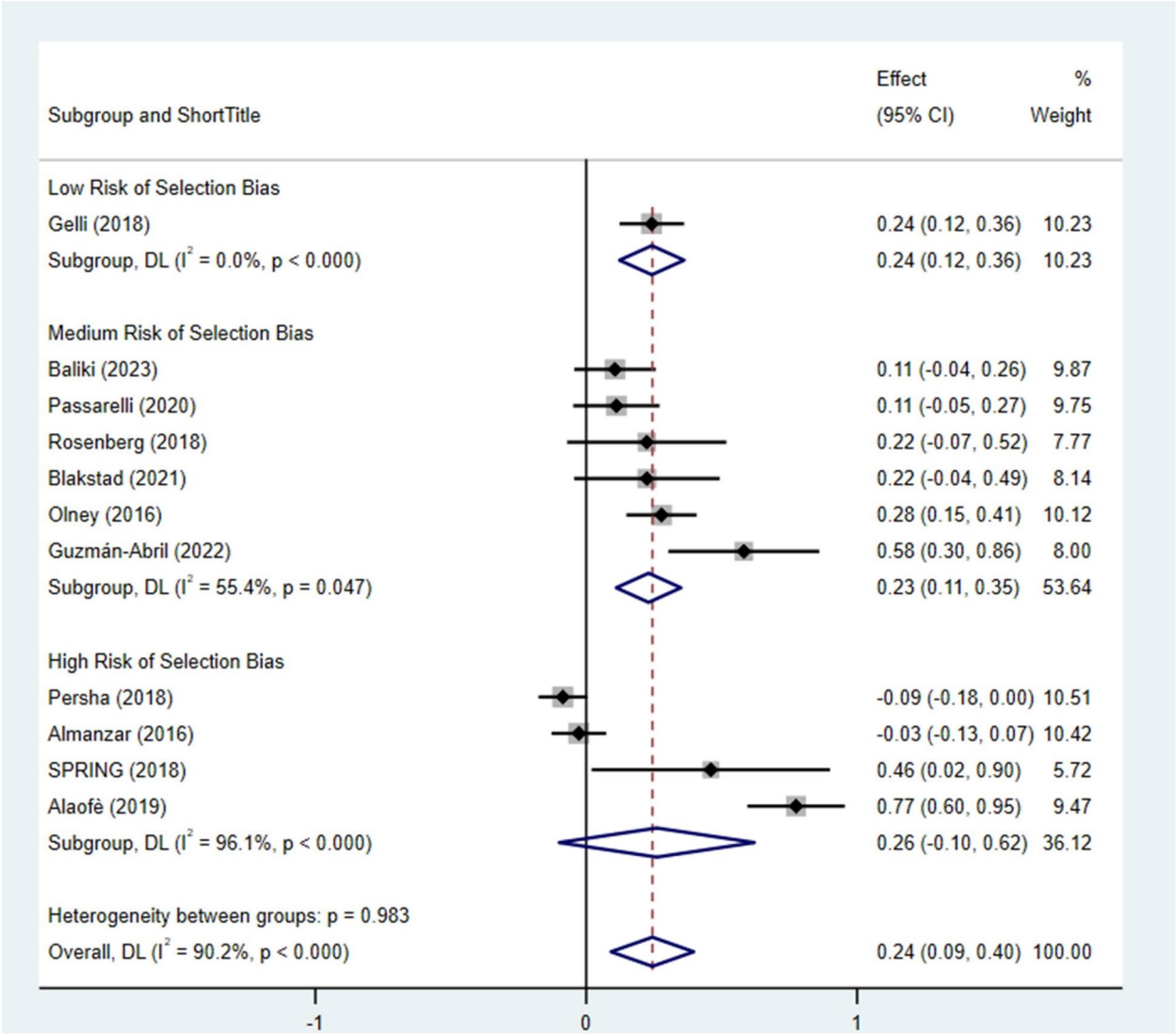

Fig. 12 Effects of homestead food production programs on dietary diversity. Weights and between-subgroup heterogeneity test from random effects model [6]

and livestock interventions found mixed results, while an intervention in Ethiopia found no significant effects on anemia after 6 months [71]. Another RCT in Ethiopia, examining the effects of providing egg-laying hens to children, reports a significant increase in hemoglobin levels and a 64% reduction in the odds of being anemic (OR 0.36, 95% CI: 0.24, 0.54) [69]. Finally, a study in Burkina Faso linking an enhanced homestead food production intervention and BCC components involving older women or health committees reported significant reductions in anemia of children but only when the BCC was provided by health committees [24, 44, 68].

There is a moderate level of evidence on the impact of nutrition-sensitive agriculture interventions on children's and women's anemia.

How does implementation influence the effectiveness of nutrition-sensitive agriculture programs?

The qualitative analysis reveals that organized sales strategies may facilitate more outcomes of agricultural programs [80], while oversaturation in agricultural markets may hinder participating farmers [73]. The analysis suggests that environmental and climate-related factors, such as land use, water access, and rainfall, could result

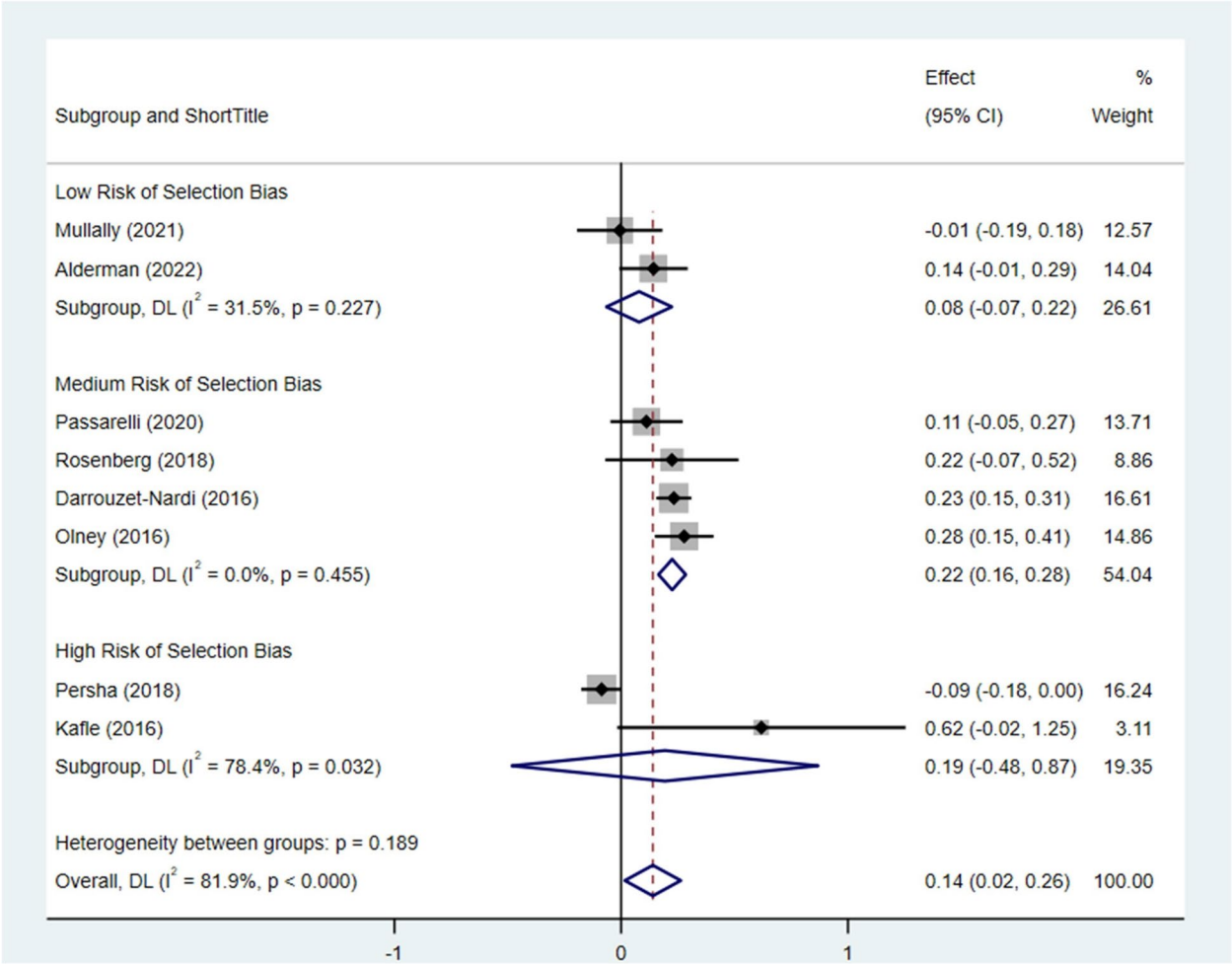

Fig. 13 Effects of agriculture and livestock programs on dietary diversity. Weights and between-subgroup heterogeneity test from random effects model

in implementation challenges [73],Olney, Behrman, Iruhiriye, van den Bold, & Pedehombga, 2013; 69], thus demonstrating the importance of carefully considering the assumptions made on pathways to outcomes for nutrition-sensitive agriculture programs These factors pose challenges in designing and implementing interventions as well as methodological challenges when systematizing the evidence.

Impact of WASH interventions

This section summarizes our narrative synthesis results on the impact of WASH interventions on anthropometric outcomes as well as on anemia (a lack of eligible studies precludes a review on LBW and breastfeeding outcomes).

Evidence on anthropometric outcomes The evidence on the impact of WASH interventions is insufficient to present conclusive results regarding the interventions' effects on anthropometric outcomes. However, the evidence that exists suggests that WASH interventions have larger effects on anthropometric outcomes when combined with nutrition-specific services or when they include multiple WASH components (such as sanitation and hygiene services in addition to improved water access). Existing meta-analyses show that WASH interventions have larger effects on height-for-age when they are combined with nutrition-specific programs (0.13 SMD, 95% CI: 0.08, 0.17) [13]. Further, WASH interventions seem to have larger effects on height-for-age if they combine water access with sanitation or hygiene programs than if they only provide water services (0.15 SMD, 95% CI: 0.09, 0.20) and larger effects on height-for-age for children younger than two years old (0.07 SMD, 95% CI: 0.01, 0.13; 0.20 SMD, 95% CI: 0.11, 0.29) [13, 37]. The number of studies included in these meta-analyses, however, is too small for definitive conclusions on which WASH services have the largest effects on nutrition outcomes. Further, existing reviews do not distinguish

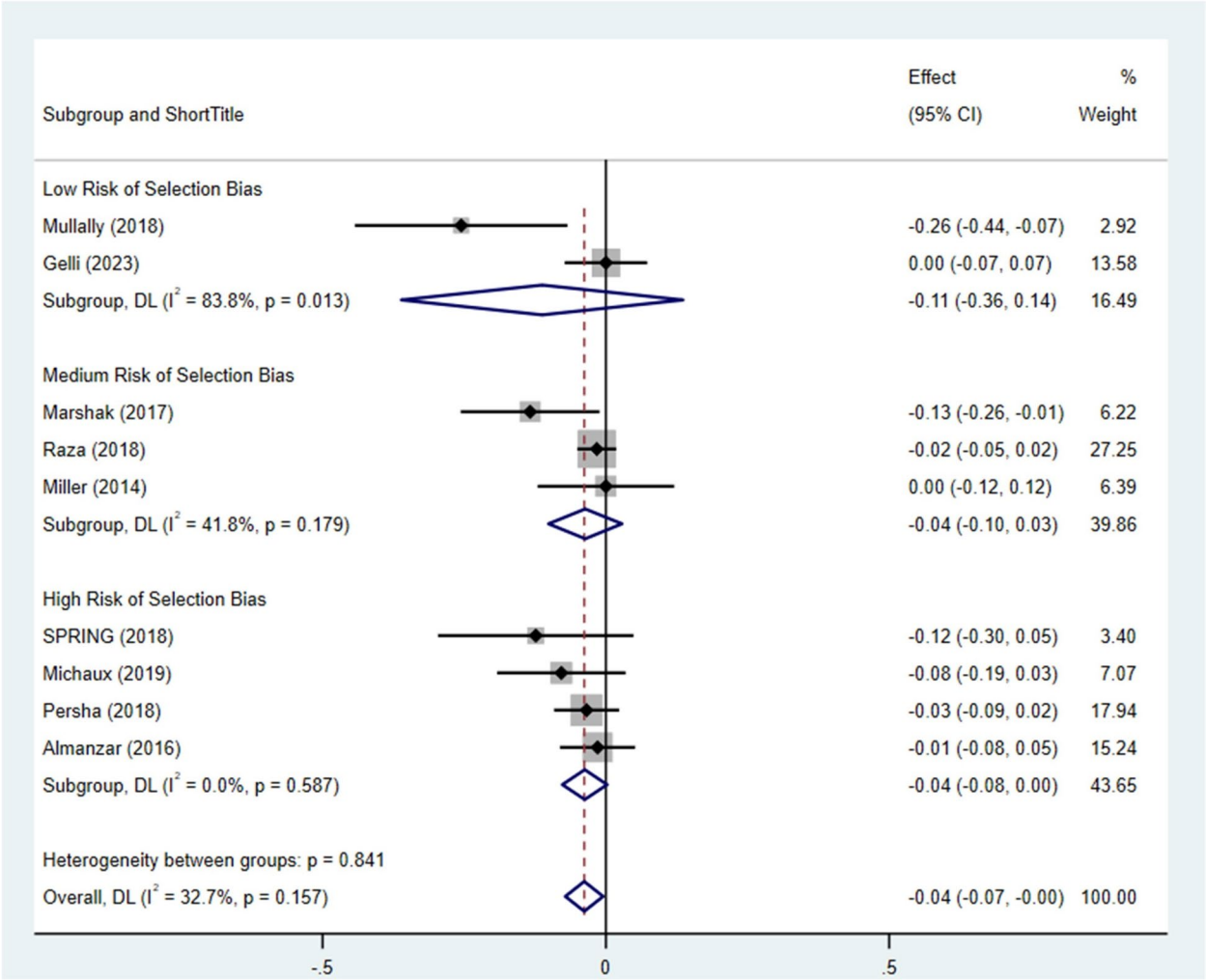

Fig. 14 Effects of agriculture and livelihoods programs on the incidence of stunting. Weights and between-subgroup heterogeneity test from random effects model

between the effects of water supply and water quality interventions on nutrition outcomes despite previous evidence suggesting that water quality interventions are, on average, more effective than water supply interventions in reducing diarrhea incidence [13].

Despite these shortcomings, some promising research exists on the benefits of WASH interventions on anthropometric outcomes, though it remains challenging to distinguish between the effects of WASH services and nutrition-specific program components. For instance, a cluster-RCT in Kenya showed that an integrated package with agriculture, nutrition, and WASH services had a larger effect on height-for-age than the agriculture program alone, without nutrition and WASH services (0.11 SMD, 95% CI: 0.01, 0.19) [98]. Moreover, a cluster-RCT assessing a community-led total sanitation campaign in Mali found improvements in children's height-for-age (0.18 SMD, 95% CI: 0.03, 0.32) and reductions in stunting (0.86 PR, 95% CI: 0.74, 1.0) [74].

One important element to consider in future studies is that WASH interventions may have spillovers- that is, effects that extend beyond individuals or households that receive the intervention to others inside or outside the community-, which could lead to an underestimation of the impact of WASH interventions in individual-level RCTs. Moreover, a paper by Cameron et al. indicates that community-led total sanitation campaigns may only lead to improvements in health outcomes if they reach community coverage of 50 to 75 percent, though these effects stagnate after this threshold is met [20].

Evidence on anemia Table 6 summarizes 5 RCTs included in the targeted search, that compare WASH

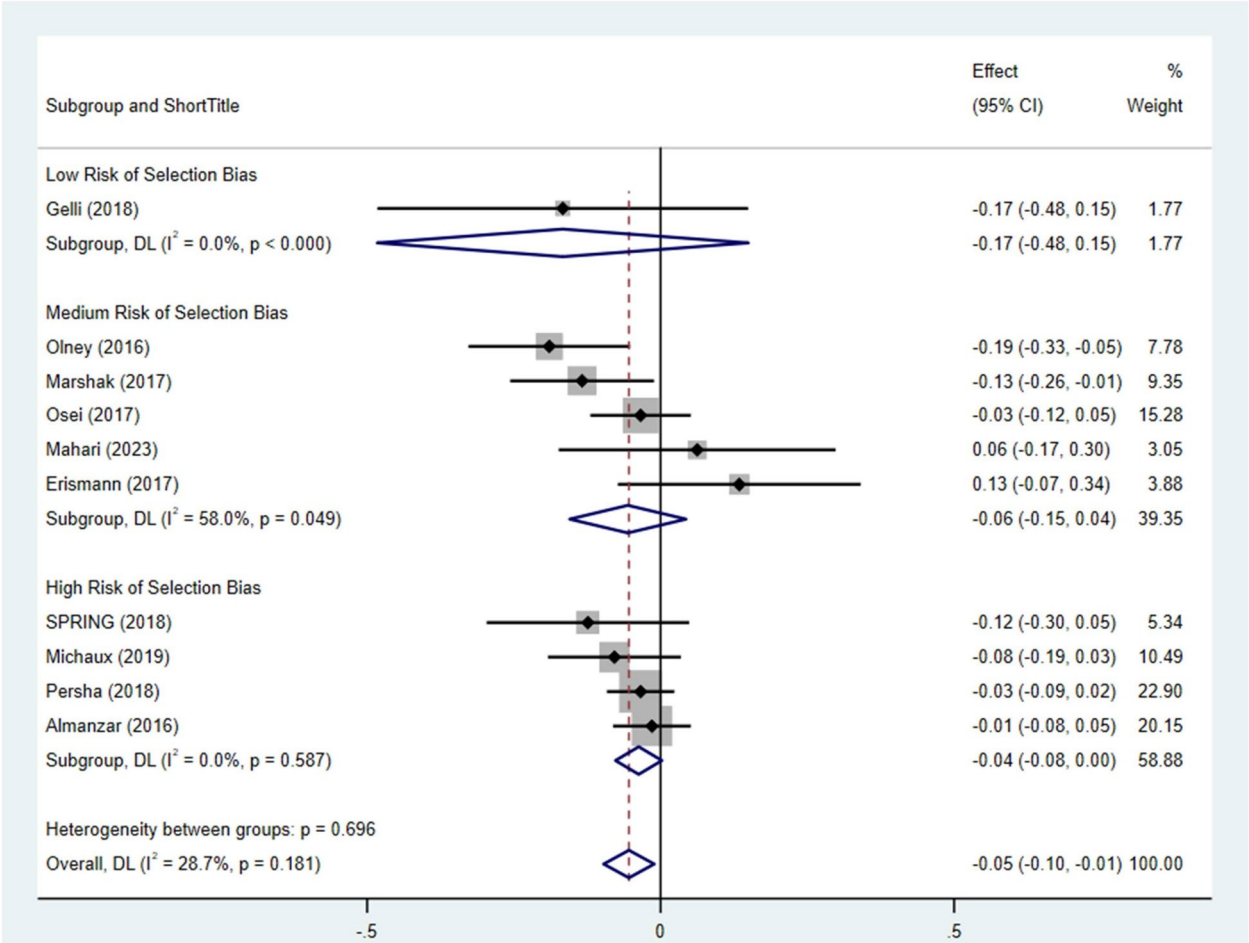

Fig. 15 Effects of homestead food production programs on the incidence of stunting. Weights and between-subgroup heterogeneity test from random effects model

and/or nutrition components in sub-Saharan Africa ($n=5$) and South Asia ($n=1$) (one study included two countries from different regions). With the exception of one study comparing WASH/malaria education to nutrition counseling [27], the remaining studies focus on assessing the impact on WASH (or some of its components) plus nutrition interventions – such as BCC, infant and young child feeding, counseling or education – on anemia or hemoglobin levels. While the evidence is inconclusive and more research is needed, studies finding an impact on anemia tend to combine nutrition-specific elements and WASH interventions, and the interventions tend to be delivered within the community-household context [89]. Basic WASH interventions seem insufficient to reduce anemia, and some evidence suggests that combining WASH services with nutrition-specific components does not result in larger effects than nutrition-specific interventions focused on infant and young child feeding practices.

Challenges in measuring the impact of WASH interventions on nutrition outcomes

In general, more research is needed to determine the optimal mix of agriculture, nutrition, and WASH services to affect nutrition outcomes. WASH interventions are considered critical for reducing the incidence of diarrheal diseases, which remain a leading cause of morbidity and mortality among children under five, as suggested by a meta-analysis indicating that water treatment reduces the odds of all-cause in this age group [51], but the evidence for the impact of WASH on anthropometric outcomes is inconclusive. WASH interventions may improve height-for-age z-scores for children under two years of age and when water, sanitation, and hygiene services are combined with each other. By improving access to clean water and sanitation facilities, WASH programs can help to prevent the spread of infections and diseases that can cause or exacerbate anemia (i.e., hookworm); however, evidence is inconclusive and scarce on how

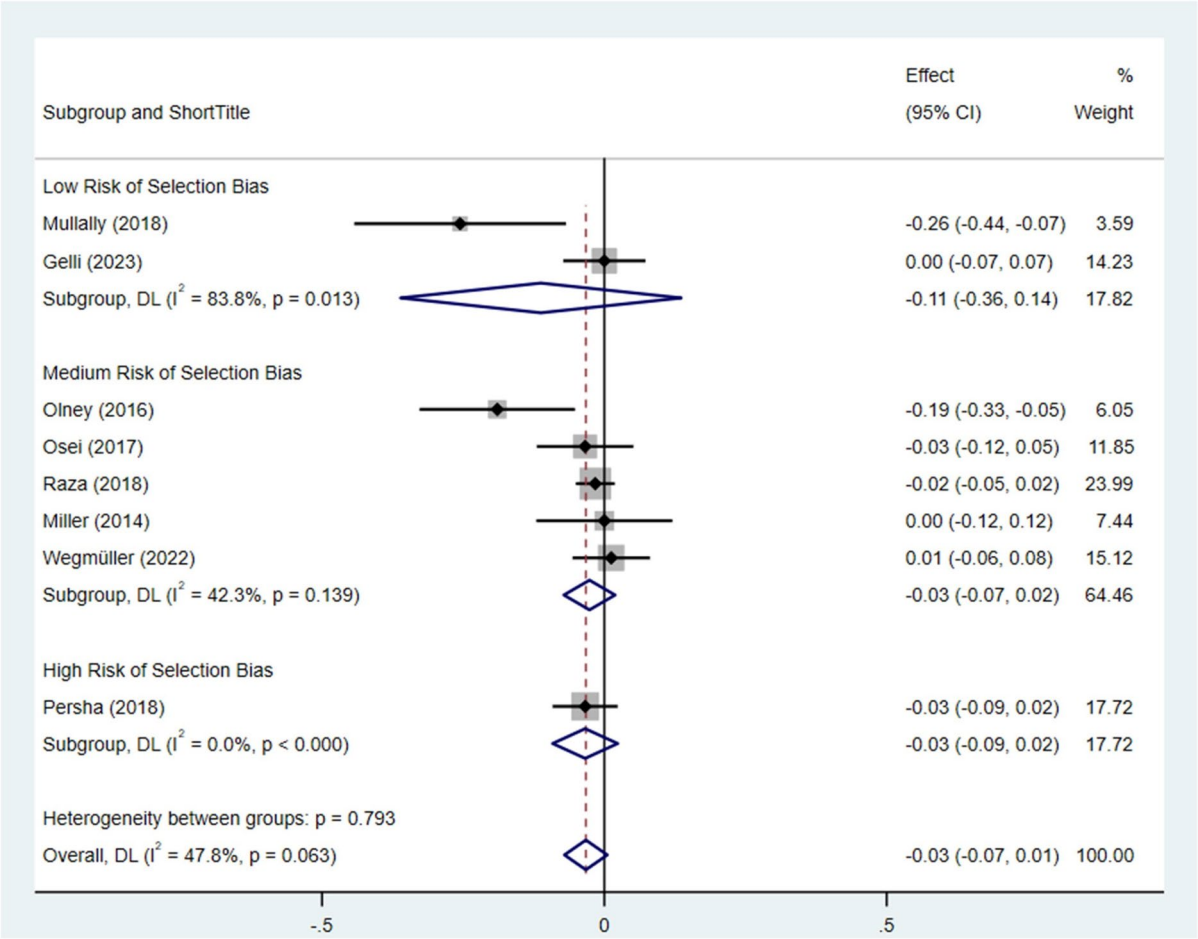

Fig. 16 Effects of agriculture and livestock programs on the incidence of stunting. Weights and between-subgroup heterogeneity test from random effects model

these interventions ultimately affect nutrition outcomes despite reductions in mortality [51]. Evidence-gaps also exist on whether water quality interventions are more effective than water supply interventions in improving nutrition outcomes, on whether additional sanitation and hygiene interventions increase the effects of water interventions on nutrition, and on the spillovers of WASH interventions.

Impact of school nutrition programs

This section describes the results of the targeted search to assess the impact of school feeding and other school nutrition programs on nutrition outcomes. School nutrition in this context refers to food transfers, usually presented as meals, provided at school. Table 7 summarizes the 18 studies included in the review. Studies were grouped into four categories: (i) Synthesis reviews ($n=4$); (ii) Impact evaluations of school feeding interventions including fortified foods ($n=6$); (iii) Impact evaluations of school feeding interventions based on provision of meals ($n=5$); and (iv) Impact evaluations of school feeding programs including the distribution of supplements ($n=3$), which usually include ready-to-use supplementary foods (RUSF).

Evidence on anthropometric outcomes The reviews suggest a statistically significant effect of school nutrition programs on weight-for-age (WAZ) based on a meta-analysis (0.10 SMD, 95% CI: 0.01, 0.11) [97] and a systemic review [52]. Studies that measured impacts on height-for-age (HAZ) all found significant effects as well [9, 65]. None of the studies reported adverse effects on the risk of overweight and obesity [52], [21]. Supplementation within school nutrition programs generally produced no effects on anthropometric outcomes [12, 47, 48].

Evidence on anemia School nutition programs seem to result in improvements in hemoglobin concentrations

Table 5 Summary of the evidence of nutrition-sensitive agriculture on anemia outcomes

Authors (year), region	Features of the study	Outcome	Evidence
Systematic reviews			
Muema et al. [64], Africa	Systematic review ($n=23$)	· Anemia · Hemoglobin concentration	*Impact of nutrition-sensitive agriculture* - 4/23 studies measured anemia prevalence and/or hemoglobin concentration, and 3/4 found significant ↑ hemoglobin levels and/or ↓ anemia prevalence (2 of those studies are included as RCTs of the current review)
Sharma et al. [84], global	Systematic review ($n=43$)	· Anemia · Hemoglobin concentration	*Impact of nutrition-sensitive agriculture* −3/8 studies reported ↑ in hemoglobin, and 4/8 ↓ anemia in children −1/3 ↓ anemia in women but lacked effects on hemoglobin concentrations
Integrated agriculture and nutrition programs			
Blakstad et al. [17], Tanzania	RCT, agriculture inputs + agricultural extension training + nutrition and health education vs control	· Anemia (women & children) · Hemoglobin concentration (women & children)	*Intervention vs control* -No statistically significant differences either for women or children
Agricultural livelihoods programs			
Le Port et al. [53], Senegal	RCT, households with children willing to deliver milk to the dairy factory, 2 arms: 1) received one sachet of fortified yoghourt per child per day for seven consecutive days + payment for milk delivered, and 2) only received the payment (control)	· Anemia · Hemoglobin levels	*Intervention vs control* -↑ 0.24 g/dL hemoglobin in the intervention group compared to the control group -No statistically significant differences between groups
Homestead food production and vegetable garden programs			
Osei et al. [70], Nepal	RCT, EHFP (home garden, poultry raising and nutrition education) included seeds, chicks, and a BCC program; vs control	· Anemia · Hemoglobin concentration	*Intervention vs control* -↑ mean hemoglobin concentration in children (baseline treatment 115.3 ± 0.1 vs control 113.6 ± 0.1; follow-up treatment 114.3 ± 0.1 vs control 110.8 ± 0.1) -children ↓ 24% less likely to be anemic (OR 0.76, CI 0.59–0.98) -No statistically significant differences in maternal anemia or hemoglobin concentration
Michaux et al. [62], Cambodia	RCT, 2 treatment arms: 1) pant-based enhanced homestead food production (EHFP) and BCC, and 2) EHFP + fishponds	· Anemia nonpregnant women · Anemia in children	*Intervention arms vs control* -No statistically significant differences in anemia for *nonpregnant* women between intervention arms -↓ 14 percentage points ($p=0.02$) in anemia from baseline to 22 months in EHFP in children -No statistically significant differences in anemia in EHFP + fishponds

Table 5 (continued)

Authors (year), region	Features of the study	Outcome	Evidence
Olney et al. [68], Burkina Faso	RCT, two treatment arms: 1) BCC strategy implemented by older women leaders + EHFP, and 2) BCC strategy implemented by health committee member + EHFP*	· Anemia	*Intervention arms vs control* -↓ 14.6 percentage points ($p = 0.02$) in anemia among children 3–59 mo in villages with health committee members
Heckert et al. [44], Burkina Faso		· Hemoglobin concentration	*Intervention arms vs control* -No statistically significant differences in Hb levels
Dillon et al. [24], Burkina Faso		· Anemia in infants · Hemoglobin concentration in infants	*Intervention arms vs control* -No statistically significant differences in anemia or hemoglobin concentration post-intervention
Baliki et al. [11], Nepal	RCT, integrated school & home gardens + nutrition education vs control	· Anemia · Hemoglobin concentration	*Intervention vs control* -No statistically significant impact on anemia (or hemoglobin levels) after program support ended
Agricultural livestock programs			
Passarelli et al. [71], Ethiopia	RCT, two treatment arms: 1) chicken production intervention, and 2) chicken intervention plus nutrition BCC	· Anemia in children	*Intervention vs control* -No statistically significant impact on anemia
Omer et al. [69], Ethiopia	RCT, children received egg-laying hens with caging in a cultural ceremony (parents promised to feed eggs to the child) vs control	· Anemia in children · Hemoglobin concentration	*Intervention vs control* -↑ hemoglobin by 0.53 g/dL -↓likelihood of anemia (OR 0.36, CI: 0.24–0.54)

Table 6 Summary of the evidence of WASH interventions on anemia outcomes

Authors (year), region	Features of the study	Outcome	Evidence
Erismann et al. [26], Burkina Faso	RCT, treatment included: WASH (with several components) + NSA + BCC on hygiene and nutrition + deworming and iron supplements in schools, vs control	· Anemia	*Intervention vs control* -No statistically significant differences in anemia
Humphrey et al. [46], Zimbabwe (Humphrey, et al., 2019)	RCT, 3 treatment arms: only WASH, only IYCF, WASH & IYCF, vs standard of care (some promotion through CWH)	· Hemoglobin concentration	*WASH vs no-WASH* -No statistically significant differences in hemoglobin concentration *IYCF vs no-IYCF* -↑ 2.03 g/L mean hemoglobin concentration
Stewart et al. [89], Bangladesh & Kenya	RCT, 3 treatment arms: only WSH, only nutrition (LNS + IYCF counseling, and WSH + nutrition	· Anemia · Hemoglobin concentration	*Interventions control* -↓ anemia prevalence in Kenya (↓ 32.6% only nutrition, ↓ 27.3% WSH + Nutrition) and Bangladesh (↓ 8.7% only nutrition, ↓ 7.9% WSH + Nutrition)
Shrestha et al. [88], Nepal	RCT, 2 treatment arms: school garden program, and school garden + WAS, health and nutrition	· Anemia · Hemoglobin concentration	*Baseline compared to baseline* -↓ 1 percentage point in the school garden plus intervention (no statistically significant evidence in control or only school garden intervention)
Fançony et al. [27], Angola	RCT, 2 treatment arms: nutrition counseling, and WASH/Malaria education	· Anemia · Hemoglobin concentration	*Interventions vs control* -No statistically significant differences between the 3 groups in the reduction of anemia or improvements of hemoglobin concentration

[11, 21, 52]. All studies found significant associations between school nutrition and the prevalence of anemia and/or the hemoglobin concentration levels. In addition, most studies targeted particularly vulnerable populations such as displaced groups [2], rural [30], and low-income populations [50]. Studies assessing school nutrition programs providing supplements also reported improvements in anemia related indicators [12, 47, 48]. These studies suggested that schools might be a good setting to provide supplements for vulnerable children and increase the chances of adequate use and consumption.

Overall, there is a moderate strength of evidence for positive impacts of school nutrition interventions on anemia related indicators.

Implementation challenges related to school nutrition

There are different implementation challenges linked to school feeding and other school nutrition programs in LMICs. Monitoring and evaluation are essential to track the appropriateness and quality of the interventions in addressing the nutritional outcomes of children, and to avoid secondary problems (such as increased risks of overweight and obesity). Cultural acceptance of the products and community engagement are also fundamental components of school nutrition interventions, both of which can be important influencers of school attendance, which is fundamental for the interventions to have the desired effects. In fragile settings, the delivery of school meal programs has other layers of logistical and political challenges. Armed conflicts produce fear and reduced mobility – resulting in fewer trips to school for children. Attempts by non-state actors to deliver meals is often misunderstood as siding with one side. One study found meaningful stakeholder engagement and strengthening community involvement as an innovative strategy to diffusing tensions and improving delivery coverage [34, 35].

Discussion

This review presents a synthesis of the effects of multisectoral nutrition-sensitive approaches on most of the nutrition outcomes of the SDG 2.2 targets (excluding obesity), and dietary diversity. The results indicate that while nutrition-sensitive programs can contribute to improvements in nutrition outcomes, the effectiveness of such approaches differs substantially across intervention types and contexts.

Reaching the nutrition targets set by SDG 2.2 requires multisectoral nutrition interventions capable of addressing the multiple determinants of malnutrition. Nutrition-specific approaches implemented through the health sector – which encompass a wide range of strategies that

Table 7 Summary of the evidence of school feeding interventions on nutrition outcomes

Authors (year), region	Features of the study	Outcome	Evidence
Synthesis studies			
Wang et al. [97], global	Systematic review & meta-analysis including studies from 20 LMICs	HAZ WAZ Hemoglobin	*School feeding vs control (operationalize mainly as no intervention or some sort of placebo)* ↑ 0.100 mean difference WAZ No significant effects on HAZ No significant effects on hemoglobin concentration levels
Choedon et al. [21], South Asia	Scoping review including studies from 7 South Asian countries	Stunting Thinness BMI	*School feeding vs control (operationalize mainly as no intervention or some sort of placebo)* ↓ stunting 1/4 studies significant No significant effects on thinness No significant effects on BMI
Kyere et al. [52], Sub-Saharan Africa	Systematic review including studies from 6 Sub-Saharan countries	WAZ, weight BMI Hemoglobin	*School feeding vs control (operationalize mainly as no intervention or some sort of placebo)* ↑ WAZ or total weight 2/2 studies ↑ Hb concentrations 4/6 studies Majority did not report significant effects on BMI (5/8)
Mideksa et al. [63], Ethiopia	Scoping review	Stunting Weight Anemia	Mixed and inconclusive findings
School feeding interventions based on fortified foods			
Von Grafenstein et al. [94], India	RCT, phase-in early vs late initiation of double-fortified salt in school lunch program	Anemia	*Early treatment group vs late treatment group* ↑ MD 0.267 g/dL hemoglobin levels ↓ 13.4 percentage points likelihood of anemia
Krämer et al. [50], India	RCT, treatment meal with double-fortified salt, and control conventional iodized salt	Anemia	*Intervention with double fortified salt vs conventional salt* ↑ 0.19 g/dl Hb levels (or 1.6%) ↓ 9.9 percentage points (or 22%) less likely to suffer from any form of anemia ↓ 5.3 percentage points (or 27%) less likely to suffer from mild anemia No significant effects for moderate or severe anemia
Finkelstein et al. [30], Mexico	RCT, 2 daily rations of beans, treatment biofortified with iron, control common beans	Anemia	*Intervention biofortified beans vs control common beans* Iron status improve in both groups No significant effects on anemia (or related indicators)
Adelman et al. [2], Uganda (internally displaced camps)	RCT, two arms, a school feeding program providing multiple-micronutrient-fortified meals and a nutritionally equivalent take-home ration	Anemia	*School feeding pooled vs control (operationalize mainly as no intervention or some sort of placebo)* ↓ 25.7 percentage points any anemia and ↓19.3 moderate-severe anemia among teen girls 10–13 years *Take-home ration vs control* ↓12.8 percentage points moderate-severe anemia among women ≥ 18 years
Perignon et al. [72], Cambodia	RCT, among children in school feeding program the portion of rice, control unfortified, treatment three types of fortification	Anemia	*Lunch with fortified rice vs lunch with unfortified rice* ↑ 0.80 g/Lg Hb ultra rice new at 3 months No significant effects on Hb level for NutriRice or ultra rice original

Table 7 (continued)

Authors (year), region	Features of the study	Outcome	Evidence
Pinkaew et al. [75], Thailand	RCT, intervention triple fortified rice	Hemoglobin	*Intervention triple fortified rice vs control* Protective effect on Hb concentration
School feeding interventions based on meals or school gardens			
Wang et al. [96], Tanzania	RCT, two treatment arms, full intervention (meals, garden, nutrition education, community workshop), and partial intervention (without school meals)	Anemia BMI	*Intervention (with or without school meals) vs control* ↓ odds of overweight and obesity (OR 0.29 partial; OR 0.47 full) No significant effects in hemoglobin concertation or odds of anemia
Baliki et al. [11], Nepal	RCT, intervention included school garden and nutrition education	Anemia Dietary diversity	*Intervention vs control* No significant effects on anemia or dietary diversity at 6 months ↑ hemoglobin levels (indirect effect) among children,12 years
Anitha et al. [9], India	RCT, intervention millet-based mid-day meals	HAZ BMI	*Intervention daily meals vs control* ↑ 0.07 mean HAZ ↑ 0.166 mean BMI
Murayama et al. [65], Bangladesh	RCT, intervention school meal with local foods including soybean	HAZ WAZ BMI Anemia	*Intervention school meal vs control* ↑ HAZ ↑ Hb No significant effects on weight, BMI, or anemia prevalence
Gelli et al. [33], Ghana	RCT, treatment hot meal/daily provided by caterers	HAZ BAZ	*School meals vs control* ↑ 0.12 SD HAZ children 5–8 years ↑ 0.21 SD HAZ children 5–8 years from poor households ↑ 0.11 SD HAZ school-aged girls ↑ 0.19 SD BAZ boys 5–8 years
School meals interventions providing supplements			
(Ahmed, Hoddinott, & Roy, Food transfers, cash transfers, behavior change communication and child nutrition Evidence from Bangladesh, 2019)Iannotti et al. [48], Haiti	RCT, treatment and control received deworming, treatment included a daily supplement and hand hygiene	HAZ WAZ Hemoglobin	*School feeding intervention vs control* ↓88 percent odds of anemia and significant protective effect on Hb concentration levels No significant effects on HAZ and WAZ
Batra et al. [12], Guinea-Bissau	RCT, treatment and control received a lunch, in addition two treatment arms, adding a RUSF 15% protein and RUSF 33% protein	WAZ Anemia	*Lunch plus RUSF vs only lunch* ↑ WAZ greater among lunch plus RUSF among children that attended > 50 days Protective effect of Hb concentration (larger in RUSF 33%)
Iannotti et al. [47], Haiti	RCT, two treatment arms, a peanut butter paste (RUSF), unfortified cereal bar	Anemia BMI	*RUSF vs control* ↓ odds of developing anemia for children by 28% (OR 0.72) ↑ 0.25 BMI z-score No significant effects on

focus both on health care settings and community-based strategies – can achieve larger effects on dietary diversity or nutrition outcomes when combined with multisectoral nutrition-sensitive strategies outside the health sector, such as cash transfers.

However, this evidence is not always conclusive, considering that cash transfers with nutrition-specific components do not show larger effects on stunting and wasting than cash transfers without nutrition-specific components. Similarly, the evidence does not suggest larger effects of nutrition-sensitive agriculture programs when they are combined with nutrition-specific components. Nonetheless, the qualitative synthesis indicates that a multisectoral approach can create more coherent strategies and limit duplication of efforts. In addition, some individual studies indicate larger effects when nutrition-sensitive programs are combined with nutrition-specific components in multi-arm cluster-RCTs.

Despite a large increase in the number of RCTs and quasi-experimental studies, significant evidence gaps remain. While cash transfers show larger effects on dietary diversity when combined with nutrition-specific components, there are too few studies to examine whether cash transfers lead to larger reductions in stunting or wasting when they are combined with nutrition-specific components. There is also insufficient evidence to conclusively determine whether nutrition-sensitive agriculture and WASH interventions have larger effects on dietary diversity or nutrition outcomes when combined with nutrition-specific components.

While the meta-analyses suggest an increase in cash transfers' effects on dietary diversity when combined with nutrition-specific components, we do not find evidence that the impact of agriculture programs on dietary diversity increases when combined with nutrition-specific components. It is unclear whether nutrition-specific components are less effective in bolstering agriculture programs than cash transfers, or whether contextual characteristics or the higher risk of bias of evaluations of agriculture programs may explain this contradiction. Regardless, this finding indicates a need for multi-arm cluster-randomized controlled trials and quasi-experimental studies that compare the impact of agriculture programs with and without nutrition-specific components.

Figure 17 presents a visual overview of the existing evidence. It summarizes the evidence on the interventions for which we documented some level of evidence.

In general, the available evidence and its strength highlight a need for research examining differences in the effectiveness of nutrition-sensitive programs with different implementation models, including more evaluations employing robust study designs (e.g., multi-arm cluster-randomized controlled trials or quasi-experimental studies) and the use of implementation research to better understand the barriers, facilitators, and strategies that can support the effective implementation and scale-up of these nutrition-specific interventions. Currently, only very few studies use mixed-methods designs, which limits the ability of researchers to understand why and how nutrition-sensitive interventions do (or do not) influence dietary diversity and nutrition outcomes. This knowledge gap shows the importance of investing in combining quantitative and qualitative methods.

Below we present more details on the effects of different nutrition-sensitive interventions as well as research gaps related to the effects of the interventions.

Cash transfers

The meta-analyses indicate that cash transfers are likely to have a substantial positive impact on dietary diversity, especially when they are combined with nutrition-specific components such as BCC, and may reduce incidence of stunting and wasting. Some evidence suggests that cash transfers may improve birthweight, breastfeeding practices, and anemia outcomes – possibly through an increase in food security and dietary diversity. Insufficient evidence exists to examine whether unconditional or conditional cash transfers have larger effects on stunting or wasting, and there is not enough evidence to assess whether cash transfer programs with or without nutrition-specific components, with different cash recipients, different modalities, or different frequency of transfers (e.g., monthly transfers vs one-time lumpsum transfers) have different effects on nutrition outcomes. Some evidence suggests that cash transfers may sustain positive impacts on anthropometric outcomes in the longer term [19]. However, more evidence is needed on longer-term impacts of cash transfer programming.

Multi-arm RCTs or quasi-experimental studies could provide more definitive evidence about the relative effects and cost-effectiveness of cash transfers with and without nutrition-specific components, such as BCC. Without a critical body of multi-arm impact evaluations, it remains challenging to examine what cash transfer implementation models are most effective in improving nutritional outcomes. Nonetheless, the current evidence base indicates that cash transfers have larger effects on dietary diversity when they are combined with nutrition-specific components.

Food transfers and vouchers

Targeted searches suggest that food transfers and voucher interventions, when implemented alongside nutrition-specific components (e.g. nutrition supplements) may positively impact stunting and dietary diversity. Such

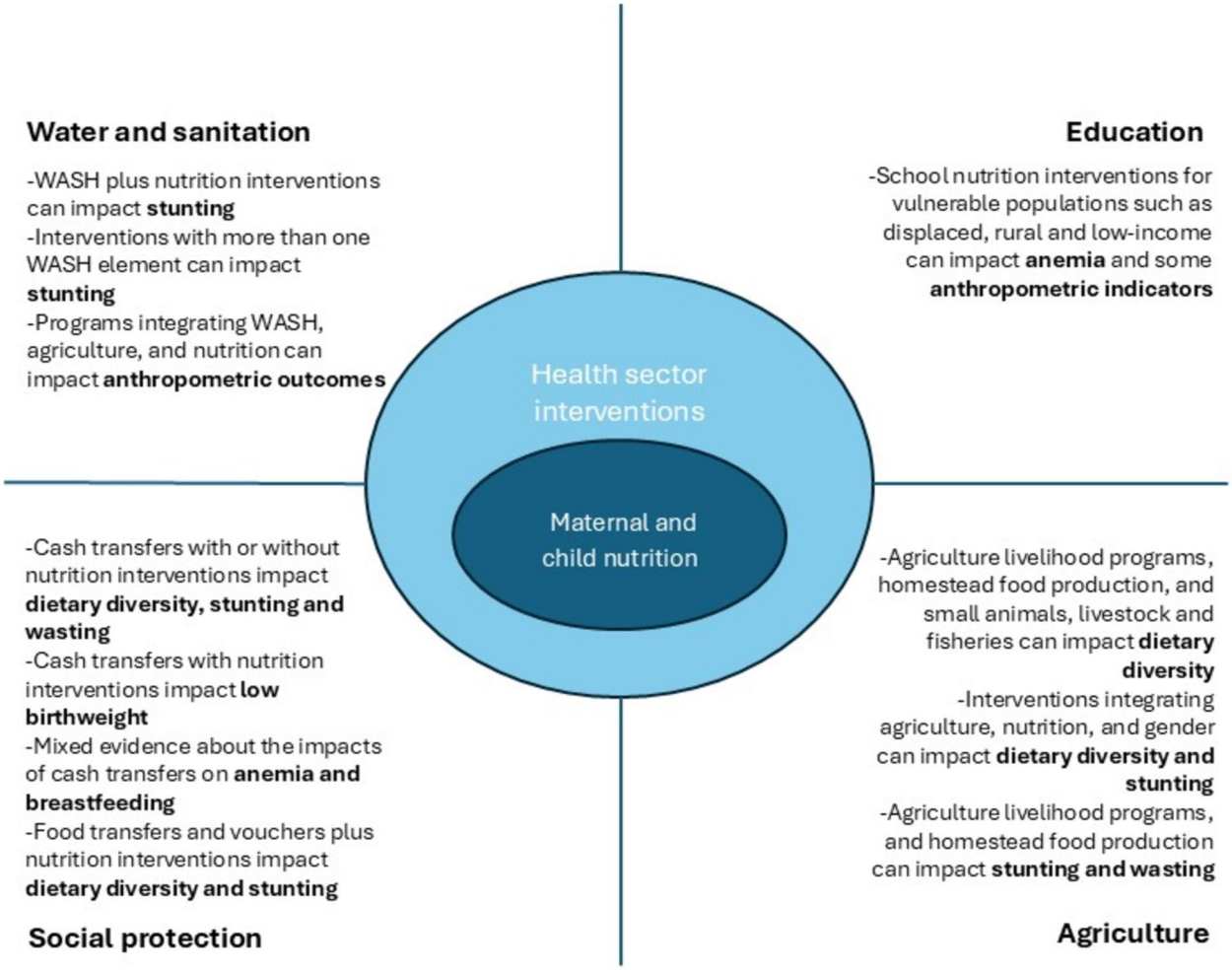

Fig. 17 Summary of existing evidence

interventions may have larger effects on nutritional outcomes in humanitarian contexts where food markets are often missing. At the same time, some evidence suggests that cash transfers are often more cost-effective than food transfers in improving nutritional outcomes. This is because of the higher logistical costs of food transfers.

More research is needed to determine the optimal mix of food transfers, vouchers, and cash transfers as well as their synergies with maternal nutritional supplementation. Such research could focus on the relative effects of food transfers, vouchers, and cash transfers after government implementation, and ways to cost-effectively scale up food transfers, vouchers, and cash transfers, especially in humanitarian contexts.

Agriculture

Similar to the evidence on cash transfers, the meta-analyses show that nutrition-sensitive agriculture interventions are a promising way to improve dietary diversity and may also reduce stunting and wasting. Such interventions may reduce anemia among women and children as well.

A previous narrative synthesis suggests that nutrition-sensitive agriculture programs are possibly more effective when they include nutrition and health behavior change communication and women's empowerment interventions [78]. A meta-analysis of women's empowerment interventions within food systems also suggests positive effects of these programs on food security, dietary diversity, and anthropometric outcomes [15]. However, the meta-analysis does not show clear evidence that agriculture programs have larger effects with or without nutrition-specific components. This is likely because of the substantial variation in nutrition-sensitive agriculture programs, demonstrating the potential of multi-arm RCTs and quasi-experimental studies of nutrition-sensitive agriculture programs.

WASH

There is inconclusive evidence on the effect of WASH interventions on nutritional outcomes. While a meta-analysis suggests that WASH services reduce mortality [51], evidence-gaps remain on whether water quality interventions are more effective than water supply interventions in improving nutrition outcomes, on whether additional sanitation and hygiene interventions increase the effects of water interventions on nutrition, and on the spillovers of WASH interventions. Programs that combine agriculture with WASH interventions could have larger effects on anthropometric outcomes, but evidence on the relative cost-effectiveness of these programs remains inconclusive.

Overall, multi-arm RCTs and quasi-experimental studies could examine the optimal mix of WASH services, agriculture interventions, and nutrition-specific components. Such studies could assess whether WASH interventions may have larger effects on nutritional outcomes in the presence of nutrition-specific components, and whether joint agriculture and WASH interventions have larger effects on nutritional outcomes than WASH interventions and agriculture programs alone. Additional mixed-methods, multi-arm cluster-RCTs and quasi-experimental studies with careful collection of cost data can contribute to such decision-making, but requires more standardization in the measurement instruments, while keeping in mind contextual differences across settings. In addition, it is critical to assess the effective scale-up of WASH services, for example through implementation science focused on government-supported programs.

An aspect that is increasingly recognized is that WASH indicators do not necessarily reflect the experiences of individuals and households around water. The Water Insecurity Experience (WISE) Scales bring a user-centered approach capturing the actual experiences and interactions in daily lives. WISE Scales are better predictors of nutrition and health outcomes than water infrastructure and availability indicators [100]. Hence, future studies could consider using the WISE scale when evaluating nutrition-sensitive WASH interventions [99].

School nutrition programs

Schools are an important platform to deliver nutrition interventions that go beyond the traditional school feeding approach. Although further research is needed, various studies suggest that school nutrition programs could improve anemia indicators.. Optimizing school nutrition programs will require assessing the relative effects of school feeding programs with and without nutritional supplements. In addition, it is critical to examine financial and non-financial barriers toward the scale-up of school nutrition programs. Because of the large financial gaps in financing of nutrition interventions, the scale-up school nutrition programs as part of government systems should be guided by robust implementation science and evidence on cost-effective programming. In addition, when implementing school nutrition interventions, it is fundamental to account for the context, as sustaining their effects imply consistently providing meals, fortified products and/or supplements, which can be easily interrupted in fragile contexts and changes in government. Some of the evaluated interventions require adequate infrastructure to store, prepare and consume school meals and supplements. Inadequate infrastructure can jeopardize the quality of the interventions.

Limitations

The breadth and heterogeneity of existing nutrition-sensitive interventions presents a substantial challenge for compiling evidence of impact. Our two-step process of an initial broad search followed by a more targeted search mitigated this challenge by striking a balance between comprehensiveness and efficiency, allowing us to hone a deeper focus on the evidence of specific interventions and nutrition outcomes. The targeted searches revealed that, while more evidence is generally needed on the impact of nutrition sensitive interventions on nutritional outcomes, certain regions, such as Latin America, have even less available evidence. In Latin-America, it is particularly important to focus on the double burden of nutrition, considering the potential effects of nutrition-sensitive programs on obesity [31, 81].

Considerable evidence-gaps exist on the impact of nutrition-sensitive agriculture programs. Only a small number of impact evaluations of nutrition-sensitive agriculture programs have a low risk of selection-bias. In some cases, there are notable differences in the effect size between studies with a low, medium, or high risk of selection-bias, indicating that selection-bias may play a substantial role in explaining the results of the meta-analyses. This shows the importance of increasing the rigor of impact evaluations focused on nutrition-sensitive agriculture programs.

Consistent with existing meta-analyses [60] and because of the limited number of studies, we pooled effects on children's, maternal and household dietary diversity. Our combined indicator includes dietary diversity measured on different scales as both binary and continuous outcomes. We recognize that combining these different measures creates some limitations. However, the number of impact evaluations is too small to examine the effects of different nutrition-sensitive agriculture interventions on different measures of dietary diversity. In general, most studies focus on children's dietary

diversity, but some studies also focus on maternal or household dietary diversity.

Integration of nutrition into social protection, agriculture, and education sectors is essential to address the underlying causes of malnutrition by targeting the social, economic, and environmental determinants of health, and leveraging the adoption of optimal dietary behaviors. Interventions such as cash transfers, food transfers and vouchers, WASH interventions, nutrition-sensitive agriculture programs, and school feeding programs, can play crucial roles in achieving sustainable improvements in nutrition.

The cost-effective scale-up of nutrition-sensitive interventions does, however, require recognition that there are large differences in the impacts of different nutrition-sensitive interventions, including large differences across contexts. This shows the importance of continuing to build a rigorous evidence base using multi-arm RCTs or quasi-experimental studies combined with implementation science to enable the cost-effective scale-up of nutrition-sensitive programs by governments.

The current evidence base only includes limited evidence for differential effects of cash transfer, agriculture, and WASH programs with and without nutrition-specific elements. This is likely because few studies examine the effects of these programs using multi-arm cluster-RCTs, making it challenging to provide inferences about the relative effectiveness of these programs. This shows the importance of focusing future research on multi-arm RCTs and quasi-experimental studies to examine the relative effects and cost-effectiveness of cash transfer and nutrition-sensitive agriculture programs as well as WASH services with different implementation models. Implementation science in collaboration with government agencies could also contribute to optimizing the cost-effective scale-up of these programs by governments.

Conclusions

This paper presents the results of a systematic review and meta-analyses that examine the effects of interventions outside the health sector on maternal and child nutrition outcomes and dietary diversity. Overall, we find consistent evidence that these programs contribute to dietary diversity and may have small but positive effects on nutrition outcomes, such as anthropometric outcomes and anemia.

We find that cash transfers have larger effects on dietary diversity when they include behavior change communication or other nutrition-specific elements. Nutrition-sensitive agriculture programs also tend to have positive effects on dietary diversity. This includes programs such as agricultural livelihoods programs, homestead food production or vegetable garden programs, and programs that focus on small animals, livestock, and fisheries. There is limited evidence showing that agriculture programs with nutrition-specific elements have larger effects on dietary diversity than agriculture programs without nutrition-specific elements.

In general, cash transfer and nutrition-sensitive agriculture programs as well as WASH services tend to have small but positive effects on anthropometric outcomes such as stunting and wasting. While the effects are not always statistically significant, conditional and unconditional cash transfers with and without nutrition-specific elements tend to have small effects on reductions in stunting and wasting, just like various nutrition-sensitive agriculture programs and WASH services.

Various factors contributed to increased effectiveness of nutrition interventions outside the health sector. Qualitative evidence suggests that cash transfers could generate larger effects when transfer amounts increase or receive adjustments for inflation. Technical assistance from international organizations, low opportunity costs, local ownership, and adaptability of implementation strategies were other factors that likely increased the impacts of these programs on maternal and child nutrition outcomes and dietary diversity. Barriers to implementation are highly context specific but often include limited human resources and poor community sensitization efforts.

While interventions had limited integration across sectors (such as health, nutrition, social protection, WASH, agriculture, education), qualitative analysis indicated that most interventions such as cash transfers, agriculture interventions, and WASH interventions were delivered through a community-based approach that leveraged existing institutions such as mother support groups, schools in the community, and health facilities. This finding suggests that existing platforms could create opportunities to effectively scale-up nutrition programs outside the health sector.

Abbreviations

BCC	Behavior change communication
BMI	Body mass index
HAZ	Height-for-age z-score
LBW	Low birthweight
LMIC	Low- or middle-income country
RCT	Randomized-controlled trial
RUSF	Ready-to-use supplementary food
SDG	Sustainable development goal
WASH	Water, sanitation, and hygiene
WAZ	Weight-for-age z-score
WHZ	Weight-for-height z-score

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
TDH, MVC, and HTMN designed the study. TDH, AM, RW, AL, TB, AC, GS, and VR carried out the initial search, while SHC, VLM, BFL, and PGR conducted the targeted searches. TDH, AM, RW, AL, TB, AC, GS, and VR conducted the analysis based on the initial search. HC, VLM, BFL, and PGR conducted the analysis based on the targeted search. TDH, AM, RW, TB, SHC, VLM, BFL, MVC, and HTMN drafted the initial version of the manuscript. All authors contributed to and approved the final version. All authors reviewed the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Abdoulayi S, Angeles G, Barrington C, Brugh K, Handa S, Kilburn K, Molotsky A. Evaluating the effectiveness of an unconditional social cash transfer programme for the ultra poor in Malawi. International Initiative for Impact Evaluation. 2017. Retrieved from https://developmentevidence.3ieimpact.org/search-result-details/impact-evaluation-repository/evaluating-the-effectiveness-of-an-unconditional-social-cash-transfer-programme-for-the-ultra-poor-in-malawi/4852. Accessed Jan 2024.
2. Adelman S, Gilligan DO, Konde-Lule J, Alderman H. School feeding reduces anemia prevalence in adolescent girls and other vulnerable household members in a cluster randomized controlled trial in Uganda. J Nutr. 2019;149(4):659–66. https://doi.org/10.1093/jn/nxy305.
3. Ahmed AU, Hoddinott JF, Roy S. Food transfers, cash transfers, behavior change communication and child nutrition Evidence from Bangladesh. IFPRI Discussion Paper 01868, 2019
4. Ahmed AU, Hoddinott JF, Roy S, Sraboni E, Quabili WR, Margolies A. Which kinds of social safety net transfers work best for the ultra poor in Bangladesh? Operation and Impacts of the Transfer Modality Research Initiative. International Food Policy Research Institute, World Food Programme, Dhaka, Bangladesh. 2016, Retrieved from https://hdl.handle.net/10568/148633. Accessed Jan 2024.
5. Ahmed A, Hoddinott J, Roy S. Food transfers, cash transfers, behavior change communication and child nutrition: evidence from Bangladesh. World Bank Econ Rev. 2024. https://doi.org/10.1093/wber/lhae023.
6. Alaofè H, Burney J, Naylor R, Taren D. The impact of a solar market garden programme on dietary diversity, women's nutritional status and micronutrient levels in Kalale district of Northern Benin. Public Health Nutr. 2019;22(14):2670–81. https://doi.org/10.1017/S1368980019001599.
7. Alderman H, Bundy D, Gelli A. School meals are evolving: has the evidence kept up? World Bank Res Obs. 2024;39(2):159–76. https://doi.org/10.1093/wbro/lkad012.
8. American Institutes for Research. Zambia Child Grant Program: 24-Month Impact Report. Arlington, VA. 2013, Retrieved from https://www.air.org/resource/report/zambias-child-grant-program-24-month-impact-report. Accessed Jan 2024.
9. Anitha S, Kane-Potoka J, Tsusaka TW, Tripathi D, Upadhyay S, Kavishwar A, Nedumaran S. Acceptance and Impact of Millet-Based Mid-Day Meal on the Nutritional Status of Adolescent School Going Children in a Peri Urban Region of Karnataka State in India. Nutrients. 2019;11(9):2077. https://doi.org/10.3390/nu11092077.
10. Ara G, Sanin KI, Khanam M, Sarker MS, Tofail F, Nahar B, Sarker MSA, Chowdhury IA, Boitchi AB, Gibson S, Afsana K, Askari S, Ahmed T. A comprehensive intervention package improves the linear growth of children under 2-years-old in rural Bangladesh: a community-based cluster randomized controlled trial. Sci Rep. 2022;12: 21962.
11. Baliki G, Weiffen D, Schreinemachers P, Shrestha A, Shrestha RM, Schreiner M, Bruck T. Effect of an integrated school garden and home garden intervention on anemia among school-aged children in Nepal: evidence from a cluster randomised controlled trial. Food Nutr Bull. 2023;44(3):195–206.
12. Batra P, Schlossman N, Balan I, Pruzensky W, Balan A, Carrie B, Roberts SB. A Randomized Controlled Trial Offering Higher- Compared with Lower-Dairy Second Meals Daily in Preschools in Guinea-Bissau Demonstrates an Attendance-Dependent Increase in Weight Gain for Both Meal Types and an Increase in Mid-Upper Arm Circumference for. J Nutr. 2016;46(1):124–32. https://doi.org/10.3945/jn.115.218917.
13. Bekele T, Rawstorne P, Rahman B. Effect of water, sanitation and hygiene interventions alone and combined with nutrition on child growth in low and middle income countries: a systematic review and meta-analysis. BMJ Open. 2020;10(7): e034812.
14. Berhane G, Devereux S, Hoddinott J, Hoel J, Roelen K, Abay K, . . . Woldu T. Evaluation of the social cash transfer pilot programme: Tigray Region, Ethiopia: Endline Report. International Food Policy Research Institute. 2015, Retrieved from https://hdl.handle.net/10568/151453. Accessed Jan 2024.
15. Berretta M, Kupfer M, Shisler S, Lane C. Rapid evidence assessment on women's empowerment interventions within the food system: a meta-analysis. Agric Food Secur. 2023;12:13. https://doi.org/10.1186/s40066-023-00405-9.
16. Bhutta ZA, Akseer N, Keats EC, Vaivada T, Baker S, Horton SE, Black R. How countries can reducye child stunting at scale: lessons from exemplar countries. Am J Clin Nutr. 2020;112(Supplement 2):894S-904S.
17. Blakstad MM, Mosha D, Bliznashka L, Bellows AL, Canavan CR, Yussuf MH, Mlalama K, Madzorera I, Chen JT, Noor RA, Kinabo J, Masanja H, Fawzi WW. Are home gardening programs a sustainable way to improve nutrition? Lessons from a cluster-randomized controlled trial in Rufiji, Tanzania. Food Policy. 2022;109: 102248.

18. Briaux J, Martin-Prevel Y, Carles S, Fortin S, Kameli Y, Adubra L, Renk A, Agboka Y, Romedenne M, Mukantambara F, Van Dyck J, Boko J, Becquet R, Savy M. Evaluation of an unconditional cash transfer program targeting children's first-1,000-days linear growth in rural Togo: a cluster-randomized controlled trial. PLoS Med. 2020;17(11): e1003388. https://doi.org/10.1371/journal.pmed.1003388.
19. Cahyadi N, Hanna R, Olken BA, Prima RA, Satriawan E, Syamsulhakim E. Cumulative impacts of conditional cash transfer programs: experimental evidence from Indonesia. Am Econ J Econ Policy. 2020;12(4):88–110.
20. Cameron L, Gertler P, Shah M, Alzua ML, Martinez S, Patil S. The dirty business of eliminating open defecation: the effect of village sanitation on child height from field experiments in four countries. J Dev Econ. 2022;159: 102990.
21. Choedon T, Brennan E, Joe W, Lelijveld N, Huse O, Zorbas C, Sethi V. Nutritional Status of School-Age Children (5–19 Years) in South Asia: A Scoping Review. Maternal Health Nutrition. 2024;20(2):e13607. https://doi.org/10.1111/mcn.13607.
22. de Hoop T, Molotsky A, Laar A, Chakrabarti A, Siwach G, Walcott R, Behmer T. Synthesis of Evidence on the nutritional impact of nutrition-sensitive interventions: research protocol. American Institutes for Research, Arlington, VA. 2023, Retrieved from https://www.air.org/sites/default/files/2024-01/Synthesis-of-evidence-nutrition-sensitive-interventions-maternal-childrens-nutrition-outcomes-research-protocol-Nov-2023.pdf. Accessed Jan 2024.
23. de Hoop T, Molotsky A, Laar A, Chakrabarti A, Siwach G, Walcott R, Behmer T. Synthesis of Evidence on the Impacts of Nutrition-Sensitive Interventions on Maternal and Children's Nutrition Outcomes. Arlington, VA: American Institutes for Research; 2024.
24. Dillon A, Bliznashka L, Olney DK. Experimental evidence on post-program effects and spillovers from an agriculture-nutrition program. Econ Hum Biol. 2020;36: 100820.
25. Durao S, Visser ME, Ramokolo V, Oliveira JM, Schmidt B-M, Balakrishna Y, Schoonees A. Community-level interventions for improving access to food in low- and middle-income countries. Cochrane Database of Systematic Reviews, 2020;7(7),CD011504. https://doi.org/10.1002/14651858.CD011504.pub2
26. Erismann S, Diagbouga S, Schindler C, Odermatt P, Knoblauch AM, Gerold J, Leuenberger A, Shrestha A, Tarnagda G, Utzinger J, Cissé G. School children's intestinal parasite and nutritional status one year after complementary school garden, nutrition, water, sanitation, and hygiene interventions in Burkina Faso. Am J Trop Med Hyg. 2017;97(3):904–13. https://doi.org/10.4269/ajtmh.16-0964.
27. Fançony C, Soares A, Lavinha J, Barros H, Brito M. Effectiveness of nutrition and WASH/malaria educational community-based interventions in reducing anemia in children from Angola. Sci Rep. 2021;11: 5603.
28. Fenn B, Colbourn T, Dolan C, Pietzsch S, Sangrasi M, Shoham J. Impact evaluation of different cash-based intervention modalities on child and maternal nutritional status in Sindh Province, Pakistan, at 6 mo and at 1 y: a cluster randomised controlled trial. PLoS Med. 2017;14(5): e1002305. https://doi.org/10.1371/journal.pmed.1002305.
29. Field EM, Maffioli EM. Are behavioral change interventions needed to make cash transfer programs work for children? Experimental evidence from Myanmar. NBER Working Paper No. 28443, 2021. https://doi.org/10.3386/w28443
30. Finkelstein JL, Mehta S, Villalpando S, Mundo-Rosas V, Luna SV, Rahn M, Shamah-Levy T, Beebe SE, Haas JD. A randomized feeding trial of iron-biofortified beans in schoolchildren in Mexico. Nutrients. 2019;11(2): 381. https://doi.org/10.3390/nu11020381.
31. Galicia L, López de Romaña D, Harding KB, María De-Regil L, Grajeda R. Tackling malnutrition in Latin America and the Caribbean: Challenges and Opportunities. Rev Panam Salud Publica. 2016;40(2):138–46.
32. GBD. Anaemia Collaborators. Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990–2021: findings from the Global Burden of Disease Study 2021. Lancet Haematol. 2021;2023:e713–34. https://doi.org/10.1016/S2352-3026(23)00160-6.
33. Gelli A, Aurina E, Folson G, Arhinful D, Adamba C, Osei-Akoto I, Alderman H. A School Meals Program Implemented at Scale in Ghana Increases Height-for-Age during Midchildhood in Girls and in Children from Poor Households: A Cluster Randomized Trial. J Nutr. 2019;149(8):1434–42.
34. Gelli A, Margolies A, Santacroce M, Roschnik N, Twalibu A, Katundu M, Moestue H, Alderman H, Ruel M, Ruel MT. Using a community-based early childhood development center as a platform to promote production and consumption diversity increases children's dietary intake and reduces stunting in Malawi: a cluster-randomized trial. J Nutr. 2018;148(10):1587–97. https://doi.org/10.1093/jn/nxy148.
35. Gelli A, Tranchant J-P, Bliznashka L, Diallo AS, Sacko M, Siegel E, . . . Masset E. The impact of food assistance on food insecure populations during conflict in Mali. 3ie Grantee Final Report, International Initiative for Impact Evaluation (3ie), New Delhi. 2018
36. Gilligan DO, Roy S. Resources, stimulation, and cognition: How transfer programs and preschool shape cognitive development in Uganda. Agricultural & Applied Economic Association's 2013 AAEA & CAES Annual Meeting. Washington, DC: International Food Policy Research Institute. 2013, Retrieved from https://ageconsearch.umn.edu/record/149822/?v=pdf. Accessed Jan 2024.
37. Gizaw Z, Worku A. Effects of single and combined water, sanitation, and hygiene (WASH) interventions on nutritional status of children: a systematic review and meta-analysis. Ital J Pediatr. 2019;45(1):77. https://doi.org/10.1186/s13052-019-0666-2.
38. Glassman A, Duran D, Fleisher L, Singer D, Sturke R, Angeles G, Koblinsky M. Impact of conditional cash transfers on maternal and newborn health. J Health Popul Nutr. 2013;31(4 Suppl 2):48–66.
39. Gram L, Fitchett A, Ashraf A, Daruwalla N, Osrin D. Promoting women's and children's health through community groups in low-income and middle-income countries: a mixed-methods systematic review of mechanisms, enablers and barriers. BMJ Glob Health. 2019;4(6): e001972.
40. Grellety E, Babakazo P, Bangana A, Mwamba G, Lezama I, Zagre NM, Ategbo E-A. Effects of unconditional cash transfers on the outcome of treatment for severe acute malnutrition (SAM): a cluster-randomised trial in the Democratic Republic of the Congo. BMC Med. 2017;15: 87. https://doi.org/10.1186/s12916-017-0848-y.
41. Grijalva-Eternod CS, Jelle M, Mohamed H, Waller K, Hussein BO, Barasa E, Osman Hussein B, Solomon A, Mehjabeen S, Copas A, Fottrell E, Seal AJ. Evaluation of conditional cash transfers and mHealth audio messaging in reduction of risk factors for childhood malnutrition in internally displaced persons camps in Somalia: a 2x2 factorial cluster-randomised controlled trial. PLoS Med. 2023;20(2): e1004180. https://doi.org/10.1371/journal.pmed.1004180.
42. Handa S, Seidenfeld D, Davis B, Tembo G. The social and productive impacts of Zambia's child grant. J Policy Anal Manage. 2016;35(2):357–87. https://doi.org/10.1002/pam.21892.
43. Harris-Fry HA, Paudel P, Harrisson T, Shrestha N, Jha S, Beard BJ, Copas A, Shrestha BP, Manandhar DS, Costello AMdL, Cortina-Borja M, Saville NM. Participatory women's groups with cash transfers can increase dietary diversity and micronutrient adequacy during pregnancy, whereas women's groups with food transfers can increase equity in intrahousehold energy allocation. J Nutr. 2018;148(9):1472–83.
44. Heckert J, Olney DK, Ruel MT. Is women's empowerment a pathway to improving child nutrition outcomes in a nutrition-sensitive agriculture program? Evidence from a randomized controlled trial in Burkina Faso. Soc Sci Med. 2019;233:93–102.
45. Hoddinott J, Sandström S, Upton J. The impact of cash and food transfers: evidence from a randomized intervention in Niger. Am J Agric Econ. 2018;100(4):1032–49. https://doi.org/10.1093/ajae/aay019.
46. Humphrey JH, Mbuya MN, Ntozini R, Moulton LH, Stoltzfus RJ, Tavengwa NV, Prendergast AJ. Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe: a cluster-randomised trial. Lancet Global Health. 2019;7(1):e132–47. https://doi.org/10.1016/S2214-109X(18)30374-7.
47. Iannotti LL, Henretty NM, Delnatus JR, Previl W, Stehl T, Vorkoper S, Bodden J, Maust A, Smidt R, Nash ML, Tamimie CA, Owen BC, Wolff PB. Ready-to-use supplementary food increases fat mass and BMI in Haitian school-aged children. J Nutr. 2015;145(4):813–22. https://doi.org/10.3945/jn.114.203182.
48. Iannotti L, Dulience SJ-L, Joseph S, Cooley C, Tufte T, Cox K, Eaton J, Delnatus JR, Wolff PB. Fortified snack reduced anemia in rural school-aged children of Haiti: a cluster-randomized, controlled trial. PLoS One. 2016;11(12): e0168121.

49. Keats EC, Das JK, Salam RA, Lassi ZS, Imdad A, Black RE, Bhutta ZA. Effective interventions to address maternal and child malnutrition: an update of the evidence. Lancet Child Adolesc Health. 2021;5(5):367–84.
50. Krämer M, Kumar S, Vollmer S. Improving child health and cognition: evidence from a school-based nutrition intervention in India. Rev Econ Stat. 2021;103(5):818–34. https://doi.org/10.1162/rest_a_00950.
51. Kremer M, Luby SP, Maertens R, Tan B, Więcek W. Water Treatment And Child Mortality: A Meta-Analysis And Cost-effectiveness Analysis. National Bureau of Economic of Research. Cambridge, MA: NBER. 2023 https://doi.org/10.3386/w30835
52. Kyere P, Veerman JL, Lee P, Stewart DE. Effectiveness of school-based nutrition interventions in sub-Saharan Africa: a systematic review. Public Health Nutr. 2020;23(14):2626–36. https://doi.org/10.1017/S1368980020000506.
53. Le Port A, Bernard T, Hidrobo M, Birba O, Rawat R, Ruel MT. Delivery of iron-fortified yoghurt, through a dairy value chain program, increases hemoglobin concentration among children 24 to 59 months old in Northern Senegal: a cluster-randomized control trial. PLoS One. 2017;12(2): e0172198.
54. Leroy JL, Frongillo EA, Kase BE, Alonso S, Chen M, Dohoo I, Huybregts L, Kadiyala S, Saville NM. Strengthening causal inference from randomised controlled trials of complex interventions. BMJ Glob Health. 2022;7(6): e008597. https://doi.org/10.1136/bmjgh-2022-008597.
55. Leroy JL, Koch B, Roy S, Gilligan D, Ruel MT. Social assistance programs and birth outcomes: A systematic review and assessment of nutrition and health pathways. J Nutr. 2021;151(12):3841–55. https://doi.org/10.1093/jn/nxab292.
56. Leroy JL, Olney DK, Ruel MT. Tubaramure, a food-assisted integrated health and nutrition program in Burundi, increases maternal and child hemoglobin concentrations and reduces anemia: a theory-based cluster-randomized controlled intervention trial. J Nutr. 2016;146(8):1601–8.
57. Leroy JL, Olney DK, Ruel MT. Tubaramure, a food-assisted integrated health and nutrition program, reduces child stunting in Burundi: a cluster-randomized controlled intervention trial. J Nutr. 2018;148(3):445–52. https://doi.org/10.1093/jn/nxx063.
58. Leroy JL, Olney DK, Bliznashka L, Ruel MT. Tubaramure, a food-assisted maternal and child health and nutrition program in Burundi, increased household food security and energy and micronutrient consumption, and maternal and child dietary diversity: a cluster-randomized controlled trial. J Nutr. 2020;150(4):945–57.
59. Lisboa CS, Sernizon Guimaraes N, Fortes Ferreira AJ, Beck da Silva KB, Oliveira Alves FJ, Dos Santos Rocha A, Lima Barreto M. Impact of cash transfer programs on birth and child growth outcomes: systematic review. Ciencia & Saude Coletiva, 2023;28(8),2417–2432.
60. Manley J, Alderman H, Gentilini U. More evidence on cash transfers and child nutritional outcomes: a systematic review and meta-analysis. BMJ Glob Health. 2022;7(4): e008233. https://doi.org/10.1136/bmjgh-2021-008233.
61. Margolies A, Kemp CG, Choo EM, Levin C, Olney D, Kumar N, Go A, Alderman H, Gelli A. Nutrition-sensitive agriculture programs increase dietary diversity in children under 5 years: a review and meta-analysis. J Glob Health. 2022;12: 08001. https://doi.org/10.7189/jogh.12.08001.
62. Michaux KD, Hou K, Karakochuk CD, Whitfield KC, Ly S, Verbowski V, Stormer A, Porter K, Li KH, Houghton LA, Lynd LD, Talukder A, McLean J, Green TJ. Effect of enhanced homestead food production on anaemia among Cambodian women and children: a cluster randomized controlled trial. Matern Child Nutr. 2019;15(Suppl 3): e12757.
63. Mideksa S, Getachew T, Bogale F, Woldie E, Ararso D, Samuel A, Girma M, Tessema M, Hadis M. School feeding in Ethiopia: a scoping review. BMC Public Health. 2024;24: 138. https://doi.org/10.1186/s12889-023-17613-4.
64. Muema J, Mutono N, Kisaka S, Ogoti B, Oyugi J, Bukania Z, Daniel T, Njuguna J, Kimani I, Makori A, Omulo S, Boyd E, Osman AM, Gwenaelle L, Jost C, Thumbi SM. The impact of livestock interventions on nutritional outcomes of children younger than 5 years old and women in Africa: a systematic review and meta-analysis. Front Nutr. 2023;10: 1166495. https://doi.org/10.3389/fnut.2023.1166495.
65. Murayama N, Magami M, Akter S, Hossain IA, Ali L, Faruquee MH, Ahmad A. A pilot school meal program using local foods with soybean in rural Bangladesh: effects on the nutritional status of children. Food Nutr Sci. 2018;9(4):290–313. https://doi.org/10.4236/fns.2018.94023.
66. Nguyen HT, Hernandez-Cordero S, Gaitan-Rossi P, Franco-Lares B, Lara-Mejia V, Tapia-Hernandez B, Beltran LF. Impacts of nutrition-sensitive interventions on nutrition outcomes in low- and middle-income countries. An update of the evidence. 2024 Retrieved from PROSPERO: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42024552449. Accessed Nov 2024.
67. Olney DK, Gelli A, Kumar N, Alderman H, Go A, Raza A. Social assistance programme impacts on women's and children's diets and nutritional status. Matern Child Nutr. 2022;18(4): e13378. https://doi.org/10.1111/mcn.13378.
68. Olney DK, Pedehombga A, Ruel MT, Dillon A. A 2-year integrated agriculture and nutrition and health behavior change communication program targeted to women in Burkina Faso reduces anemia, wasting, and diarrhea in children 3–12.9 months of age at baseline: a cluster-randomized controlled trial. J Nutr. 2015;145(6):1317–24.
69. Omer A, Hailu D, Whiting SJ. Child-owned poultry intervention effects on hemoglobin, anemia, concurrent anemia and stunting, and morbidity status of young children in southern Ethiopia: a cluster randomized controlled community trial. Int J Environ Res Public Health. 2023;20(7): 5406.
70. Osei A, Pandey P, Nielsen J, Pries A, Spiro D, Davis D, Quinn V, Haselow N. Combining home garden, poultry, and nutrition education program targeted to families with young children improved anemia among children and anemia and underweight among nonpregnant women in Nepal. Food Nutr Bull. 2017;38(1):49–64.
71. Passarelli S, Ambikapathi R, Gunaratna NS, Madzorera I, Canavan CR, Noor AR, Worku A, Berhane Y, Abdelmenan S, Sibanda S, Munthali B, Madzivhandila T, Sibanda LM, Geremew K, Dessie T, Abegaz S, Assefa G, Sudfeld C, McConnell M, Davison K, Fawzi W. A chicken production intervention and additional nutrition behavior change component increased child growth in Ethiopia: a cluster-randomized trial. J Nutr. 2020;150(10):2806–17.
72. Perignon M, Fiorentino M, Kuong K, Dijkhuizen MA, Burja K, Parker M, Dijkhuizen M, Chamnan C, Berger J, Wieringa F, Wieringa FT. Impact of multi-micronutrient fortified rice on hemoglobin, iron and vitamin A status of Cambodian schoolchildren: a double-blind cluster-randomized controlled trial. Nutrients. 2016;8(1): 29. https://doi.org/10.3390/nu8010029.
73. Persha L, Haugan G. Yaajeende final impact evaluation report : an impact evaluation of the Yaajeende nutrition-led agriculture program in senegal (2011–2017). United States Agency for International Development, Washington, DC. 2018 Retrieved from https://pdf.usaid.gov/pdf_docs/PA00TZ2D.pdf. Accessed Jan 2024.
74. Pickering AJ, Djebbari H, Lopez C, Coulibaly M, Alzua ML. Effect of a community-led sanitation intervention on child diarrhoea and child growth in rural Mali: a cluster-randomised controlled trial. Lancet Glob Health. 2015;3(11):e701–11.
75. Pinkaew S, Winichagoon P, Hurrell RF, Wegmuller R. Extruded rice grains fortified with zinc, iron, and vitamin A increase zinc status of Thai school children when incorporated into a school lunch program. J Nutr. 2013;143(3):362–8. https://doi.org/10.3945/jn.112.166058.
76. Premand P, Barry O. Behavioral change promotion, cash transfers and early childhood development: experimental evidence from a government program in a low-income setting. J Dev Econ. 2022;158: 102921. https://doi.org/10.1016/j.jdeveco.2022.102921.
77. Ramírez-Luzuriaga MJ, Unar-Munguía M, Rodríguez-Ramírez S, Rivera JA, González de Cosío T. A food transfer program without a formal education component modifies complementary feeding practices in poor rural Mexican communities. J Nutr. 2016;146(1):107–13.
78. Ruel MT, Quisumbing AR, Balagamwala M. Nutrition-sensitive agriculture: what have we learned so far? Glob Food Secur. 2018;17:128–53. https://doi.org/10.1016/j.gfs.2018.01.002.
79. Ruel MT, Alderman H, Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet. 2013;382(9891):536–51.
80. Rutherford DD, Burke HM, Cheung KK, Field SH. Impact of an agricultural value chain project on smallholder farmers, households, and children in Liberia. World Dev. 2016;83:70–83.
81. Sagastume D, Barrenechea-Pulache A, Ruiz-Alejos A, Polman K, Beňová L, Ramírez-Zea M, Peñalvo JL. Quantifying overlapping forms of

malnutrition across Latin America: a systematic literature review and meta-analysis of prevalence estimates. Adv Nutr. 2024;15(5): 100212. https://doi.org/10.1016/j.advnut.2024.100212.
82. Saville NM, Shrestha BP, Style S, Harris-Fry H, Beard BJ, Sen A, Pulkk. Impact on birth weight and child growth of Participatory Learning and Action women's groups with and without transfers of food or cash during pregnancy: Findings of the low birth weight South Asia cluster-randomised controlled trial (LBWSAT) in Nepal. PLoS One, 2018;13(5), e0194064. https://doi.org/10.1371/journal.pone.0194064
83. Segura-Perez S, Grajeda R, Perez-Escamilla R. Conditional cash transfer programs and the health and nutrition of Latin American children. Rev Panam Salud Publica. 2016;40(2):124–37.
84. Sharma IK, Di Prima S, Essink D, Broerse JE. Nutrition-sensitive agriculture: a systematic review of impact pathways to nutrition outcomes. Adv Nutr. 2021;12(1):251–75. https://doi.org/10.1093/advances/nmaa103.
85. Sharp K, Visram A, Bahety G, Kardan A. Child development grant programme evaluation. final process evaluation report: Round I. ePact, Oxford Policy Management, Oxford, UK. 2016. Retrieved from https://www.opml.co.uk/sites/default/files/migrated_bolt_files/cdg-final-process-evaluation-round-1.pdf. Accessed Jan 2024.
86. Shekar M, Kakietek J, D'Alimonte MR, Rogers HE, Eberwein JD, Akuoku JK, Hecht R. Reaching the global target to reduce stunting: an investment framework. Health Policy & Planning, 2017; 32(5), 657–668. https://doi.org/10.1093/heapol/czw184
87. Shekar M, Okamura KS, Vilar-Compte M, Dell'Aira C, editors. Investment framework for nutrition 2024. Washington, DC: World Bank; 2024.
88. Shrestha A, Schindler C, Odermatt P, Gerold J, Erismann S, Sharma S, Koju R, Utzinger J, Cissé G. 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. 2020;20: 158. https://doi.org/10.1186/s12889-019-8027-z.
89. Stewart CP, Dewey KG, Lin A, Pickering AJ, Byrd KA, Jannat K, Ali S, Rao G, Dentz HN, Kiprotich M, Arnold CD, Arnold BF, Allen LH, Shahab-Ferdows S, Ercumen A, Grembi JA, Naser AM, Rahman M, Unicomb L, Colford JM Jr, Luby SP, Null C. 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. Am J Clin Nutr. 2019;109(1):148–64.
90. Storhaug IG, Lane C, Moore N, Engelbert M, Sparling TM, Snilstveit B. Making the most of existing research: an evidence gap map of the effects of food systems interventions in low-income and middle-income countries. BMJ Open. 2022;12: e055062. https://doi.org/10.1136/bmjopen-2021-055062.
91. Thomas J, Graziosi S, O'Driscoll P, Brunton J. EPPI Reviewer: Advanced software for systematic reviews, maps and evidence synthesis. London: Social Research Institute, University College London. 2022 Retrieved from EPPI Reviewer: Advanced software for systematic reviews, maps and evidence synthesis.: https://eppi.ioe.ac.uk/eppireviewer-web/home
92. United Nations Children's Fund, World Health Organization, World Bank Group. Levels and trends in child malnutrition: key findings of the 2021 edition of the joint child malnutrition estimates. Geneva: World Health Organization. 2021 Retrieved from https://www.who.int/publications/i/item/9789240025257. Accessed Jan 2024.
93. Vilar-Compte M, Nguyen HT, Okamura KS, Blakstad M (2024) Interventions that address all forms of malnutrition. In M. Shekar, K. S. Okamura, M. Vilar-Compte, & C. Dell'Aira, *Rearching the global nutrition targets: What will it take? An update to the investment framework on nutrition.* Washington, DC: The World Bank.
94. von Grafenstein L, Kumar A, Kumar S, Vollmer S. Medium-run impacts of iron-fortified school lunch on anaemia, cognition, and learning outcomes in India. Oxf Bull Econ Stat. 2023;85(6):1262–94.
95. Waddington H, White H, Snilstveit B, Hombrados JG, Vojtkova M, Davies P, Bhavsar A, Eyers J, Koehlmoos TP, Petticrew M, Valentine JC, Tugwell P. How to do a good systematic review of effects in international development: a tool kit. J Dev Eff. 2012;4(3):359–87. https://doi.org/10.1080/19439342.2012.711765.
96. Wang D, Katalambula L, Modest A, Ismail A, Malero A, Bray D, Katalambula LK, Modest AR, Cinq-Mars H, Tinkasimile A, Sando MM, Vuai S, Fawzi WW. Meals, education, and gardens for in-school adolescents: a cluster randomized trial of an adolescent nutrition intervention package in Tanzania. J Adolesc Health. 2024. https://doi.org/10.1016/j.jadohealth.2024.02.032.
97. Wang D, Shinde S, Young T, Fawzi WW. Impacts of school feeding on educational and health outcomes of school-age children and adolescents in low- and middle-income countries: A systematic review and meta-analysis. J Glob Health. 2021;11:04051. https://doi.org/10.1186/s13643-020-01317-6.
98. Wegmüller R, Musau K, Vergari L, Custer E, Anyango H, Donkor WE, Kiprotich M, Siegal K, Petry N, Wirth JP, Lewycka S, Woodruff BA, Rohner F. Effectiveness of an integrated agriculture, nutrition-specific, and nutrition-sensitive program on child growth in western Kenya: a cluster-randomized controlled trial. Am J Clin Nutr. 2022;116(2):446–59.
99. Young SL, Bethancourt HJ, Cafiero C, Gaitán-Rossi P, Koo-Oshima S, McDonnell R, Frongillo EA. Acknowledging, measuring and acting on the importance of water for food and nutrition. Nature Water. 2023;1:825–8. https://doi.org/10.1038/s44221-023-00146-w.
100. Young SL, Frongillo EA, Jamaluddine Z, Melgar-Quiñonez H, Pérez-Escamilla R, Ringler C, Rosinger AY. Perspective: the importance of water security for ensuring food security, good nutrition, and well-being. Adv Nutr. 2021;12(4):1058–73. https://doi.org/10.1093/advances/nmab003.

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