REVIEW

Design Factors for Food Supplementation and Nutrition Education Interventions That Limit Conclusions about Effectiveness for Wasting Prevention: A Scoping Review of Peer-Reviewed Literature

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ABSTRACT

We conducted a scoping review to characterize the evidence base for the effectiveness of food supplementation (FS), nutrition education (NE), or FS/NE interventions to prevent wasting among children aged 6 to 59 mo. We aimed to identify gaps in peer-reviewed literature and to develop recommendations for strengthening study designs. We identified 56 unique studies (FS = 21, NE = 19, FS/NE = 16) for which we assessed intervention design factors, implementation context, evaluation methods, and wasting impact. Compared with studies focused on stunting, fewer wasting-focused studies reported weight-for-height *z* score (WHZ). Midupper arm circumference (MUAC) was more commonly reported in wasting-focused studies (71.4%) than those focused on stunting (36.8%) or wasting and stunting (30.4%). FS studies measured anthropometry (mean, 95% CI) more frequently at every 11.3 (7.8, 14.8) wk than NE interventions at 36.3 (8.8, 62.1) wk ($P = 0.036$), but not FS/NE interventions at 25.8 (5.6, 49.1) wk ($P = 0.138$). NE interventions tended to be of longer duration than FS or FS/NE interventions. Only 6 studies followed and measured children after the intervention period ended. Across all studies, 45% reported a significant effect on wasting; these included FS, NE, and FS/NE interventions. The lack of comparability across studies limits conclusions about the effectiveness of specific types of interventions. To build a more unified evidence base for wasting prevention we recommend that future studies *1*) report on a consistent set of metrics, including MUAC; *2*) attempt to measure change in wasting incidence using more frequent measures; *3*) measure wasting prevalence among the general population; *4*) follow children postintervention to assess relapse; *5*) measure food insecurity and diet quality; and *6*) use harmonized protocols across multiple settings. Such efforts to improve study comparability will strengthen the evidence base, may help unite divergent professional communities, and ultimately accelerate progress toward eliminating child undernutrition. *Adv Nutr* 2022;13:328–341.

Statement of Significance: We conducted a scoping review to characterize the evidence base for the effectiveness of food supplementation (FS), nutrition education (NE), or FS/NE interventions to prevent wasting among children aged 6–59 mo. We identified gaps in peer-reviewed literature and developed recommendations for strengthening study designs.

Keywords: acute malnutrition, interventions, nutritional status, stunting, wasting prevention

Introduction

Moderate [weight-for-height *z* score (WHZ) < −2 SDs] and severe wasting (WHZ < −3 SDs) are associated with increased risk of morbidity and mortality; wasted children are over 3 to 10 times more likely to die by age 5 compared with well-nourished children (1, 2). World Health Assembly (WHA) 2025 targets call for reducing and maintaining the prevalence of wasting among children under 5 to below 5% (3). As of 2019, an estimated 7.3% or 49.5 million children worldwide are wasted, and only half of countries are on track to meet the 2025 target (4).

Food-based and education interventions for child undernutrition are being scaled up across high-burden countries (5). A recent comprehensive literature review and expert

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consultation carried out by the Emergency Nutrition Network (ENN) concluded that there is only moderate-to-weak evidence for the impact of nutrition-specific and nutrition-sensitive interventions on wasting prevention. Macronutrient supplement interventions have a more robust evidence base than counseling-focused and other approaches (6). Others have noted a lack of evidence for interventions that impact wasting incidence and prevalence in the general population (7, 8). Wasting-focused strategies have emphasized screening and treating wasted children under 5 y using community-based protocols (9). Most studies with wasting as a primary endpoint include interventions that treat malnourished children and use the "time to recovery" rather than wasting incidence or prevalence as a primary outcome.

Reinforcing this limited evidence base for wasting prevention is a longstanding divide in the types of organizations and, by extension, interventions that address wasting. The nutrition community has been described as "divergent" in its approach to different forms of undernutrition, with development-oriented organizations more focused on stunting and emergency-oriented organizations more focused on wasting (10). A more recent study carried out by our team suggests these divides persist (11). We also found that, contrary to the ENN finding of weak-to-moderate evidence, many nutrition stakeholders assume that nutrition education (NE) and food supplementation (FS) interventions will impact both wasting and stunting outcomes (11). There is a logical basis for this assumption. Physiologically, wasting and stunting may co-exist in the same populations and can co-occur within the same individuals (12, 13). A significant proportion of both conditions originate in utero (14, 15). Both conditions share common physiological causes and consequences, including inadequate nutrient intake, impaired immunity, increased infection, and increased nutrient requirements coupled with decreased nutrient availability (16).

The aims of this scoping review are to *1*) evaluate the current state of evidence of FS and NE studies for identifying their effectiveness on preventing and treating wasting in children aged 6–59 mo and *2*) recommend improvements in these intervention study designs to better capture the impact on wasting and to bridge the wasting-stunting divide in the nutrition community. We seek to build on the recent ENN review (6) by identifying design features in the FS and NE interventions for consideration as future wasting prevention interventions are developed through these aims.

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Abbreviations used: ENN, Emergency Nutrition Network; FS, food supplementation; HAZ, height-for-age *z* score; LAC, Latin America and Caribbean; MAM, moderate acute malnutrition; MUAC, midupper arm circumference; NCHS, National Center for Health Statistics; NE, nutrition education; NE/FS, nutrition education and food supplementation; PROMIS, Innovative Approaches for the Prevention of Childhood Undernutrition; RCT, randomized controlled trial; RUSF, ready-to-use supplemental food; SA, South Asia; SAM, severe acute malnutrition; SQ-LNS, small-quantity lipid-based nutrient supplement; SSA, sub-Saharan Africa; WHA, World Health Assembly; WHZ, weight-for-height *z* score.

Methods

We reviewed published, peer-reviewed literature to identify studies that assessed the impact of FS and NE interventions on wasting-related outcomes. We classified these interventions as NE only, macronutrient FS only, and FS/NE. We use the term "wasting" to describe the nutritional status of WHZ < -2 SDs or midupper arm circumference (MUAC) $<$ 125 mm among children aged 6–59 mo. Wasting is further classified as moderate ($-3 <$ WHZ < -2 SDs and/or 115 mm $<$ MUAC $<$ 125 mm) or severe (WHZ < -3 SDs and/or MUAC $<$115 mm). We define "wasting prevention" as primary and secondary prevention of either moderate or severe wasting (6). Primary prevention studies do not target based on nutritional status but include all children. In secondary prevention studies, the intervention was targeted to children with moderate wasting in order to prevent severe wasting.

Text Box 1 summarizes the research questions guiding this review.

Text Box 1
Research questions for scoping review

Question 1	What is the available evidence to assess the impact of FS, NE, and FS/NE interventions on wasting? How is the impact of these interventions on wasting reflected when assessed by: • Intervention design factors (type, author-stated study objective, age group, supplement dose)? • Population factors (baseline nutritional status, geographical region)? • Evaluation design factors (type and frequency of growth measurements)?
Question 2	To what extent is the current evidence of FS, NE, or FS/NE studies sufficient for characterizing how effective these interventions are for preventing wasting?
Question 3	How can these studies be better designed to evaluate impact on wasting?

Inclusion criteria

Text Box 2 summarizes the inclusion and exclusion criteria.

We searched the PubMed, WHO Regional, and CAB Direct databases to identify studies that met inclusion criteria, using the search strategy reported in **Supplemental Table 1**. The literature search was conducted between 15 December 2017 and 15 May 2020.

Text Box 2
Study inclusion and exclusion criteria

Inclusion criteria
Studies published between January 1985 and April 2020 that had the following characteristics were included:

- Population. Participants were:
    - 6–59 mo of age at enrollment.
        - If study included some children above 59 mo, the article was included in the review if the majority of participants were below 59 mo.
        - If study enrolled children below 6 mo, the article was included if they provided an FS or NE intervention after 6 mo of age and if the intervention's impact could be assessed independently of the pre-6-mo period.
    - Living in low- or middle-income country (LMIC) as defined by the World Bank (17).
- Intervention. Provide food (energy and other nutrients) and/or interpersonal NE to caregivers in the 6–59-mo age group. There was no minimum duration or minimum caloric requirement for the supplement to be included in the review. Interventions that included only mass media approaches were not included as NE because that lacked interpersonal communication. Studies that treated MAM or moderate wasting as a strategy for preventing the progression to SAM, as these studies were considered to be a "secondary prevention" approach for SAM. Severe wasting and SAM treatment studies were not included in the review.
- Comparison. Compared an FS or NE intervention with a no-intervention control group.
- Outcome. Studies reported changes in at least 1 of the following metrics at population level:
    - Prevalence of stunting (% WHZ < -2 SDs)
    - Prevalence of wasting (% WHZ < -2 SDs)
    - Mean HAZ
    - Mean WHZ
    - MUAC
    - Change in weight (including growth velocity)
    - Change in height (including growth velocity)
    - Percentage recovery from MAM
- Study design. The following study designs were included:
    - Randomized controlled trials
    - Cluster randomized controlled trials
    - Nonrandomized intervention studies with a control group

Exclusion criteria
Studies were excluded if:

- The full-text article was not available in English, French, or Spanish.
- The study design was a case study, observational study, or intervention with no control group.
- The study enrolled children with SAM at baseline (e.g., was a SAM treatment study or report of a therapeutic feeding program for SAM).
- The study did not involve FS or NE.

Data extraction and management

Three research assistants reviewed the full-text articles and extracted data following the Child Health Epidemiology Reference Group systematic review guidelines (18). Article selection was based on the inclusion and exclusion criteria in Text Box 2. Data, including study population, intervention components, evaluation, outcome measures, anthropometric standards, and results, were compiled in a web-based spreadsheet by the study team and confirmed by the research team leader. We sought to evaluate evaluation differences and to compare the proportion of studies that reported a significant impact on wasting within study types (e.g., type of intervention, dose of food supplement, frequency of anthropometric assessments). At least 2 researchers from a team of 4 reviewed all abstracts. The research team met regularly to ensure consistency in article extraction. Any inconsistencies were corrected by the co-Principal Investigator (SBI), who ensured systematic reporting of article information. Details of the review process are provided in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR) checklist in **Supplemental Table 2**.

Study analysis and classifications

We examined the following aspects of the study impact, design, implementation context, and evaluation methods for each of the studies.

Type of intervention.

Studies that provided a macronutrient supplement in any amount were considered FS interventions. Studies that delivered individual or group-level NE (e.g., interpersonal counseling, group education) were considered NE interventions. Studies involving mass media were only included in the review if there was another form of interpersonal NE components (e.g., individual counseling for infant feeding) and if the control group also received the mass media. FS/NE interventions provided any combination of these approaches.

Text Box 3 summarizes the specific subtypes and examples of FS and NE studies that were included in the review.

Geographic region.

The study location was classified according to World Bank regions (17).

Age of beneficiary.

We categorized studies according to their inclusion criteria for children's age at the start of the intervention using 3 groups: 6–11 mo, 12–23 mo, and 24–59 mo. When a study spanned more than 1 age category (e.g., enrolling children aged 6–23 mo), we used the mean age of children at baseline to classify the intervention into the predominant age group.

Text Box 3
Subtypes and examples of FS and NE studies

Examples of studies with NE interventions

- Interpersonal counseling to promote appropriate complementary feeding and health-seeking behaviors (19, 20)
- Group-based nutrition education (21)
- Positive deviance/hearth (22, 23)

Examples of studies with FS interventions

- Fortified complementary food (24)
- Household or child-specific staple food rations (25)
- Small-quantity lipid-based nutrient supplements (SQ-LNSs) (26, 27)
- RUSF or fortified cereals for MAM treatment (28, 29)

"Duration of intervention" is the length of time in weeks that an individual child was exposed to the intervention. An intervention that was delivered for 12 mo was considered to be 52 wk long. The length of the postintervention follow-up was also assessed.

Dose of food supplement.

For FS and FS/NE studies, we classified the supplement size according to the criteria used in a Cochrane review of food supplementation among socioeconomically disadvantaged children (29). Food supplements that provided <30% of the DRI for energy were classified as low; those providing between 30% and 59% were classified as medium; those providing >60% of the child's DRI were considered high (30). We applied this percentage to the age-specific estimated energy needs for children to produce an estimate of the size of the food supplement to the overall child diet (31, 32). For this purpose, children's age classification was the same as the "age of beneficiary" above. **Supplemental Table 3** reports the dose and type of supplement for each study, and **Supplemental Table 4** reports the cut points for the categorization of supplement doses.

Author-stated study objective.

We used the author-stated study objectives to classify studies as "wasting-focused" and/or "stunting-focused." This classification was motivated by the nutrition community divisions between development and emergency subsectors highlighted in this paper's Introduction. Studies were classified as "wasting-focused" if the authors stated the primary study aim was to prevent or treat child wasting including moderate acute malnutrition (MAM). "Stunting-focused" studies aimed to prevent stunting or linear growth faltering in children. Studies that were "wasting and stunting-focused" sought to treat moderate wasting and to prevent both wasting and linear growth faltering. A summary of the determination about the author-stated objective is provided in **Supplemental Table 5**.

Nutritional status at baseline.

We classified studies into 3 categories using the following criteria at baseline: *1*) targeted moderately wasted children (all enrolled children have $-3 < \text{WHZ} < -2$ SDs or 115 mm < MUAC < 125 mm), *2*) in the general population without severe acute malnutrition (SAM; enrolled all kids with WHZ > -3 and/or MUAC >115 mm), and *3*) excluded moderately wasted children (only enrolled children with WHZ > -2 or MUAC >125 mm).

Food security.

The food security of study settings was assessed using Global Hunger Index estimates for the country where the study took place (33).

Outcome assessment (metrics and frequency).

For each study, we identified which anthropometric metrics were assessed and how often measurements were taken. We extracted reported values for changes in linear growth [measured by height-for-age *z* score (HAZ), % stunting] and ponderal growth (measured in grams of weight gain, WHZ, MUAC, ponderal growth velocity, % wasting, the incidence of wasting, and % recovery from MAM) and in linear growth (measured by HAZ, % stunting). The time between assessments was estimated by dividing the total number of anthropometric measurements by the study duration in weeks. **Supplemental Table 6** reports the frequency of anthropometric measurements, growth measures, and growth reference standards for the included studies.

Growth standard/reference.

Across the studies, 2 different growth references were cited for calculating WHZ scores: WHO 2006 Child Growth Standards (34) and the National Center for Health Statistics (NCHS) growth reference (35, 36). It is not possible to directly compare WHZ results using the 2 different growth references (7). The growth reference used to assess nutritional status was not specified in 4 studies. In these cases, we inferred the reference by the study year. Studies conducted before 2006 were assumed to have used the NCHS reference and those after 2006, the WHO standard. In practice, a different growth reference may have been used in these studies.

Dietary data.

The change in overall diet quality and changes in specific macro- and micronutrients may provide useful information as to how an intervention may affect stunting, wasting, or both (37). We assessed whether and how dietary intake was measured and reported (e.g., 24-h diet recall, dietary diversity measurements, or other indices of diet quality). If the authors reported only breastfeeding status, we did not consider the study to have included dietary data.

Impact on wasting.
We considered it a significant impact on wasting if, compared with control, any study subgroup demonstrated a statistically significant positive outcome for *1*) mean change in WHZ, *2*) mean change in MUAC, *3*) prevalence of wasting (WHZ < −2 SDs or MUAC <125 mm), *4*) incidence of wasting (WHZ < −2 SDs or MUAC <125 mm), or *5*) percentage of children recovering from MAM.

Ethics
Wheaton College and Johns Hopkins University School of Public Health Institutional Review Boards approved the study procedures.

Results
Our initial search yielded 5775 results from 1985 through 15 May 2020. Following a review of these abstracts, we examined the full-text articles of 80 studies. Through search terms ($n = 44$) and manual inclusion of previously identified studies from related reviews and targeted searches for published articles related to studies that produced manuscripts ($n = 12$), we selected 56 studies that met the inclusion criteria (19–29, 38–82). **Supplemental Table 7** lists the study references and details of each included study's population, intervention approach, results, and contextual factors (food security and nutritional status of targeted children).

Intervention and study design factors
Table 1 summarizes study design factors by intervention type and the predominant age of the beneficiary.

Geographic region.
Five regions were represented across the studies: sub-Saharan Africa (SSA), the Middle East/North Africa, Latin America and Caribbean (LAC), South Asia (SA), and East Asia Pacific. Most of the studies (32 of 56; 57.1%) were in SSA, and 9 (16.1%) were in SA, 5 (8.9%) were in LAC, and 7 (12.5%) in East Asia Pacific. One study was conducted in multiple sites, including SSA, LAC, and SA.

Study design and quality.
Forty-seven of 56 studies were randomized controlled trials (RCTs), including 29 cluster-RCTs. The remaining 9 were nonrandomized quasi-experimental studies, including controlled impact evaluations. The studies were mostly high quality ($n = 48$), whereas 9 were classified as moderate quality due to nonrandomized designs (23, 27, 46, 47, 58, 61, 68, 72, 80). No studies were classified as low or very low. The highest risks of bias for RCTs were lack of blinding and systematic differences in how participants were assigned to treatment and control groups. The main risks of bias in the quasi-experimental studies were selection and attrition bias.

Type of intervention.
One-third (33.3%) of the identified studies were FS interventions, 61.1% were NE studies, and 43.8% were FS/NE studies. Among the FS studies, supplements included lipid-based nutrient supplements (LNSs) [e.g., ready-to-use therapeutic foods, ready-to-use supplemental foods (RUSFs), small-quantity lipid-based nutrient supplements (SQ-LNSs)], corn-soy blend, meat, and dairy foods, or fortified porridges. The NE studies delivered information on breastfeeding and/or young child feeding including hygiene practices through community-based, school, and individual counseling platforms. Approaches included Positive Deviance models, intensive interpersonal counseling, group discussions, and recipe demonstrations.

Age of beneficiary.
Most studies included children under 24 mo, the period of highest risk for both stunting and wasting (83), and 44.6% were among the 6–11-mo age group.

Duration of intervention.
The duration of intervention varied from 8 wk (29) to 4 y (19), with a median (95% CI) duration of 32 (24, 50) wk. The median duration was more than twice as long in the NE studies [median (95% CI): 52 (24, 80) wk] compared with FS [median (95% CI): 21 (16, 50) wk]. The FS/NE study interventions had a median (95% CI) duration of 32 (24, 54) wk. With a median duration (95% CI) of 48 (26, 54) wk, interventions directed at the youngest age group (6–11 mo; $n = 25$; 44.6%) were generally longer than those conducted among older children. Among 12–23-mo-olds, the median (95% CI) duration was 26 (15, 57) wk, and among 24–59-mo-olds, it was 24 (14, 54) wk.

Author-stated study objective.
Studies were fairly evenly divided across categories: 25.0% were classified as "wasting-focused," 33.9% as stunting-focused," and 41.1% as "wasting and stunting-focused."

Nutritional status at baseline.
Nine studies (16.1%) targeted moderately wasted children, 28 (50.0%) included some moderately wasted children, and 19 (33.9%) excluded moderately wasted children.

Food security.
Most studies (44 of 56; 78.5%) were conducted in countries with serious or very serious food insecurity per Global Hunger Index classification (Supplemental Table 7). Ten studies were conducted in countries with moderate food insecurity levels, and 2 studies were conducted in food-secure countries.

Assessment of growth by study design and type
Supplemental Table 6 reports the anthropometric measurement frequency and growth measures for all included studies.

TABLE 1 Study duration, frequency of anthropometric assessments, and reported measures by intervention type and predominant age of beneficiary[1]

		Frequency of anthropometric assessments		Reported measures and growth standards							
	Intervention duration, median (95% CI), wk	Number (SE) of anthropometric assessments	Estimated mean (SE) time between measurements, wk	Reported mean WHZ pre-post intervention, *n* (%)	Reported mean HAZ or LAZ, *n* (%)	Reported MUAC, *n* (%)	Reported recovery from MAM percentage, *n* (%)	Report growth velocity, *n* (%)	Report wasting prevalence, *n* (%)	Report wasting incidence, *n* (%)	Used WHO Growth Standard, *n* (%)
Intervention type											
FS ($n = 21$)	24 (16, 48)	4.9 (0.5)	11.3 (1.7)	17 (81.0)	21 (100)	13 (61.9)	4 (19.1)	0 (0.0)	12 (57.1)	6 (28.6)	17 (81.0)
FS/NE ($n = 16$)	30 (20, 52)	5.9 (1.1)	25.8 (10.8)	11 (68.8)	16 (100)	7 (43.8)	8 (50.0)	6 (37.5)	10 (62.5)	4 (25.0)	12 (75.0)
NE ($n = 19$)	52 (25, 78)	4.1 (0.6)	36.3 (12.0)	15 (79.0)	19 (100)	5 (26.3)	4 (21.1)	1 (5.3)	9 (47.4)	1 (5.3)	13 (68.4)
All studies ($n = 56$)	32 (24, 48)	4.9 (0.4)	23.9 (5.2)	43 (76.8)	56 (100)	25 (44.6)	16 (28.6)	7 (12.5)	31 (55.4)	11 (19.6)	42 (75.0)
Predominant age of beneficiary at enrollment											
6–11 mo ($n = 25$)	48 (26, 52)	4.9 (0.6)	15.5 (2.0)	20 (80.0)	25 (100)	10 (40)	4 (16.0)	1 (4.0)	15 (60.0)	5 (20.0)	18 (72.0)
12–23 mo ($n = 14$)	26 (15, 55)	5.0 (0.8)	35.3 (16.5)	11 (78.6)	14 (100)	8 (57.1)	7 (50.0)	3 (21.4)	10 (71.4)	3 (21.4)	11 (78.6)
24–59 mo ($n = 17$)	24 (14, 52)	4.8 (0.9)	27.1 (10.3)	12 (70.6)	17 (100)	7.0 (41.2)	5 (29.4)	3 (17.7)	6 (35.3)	3 (17.7)	13 (76.5)
Author-stated study purpose											
Wasting-focused ($n = 14$)	12 (12, 17)	6.5 (1.1)	5.9 (1.4)	11 (78.6)	14 (100)	10 (74.1)	7 (50.0)	6 (42.9)	10 (78.6)	7 (50)	11.0 (78.6)
Stunting-focused ($n = 19$)	52 (41, 58)	5.0 (0.7)	37.4 (13.0)	15 (79)	19 (100)	7 (36.8)	1 (5.3)	0 (0.0)	10 (52.6)	3 (15.8)	16.0 (84.2)
Wasting- and stunting-focused ($n = 23$)	32 (24, 52)	3.7 (0.4)	23.8 (6.0)	17 (73.9)	23 (100)	7 (30.4)	8 (34.8)	1 (4.4)	13 (56.5)	1.0 (4.3)	16.0 (69.6)
Nutritional status at baseline											
Targeted children with $-3 > \text{WHZ} < 2$ ($n = 9$)	12 (12, 23)	7.2 (1.6)	6.4 (2.7)	6 (66.7)	9 (100)	7 (77.8)	6 (66.7)	5 (55.9)	3 (33.3)	3 (33.3)	5 (55.5)
Included children with WHZ < -2 ($n = 28$)	36 (24, 52)	4.3 (0.4)	25.5 (7.0)	22 (78.6)	28 (100)	9 (32.4)	8 (28.6)	1 (3.6)	15 (64.3)	3 (10.7)	22 (78.6)
Excluded children with WHZ < -2 ($n = 19$)	48 (25, 52)	4.7 (0.7)	30.0 (11.3)	15 (79.0)	19 (100)	8 (42.1)	2 (10.5)	1 (5.3)	9 (47.4)	5 (26.3)	16 (84.2)

[1]FS, food supplementation; HAZ, height-for-age *z* score; LAZ, length-for-age *z* score; MAM, moderate acute malnutrition; MUAC, midupper arm circumference; NE, nutrition education; NE/FS, nutrition education and food supplementation; WHZ, weight-for-height *z* score.

Metric of growth assessment.

The most common measurement reported in 44 (76.8%) studies was mean WHZ assessed pre/postintervention. Seven studies reported growth velocity (grams per kilogram per day), 16 reported percentage of recovery from MAM, and 24 reported MUAC. FS studies were more likely to report MUAC (61.9%) than both NE (26.3%) and FS/NE (43.8%) studies.

The metric used to assess change in wasting varied by the author-stated study objective. Compared with stunting-focused studies, fewer wasting-focused studies reported pre-post WHZ. MUAC measures were more common in wasting-focused studies (71.4%) than in stunting-focused (36.8%) or wasting- and stunting-focused (30.4%) studies. Percentage of recovery from MAM and growth velocity were only included in wasting-focused studies.

Over half (60.7%) of all studies reported prevalence of wasting at baseline and endline. The proportion of studies that reported wasting prevalence was similar across author-stated study objective groups. Only 11 of 56 (19.6%) of studies reported incident wasting. Wasting-focused studies were more likely to measure incident wasting (50.0%) than stunting-focused (15.8%) or wasting- and stunting-focused (4.3%) studies. Studies in the general population (10.7%) were less likely to report wasting incidence than those secondary prevention studies that targeted moderate wasting (33.3%) or studies that excluded children with moderate wasting (26.3%).

The WHO 2006 standard was applied in 42 interventions, whereas the NCHS reference was used in 14. Among the 44 studies published in 2008 or later, only 3 used the NCHS reference (28, 63, 66).

Frequency of growth measures.

Studies assessed growth outcomes a mean (95% CI) of 4.9 (4.1, 5.8) times per study. The mean (95% CI) time between anthropometric assessments was 23.9 (13.4, 34.4) wk, whereas the median (95% CI) time between assessments was 12.0 (10.4, 13.8) wk. FS studies measured anthropometry more frequently, making assessments every 11.3 (7.8, 14.8) wk compared with NE studies, which measured these outcomes every 36.3 (8.8, 62.1) wk ($P = 0.036$). The frequency of growth assessments was not different between FS and FS/NE studies that had a mean assessment frequency (95% CI) of 25.8 (2.8, 48.8) wk ($P = 0.138$). Only 5 studies followed and measured children after the intervention period ended (52, 56, 61, 63, 75).

Given the importance of measurement frequency for assessing the incidence of wasting cases (83), we further examined the frequency of assessment by several other factors.

Growth assessment by age at enrollment.

The total number of anthropometric assessments was similar across these 3 age groups. However, the mean (SE) time between measurements was longer among the 12–23 mo group at 35.3 (16.5) wk, compared with every 27.1 (10.3) wk and 15.5 (2.0) wk and in the 6–11- and 24–59-mo groups, respectively.

Growth assessment by status author-stated purpose.

Studies that were described by authors as "wasting-focused" were shorter, with a median (95% CI) of 12 (12, 17) wk, than wasting- and stunting-focused studies, with a median (95% CI) of 32 (24, 54) wk, and stunting-focused interventions, with a median (95% CI) of 52 (43, 60) wk. The number of total measures was similar across all study types: wasting-focused studies reported measurements a mean (95% CI) of 6.5 (4.2, 8.8) times, compared with stunting, with a mean (95% CI) of 5.0 (3.5, 6.5) times, and wasting- and stunting-focused, with a mean (95% CI) of 3.7 (3.0, 4.7) times.

Growth assessment by nutritional status at baseline.

Interventions that targeted children with wasting were shorter in duration, with a median (95% CI) of 12 (12, 23) wk, than those that either included children with wasting [median (95% CI): 36 (24, 54) wk] or excluded children with wasting [median (95% CI): 48 (25, 54) wk]. The number of total measures was higher in studies that targeted children with MAM. Studies that targeted children with MAM measured growth a mean (95% CI) of 7.2 (3.4, 11.0) times, compared with those that included [mean (95% CI): 4.3 (3.4, 5.2) times] or excluded [mean (95% CI): 4.7 (3.4, 6.1) times] children with wasting.

Dietary intake.

Dietary data were reported in 36 of the studies (64.2%). The most common measurement method was a 24-h recall, whereas the most common outcomes were the IYCF (infant and young child feeding practices) indicators such as minimum dietary diversity and meal frequency.

Impact on wasting, by intervention type and design factors

All 56 studies reported at least 1 of the 5 wasting-related outcomes at both baseline and endline, of which 25 (44.6%) found a statistically significant impact. Eighteen of the 40 RCTs (45%) and 7 of the 10 (70%) nonrandomized studies reported a positive impact on wasting-related outcomes.

Table 2 summarizes the number of studies that reported an impact on wasting by a range of intervention and study design factors. These are presented briefly below.

When the frequency of anthropometric assessments was classified as more frequent ($\leq$8 wk apart) or less frequent ($\geq$9 wk apart), the proportion of studies with a significant impact on wasting was similar between the 2 groups: 13 of 28 (46.4%) of studies with less frequent measures and 12 of 28 (42.9%) of studies with more frequent anthropometric assessments reported an impact on wasting ($P = 0.571$).

There were studies across all forms of FS ($n = 37$) that reported a significant impact on wasting (Table 2), and the differences in the proportions reporting a positive impact

TABLE 2 Intervention impact by intervention design factors and population factors[1]

	Number of studies	Statistically significant impact on wasting-related outcome, n (%)
	56 (total)	25 (44.6)
Intervention design factors		
Intervention type		
FS	21	7 (33.3)
FS/NE	16	7 (43.8)
NE	19	11 (61.1)
FS subtype ($n = 37$)		
Fortified complementary food	11	3 (27.3)
Household or child-specific staple foods	8	3 (37.5)
Small-quantity lipid-based nutrient supplements	6	4 (66.6)
Ready-to-use supplemental foods for MAM treatment	12	4 (33.3)
Supplement dose		
Low (<30% daily energy)	17	6 (35.3)
Medium (30–59% daily energy)	12	3 (25.0)
High (>60% daily energy)	8	4 (50.0)
Author-stated study purpose		
Wasting-focused	14	5 (35.7)
Stunting-focused	19	4 (21.1)
Wasting- and stunting-focused	23	16 (69.6)
Age of beneficiary at enrollment		
6–11 mo	25	11 (44.0)
12–23 mo	14	6 (42.9)
24–59 mo	17	8 (47.1)
Intervention duration		
Short duration (≤12 wk)	8	4 (50.0)
Medium duration (13–24 wk)	16	6 (37.5)
Long duration (≥25 wk)	32	15 (46.9)
Population factors		
Geographic region		
Sub-Saharan Africa	32	13 (40.6)
South Asia	10	5 (50.0)
East Asia/Pacific	5	2 (40.0)
Latin America/Caribbean	7	3 (42.9)
Middle East/North Africa	2	2 (100)
Nutritional status at baseline		
Targeted moderately wasted children	9 (4 FS, 5 FS/NE, 0 NE)	3 (33.3)
General population (included moderately wasted children)	28 (9 FS, 9 FS/NE, 10 NE)	16 (57.1)
Excluded moderately wasted children	19 (8 FS, 6 FS/NE, 5 NE)	6 (31.6)

[1]FS, food supplementation; MAM, moderate acute malnutrition; NE, nutrition education; NE/FS, nutrition education and food supplementation.

were nonsignificant by food supplement type ($P = 0.432$). FS intervention studies that provided SQ-LNSs were most likely to show an impact on 1 or more wasting outcomes (66.6%) compared with RUSFs for MAM treatment (33.3%), fortified complementary foods (27.3%), or household or child-specific staple foods (37.5%). Studies conducted among the general child population without SAM (57.1%) reported significant impacts on wasting more often than those that targeted (33%) or excluded (33%) moderately wasted children ($P = 0.170$).

Significant impacts on wasting were seen across all food supplement dose categories. Among the 37 studies that included FS, significant effects on wasting outcomes were more common in high-dose (50.0%) than low-dose (35.3%) and medium-dose (25.0%) studies ($P = 0.079$).

Based on the author-stated study purpose, a substantial number of studies across all 3 categories reported a positive impact on wasting. However, a nonsignificantly smaller proportion of stunting-focused studies (21.0%) did so compared with wasting-focused (35.7%) and wasting- and stunting-focused (69.6%) studies ($P = 0.295$).

The proportion of studies with a positive impact on wasting-related outcomes was highest in the groups that included wasted children (57.1%) compared with those that targeted (33.3%) or excluded (31.6%) wasted children, although these differences were nonsignificant ($P = 0.170$). Most studies with a positive impact on wasting (21 of 26; 80.8%) were conducted in countries with "serious" or "very serious" food insecurity.

Discussion

Our review identified a range of studies including FS, NE, and FS/NE interventions and confirmed that all 3 intervention types can impact wasting-related outcomes. While it is not possible to identify a set of optimal intervention characteristics given the diversity in both intervention and study designs, we did identify several ways in which both the intervention design and the orientation of studies may influence whether a study will detect wasting outcomes. It is notable that interventions with a combined focus on "wasting and stunting" had the highest proportion of studies with a positive impact on wasting, suggesting that a holistic view of FS and NE interventions that includes but is not limited to wasting is effective for wasting prevention. While these results shed light into promising subcategories to inform the design and targeting of wasting prevention, highlighting interventions for investment is challenging since each study represents a different combination of these attributes along with other study design factors, which collectively influence the overall impact. Coherence is needed in the intervention design and evaluation methods to move towards comparability and pooled estimates of impacts for different types of wasting-prevention interventions. This review builds on the ENN's recent work that identified FS interventions as having the most robust evidence base for wasting prevention among children under 5 y. We extend this work to highlight specific design features of FS and NE interventions that may influence the ability to detect an impact on wasting prevention (6).

Moving forward, how could coherence around measuring wasting impacts be achieved? First, studies should report on a consistent set of metrics. Most studies report mean change in WHZ using the WHO 2006 Growth Standards, and this should continue. However, relatively few NE studies included MUAC, particularly among those carried out before 2009, which is consistent with the more recent focus on the scale-up of community management of acute malnutrition. Given the feasibility, low cost, and sensitivity to detect children at risk for MAM and SAM, MUAC is more widely used in intervention settings (84). To target interventions to those who are both wasted and stunted and at the highest risk of mortality, MUAC may be more efficient for selecting children in need of treatment than WHZ and HAZ and should be included in studies to help facilitate the application of findings to practice (12). Current guidance suggests that additional metrics to assess relapse to moderate or severe wasting following treatment will add critical information on the persistence of wasting treatment as well as wasting incidence (85). A lack of postintervention follow-up data seriously limits the ability to detect sustained effects on any growth outcome.

Ideally, studies should measure anthropometry at a frequency that can capture incident wasting changes using prospective cohort designs. While the optimal timing of measurements to capture incident wasting still needs to be determined, wasting onset and recovery can occur quickly. Further, children may relapse to become wasted multiple times within a year, and wasting can predict the onset of rapid linear growth retardation (13, 86). We observed a marked difference in the frequency of assessments by study type: compared with wasting-focused studies, studies that sought to address both wasting and stunting had a 4-fold longer duration between measurements, whereas stunting-focused studies had a nearly 6-fold longer duration. Three months between measures was the mean in FS/NE studies, which may be too long to observe incident wasting effects. More frequent anthropometric assessments would help capture incident effects and are therefore recommended to improve FS/NE study designs. However, rigorous, large-scale effectiveness evaluations are expensive, and recommendations to increase intervention duration, the number of study contacts, and types of measures will add to the cost.

Most studies reported wasting-related metrics, but most did not directly (via measurement) or indirectly (via modeling) assess the prevalence of wasting in the general population with comparable age groups at baseline and endline. Studies that included children with MAM—those incorporating secondary prevention of wasting as a goal—commonly observed significant effects on wasting. Given the wide range of wasting prevention and treatment approaches, studies are needed that report on the optimal duration to achieve population-level impacts.

We recommend that MAM treatment studies measure or model impact on wasting prevalence in the general population, not only among those who were given treatment, and continue for a longer duration so the population-level preventative effect can be captured. This would enable accurate detection of whether wasting prevention interventions can be helpful strategies for making progress on global wasting targets through providing population-level estimates before and after targeted strategies for wasting prevention. This strategy will also help provide evidence to understand if these interventions have a true population-level impact. This approach was not performed in any of the studies in our review. In some cases, modeling methods may estimate the population-level impact and relate to the WHA target.

Another area for study design improvement is in measuring contextual factors that help to interpret intervention outcomes, such as local food security conditions, seasonality, and population-level wasting and stunting rates. Over half of the global burden of child wasting occurs in South Asia but fewer than 20% of the identified evaluations in this review were conducted in the region (4, 87). Our review did not identify any multicountry or multiregion studies that assessed wasting prevention. Given the complex etiology of both wasting and stunting, multisetting trials can help identify determinants and contextual factors that may influence intervention outcomes.

Studies should include population-specific and local food insecurity measures as the national-level classifications we used do not necessarily reflect the specific study area's food security status. There are validated, established scales for measuring household food insecurity that would provide a context-specific understanding of this critical determinant, such as the Household Hunger Scale and the Coping Strategies Index (88, 89). The best food security measure should ideally be validated in the study context and should be well-designed to address program goals for monitoring

(90). Measuring dietary intake offers essential and potentially actionable data on the impact pathway of interventions, such as nutrition education on dietary diversity, a strong predictor of micronutrient status (91). While not definitive, our review points to subgroups of interventions that may have a greater likelihood of wasting prevention. For example, while some studies from each FS subtype demonstrated positive impacts on wasting, SQ-LNS studies showed the highest proportion of positive outcomes among FS studies. Not surprisingly, "high dose" studies providing more than 60% of daily energy through FS were the most likely category of FS studies to report an impact on wasting. However, FS is not needed in some contexts to achieve impact on wasting. A substantial proportion of NE studies also reported a positive effect on wasting. These findings of multiple positive strategies for wasting prevention are consistent with the recent ENN report. Notably, the ENN report concludes that, while FS studies have the most robust and fastest-growing evidence base, more information is needed about the cost-effectiveness and sustainability of these interventions (6). Implementing the optimal wasting prevention approach will involve a combination of effectiveness, cost, characteristics of the implementation environment, and local contextual factors such as the baseline prevalence of wasting in a region (92).

A recent project uses a multisetting approach to evaluate wasting prevention interventions. The Innovative Approaches for the Prevention of Childhood Malnutrition (PROMIS) project, a set of cluster-randomized studies conducted in Burkina Faso, Mali, and Senegal, provides evidence for integrated prevention and treatment programs (93). The PROMIS studies evaluated a novel intervention approach that combined SQ-LNSs, behavior change, and improved screening coverage and treatment for acute malnutrition. Several of our key recommendations are reflected in the PROMIS study design, including having both wasting-focused and stunting-focused aims and including the general population, not just those malnourished at baseline. Screening coverage improved in both Burkina Faso and Mali, but positive impacts on wasting incidence were observed only in Mali (94, 95). This recent approach highlights how the treatment of moderate wasting can be one type of prevention to severe wasting, a strategy that reflects wasting etiology and appears to be cost-effective. A recent research prioritization exercise by the Wasting Prevention Working Group identified earlier detection of infants and young children at risk for wasting and integration of leveraging existing interventions in the health system for wasting prevention (96).

To achieve the ambitious WHA wasting targets, nutrition actors need to implement a combination of primary and secondary prevention strategies that bridge historically divided organizations. This review highlights that the interventions implemented by these "camps" have some important differences in evaluation designs. For example, we found a shorter duration for studies that target wasted children at baseline than studies that did not. These treatment trials for MAM are less likely to report WHZ and more likely to report MUAC, growth velocity, and recovery time than studies that exclude wasted children or that were conducted in the general population (i.e., included but did not target wasted children). Stunting-focused studies had a longer duration and measured wasting outcomes less frequently than those focused on wasting or both outcomes—and were less likely to report incident wasting than other types.

Strengths and limitations

Our study's strengths include in-depth analysis of study design factors, such as the author-stated objectives and frequency of anthropometric assessment, that were not evaluated in prior reviews.

Several factors limited our review. First, we did not assess the measurement of acute illness by studies, which is a determinant in the etiology of wasting. Second, our study definition of wasting is consistent with the concept of "acute malnutrition" used in humanitarian and clinical contexts but does not include edema as a criterion. We excluded this component of wasting in our definition because edema was infrequently reported by studies and would have substantially limited the number of included studies, especially from those that were classified as stunting focused. Third, we used a liberal classification for categorizing wasting- and stunting-focused studies. While trials that sought to prevent malnutrition suggest a goal of simultaneous focus on preventing wasting and stunting, some of these studies were not intentionally designed by authors to impact both outcomes. This selection decision may have underestimated the true proportion of impact on wasting from this category since interventions with a more intentional design to address both outcomes would be arguably more likely to influence wasting. Fourth, the large heterogeneity of study types limits a recommendation for a specific best strategy for wasting prevention.

Conclusions

With most countries off-track to meet the 2025 target for reducing the wasting prevalence and increasing treatment access (97), the global community urgently needs to identify and scale up evidence-based wasting prevention strategies. This review demonstrates the diversity—in terms of both intervention and research design—of the current evidence base for FS and NE on wasting prevention. This variation is productive as we must continue to promote multiple intervention strategies tailored to specific contexts. However, this diversity makes it challenging to develop a universal intervention strategy to reduce child wasting and stunting.

Based on the findings from this review and current global discourse on bridging the gap between wasting and stunting, we recommend that efforts be made to design, fund, and implement studies appropriately designed to evaluate wasting and stunting outcomes over time. In response to global targets to reduce wasting in high-burden countries, the WHO recently coordinated and promoted a Global

Action Plan on child wasting, which emphasizes the need for improved efforts in both wasting prevention and treatment, and clarifies the complementary roles of FAO, United Nations High Commissioner for Refugees, WHO, UNICEF, and the World Food Program for addressing wasting (34). This strategy reflects the type of harmonization needed to bridge divergent technical communities by emphasizing the need for coordinated wasting treatment and prevention efforts. As such, this action plan provides an umbrella under which the design features identified in this review can be incorporated.

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