

BMJ Open Making the most of existing research: an evidence gap map of the effects of food systems interventions in low-income and middle-income countries

Ingunn Gilje Storhaug ¹, Charlotte Lane ², Nick Moore,^{1,3} Mark Engelbert ¹, Thalia Morrow Sparling ⁴, Birte Snilstveit¹

To cite: Storhaug IG, Lane C, Moore N, *et al.* 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. doi:10.1136/bmjopen-2021-055062

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-055062>).

Received 13 July 2021
Accepted 08 May 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹International Initiative for Impact Evaluation, London, UK

²International Initiative for Impact Evaluation, Washington, District of Columbia, USA

³Integrity, London, UK

⁴Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA), London School of Hygiene and Tropical Medicine Faculty of Epidemiology and Population Health, London, UK

Correspondence to

Ingunn Gilje Storhaug;
istorhaug@3ieimpact.org

ABSTRACT

Objective Identify and describe the available evidence on the effects food systems interventions on food security and nutrition outcomes in low-income and middle-income countries.

Methods An adapted version of the high-level panel of experts food systems framework defined the interventions and outcomes included studies. Included study designs were experimental and quasi-experimental quantitative impact evaluations and systematic reviews. Following standards for evidence gap maps developed by 3ie, a systematic search of 17 academic databases and 31 sector-specific repositories in May 2020 identified articles for inclusion. Trained consultants screened titles/abstracts, then full texts of identified articles. Studies meeting eligibility criteria had meta-data systematically extracted and were descriptively analysed. Systematic reviews were critically appraised.

Results The map includes 1838 impact evaluations and 178 systematic reviews. The most common interventions, with over 100 impact evaluations and 20 systematic reviews each, were: provision of supplements, fortification, nutrition classes, direct provision of foods and peer support/counselling. Few studies addressed national-level interventions or women's empowerment. The most common final outcomes were: anthropometry, micronutrient status, and diet quality and adequacy. Intermediate outcomes were less studied.

Most evaluations were conducted in sub-Saharan Africa (33%) or South Asia (20%). Many studies occurred in lower-middle-income countries (43%); few (7%) were in fragile countries. Among studies in a specific age group, infants were most frequently included (19%); 14% of these also considered mothers.

Few evaluations considered qualitative or cost analysis; 75% used randomisation as the main identification strategy.

Discussion The uneven distribution of research means that some interventions have established impacts while other interventions, often affecting large populations, are underevaluated. Areas for future research include the evaluation of national level policies, evaluation of efforts to support women's empowerment within the food system, and the synthesis of dietary quality. Quasi-experimental approaches should be adopted to evaluate difficult to randomise interventions.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Broad scope including intermediate outcomes.
- ⇒ Protocol developed and implemented in a 9-month period drawing on latest advances in synthesis project management.
- ⇒ Not able to carry out forward citation checking due to high volume of included studies.
- ⇒ Only included studies published in English; however, research has found that synthesis results are not affected when the effect sizes from non-English studies are removed from the analysis.³⁰

INTRODUCTION

The triple burden of malnutrition refers to the concurrent presence of micronutrient deficiency, insufficient energy intake (ie, underweight) and excessive energy intake (ie, overweight and obesity) in a population.¹ Between 720 and 811 million people experience hunger and 2.37 billion lack key vitamins and minerals in their diets.² Furthermore, worldwide obesity nearly tripled between 1975 and 2014 with over 1.9 billion adults classed as overweight in 2016, of whom 650 million were obese.^{3,4} The prevalence of the triple burden of malnutrition is highest in low-income and middle-income countries (L&MICs), and especially, in fragile and conflict affected countries.⁵

The realities and challenges of the triple burden of malnutrition refocused the international community on food systems. Governments are expanding nutrition targets and increasing spending on nutrition-sensitive interventions, as these have the potential to simultaneously address multiple forms of malnutrition.⁵ The number of interventions implemented and evaluations of these interventions increased substantially in recent years.^{6–8}

As a result, there is an extensive, heterogeneous and rapidly growing body of literature evaluating the effects of food systems interventions on food security and nutrition in L&MICs. There have been several efforts to synthesise portions of this literature to support evidence-informed decision making. Most of the empirical focus has been on nutrition-sensitive agriculture^{6 9–11}; although, there is growing research on food policy and food systems in general,^{12–14} and development of methods used to study these complex relationships.^{5 15 16} However, there is a need for a broad, comprehensive overview of the evidence on all types of food systems interventions and their impacts on nutrition and food security.

The evidence gap map (EGM) presented here provides an overview of the existing literature and identifies evidence gaps to address the need for such a comprehensive overview. EGMs have the twin objectives of making existing evidence more easily available and informing strategic approaches to address extant evidence gaps.^{17 18} Such work assists stakeholders in identifying high-quality evidence and key areas for future research investments. This paper describes the methods and results of the mapping exercise and presents the results related to the distribution of the evidence base. 3ie's interactive online platform displays the final EGM.¹⁹ It uses a matrix format to reflect the distribution of evidence relating interventions within the food system (y-axis) to food security and nutrition outcomes (x-axis).

METHODS

We followed standards and methods established by 3ie in this EGM.^{17 18} In doing so, we used a systematic approach to identify, describe and map existing impact evaluations (IEs) and systematic reviews (SRs) assessing food systems interventions to improve food security and nutrition outcomes in L&MICs. The EGM was not registered, but the protocol was published on 3ie's Development Evidence Portal.¹⁹

Defining the intervention-outcome framework

Interventions:

We adapted the high-level panel of experts (HLPE) framework from 201²⁰ (extended by the International Food Policy Research Institute (IFPRI)²¹) to define the food system and categorise relevant interventions. The framework includes three domains: the food supply chain, the food environment and consumer behaviour (online supplemental appendix A). They reflect groups of actions and interventions, not a sequential flow of activities leading to one another.

The primary difference between the HLPE/IFPRI framework and our adaptation is that each intervention was assigned to only one domain to facilitate categorisation and maintain visual clarity (figure 1). Each domain was disaggregated into specific intervention groups (table 1). The HLPE/IFPRI framework outlines four activities within the food supply chain: production,

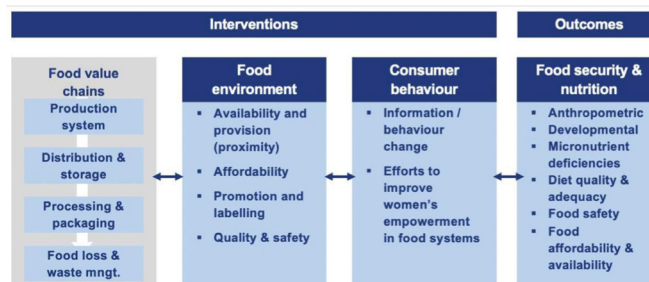


Figure 1 EGM framework, adapted from the HLPE/IFPRI framework. EGM, evidence gap map; HLPE, high-level panel of experts; IFPRI, International Food Policy Research Institute.

storage and distribution, processing and packaging, and food loss and waste management. The food environment domain includes interventions that engage with the physical, economic, political and sociocultural surroundings, opportunities and conditions that create, prompt and shape dietary preferences and choices and nutritional status.^{21–23} Finally, consumer behaviour interventions focus on individual preferences related to consumption, food prices and income available for food.^{21 22} The HLPE/IFPRI framework outlines five main drivers of change in (global) food systems: biophysical and environmental; innovation, technology and infrastructure; political and economic; sociocultural and demographics.^{20 21} These drivers are often exogenous factors in our interventions of interest and are excluded from the scope of this EGM.

Outcomes:

All measures of food security and nutrition were included as final outcomes. Intermediate outcomes, measuring steps along the theory of change such as income changes or food loss, were also included (table 2).

Study inclusion criteria

We included studies in L&MICs defined by the World Bank classification during the year of publication. Studies in populations with specific health conditions, such as HIV, anaemia or severe malnutrition, were excluded as the nutritional needs of these populations are unique. Included interventions and outcomes are defined above. Included study designs were quasi-experimental or experimental IEs and SRs of studies employing these methods (online supplemental appendix B). Only studies published in or after year 2000 and English language were included. Both ongoing and completed studies were included.

Search strategy

We systematically searched for English-language reports in 17 academic bibliographic databases in May 2020: MEDLINE, EMBASE, EconLit, Oxfam Policy, Repec, World Bank eLibrary, Cochrane Library, Agris, CINAHL, CAB Global Health, CAB Abstracts, Agricola, PsycINFO, Africa-Wide Information, Academic Search Complete, Scopus and WHO Global Index Medicus. See online supplemental appendix C for full search strings. We used

Table 1 Interventions included in the EGM framework

Domain	Intervention category	Intervention	
Food supply chain	Production system	Provision of improved water access and management systems	
		Provision of free or reduced-cost access to improved seed varieties	
		Provision of free or reduced-cost access to fertiliser	
		Provision of free or reduced-cost access to pesticides/herbicides	
		Provision of free or reduced-cost access to livestock	
		Provision of free or reduced-cost access to other/unspecified agricultural inputs	
		Provision of mechanical equipment	
		Education/information—farmer field schools	
		Education/information—agricultural extension programmes	
		Education/information—information guidance	
		Education/information—other educational programmes	
		Other efforts to improve the production system—insurance	
		Other efforts to improve the production system—contract farming	
		Other efforts to improve the production system—market support	
		Other efforts to improve the production system—land markets and management	
		Other efforts to improve the production system—agricultural credit/savings	
		Other efforts to improve the production system—other	
		Distribution and storage	Support for creating storage structure at farms
	Trade regulations		
	Implementation of distribution centres		
	Improved transportation from farms to markets		
	Education regarding improved storage and distribution techniques		
	Cold chain initiatives		
	Processing and packaging	Fortification	
		Packaging	
		On farm, postharvest processing	
		Provision of good or services to support food processes of business models	
		Education regarding improved processing and packaging techniques	
	Food loss and waste management	Private food donation	
		Use of and education regarding the use of spoiled, near spoiled, or traditionally uneaten food	
		Composting	
	Food environment	Availability	Designations of space and zoning laws
			Direct provision of foods
Provision or use of supplements			
Affordability		Cash-for-food programmes	
		Governmental price manipulations (excluding tariffs)	
Promotion and labelling		Advertising regulations	
		Innovative store design	
		Labelling regulations	
Quality and safety		Food safety regulations	

Continued

Table 1 Continued

Domain	Intervention category	Intervention
Consumer behaviour	Efforts to increase women's decision-making power	Efforts to increase women's decision-making power
	Information/behaviour change communication	Peer support/counsellors
		Professional services (dietitians/ nurses)
		Community meetings
	Classes	
Healthy food social marketing campaigns	Healthy food social marketing campaigns	
Information/behaviour change communication	Door-to-door campaigns	

EGM, Evidence Gap Map.

terms for relevant interventions, study designs and publication year. To identify studies taking place in L&MICs, we applied the Cochrane Effective Practice and Organisation of Care Group 'LMIC Filters' 2020.

We completed a grey literature search of 31 sector specific databases and websites using basic search strings tailored to each database or website (online supplemental appendix C). We cross-checked all citations from included SRs for inclusion. We requested additional relevant literature from the advisory and policy stakeholder groups and through a blog post on the 3ie website that was promoted using social media; any studies identified before the end of September 2020 were also included.

Screening and data extraction procedure

After we removed duplicates, the research team screened titles and abstracts, followed by eligible full text reports, according to predefined criteria. Single screening with a safety-first approach was carried out; if the first reviewer was uncertain, she marked it for a second review.²⁴ Periodic meetings were held to discuss and resolve screening decisions for studies marked for a second opinion, for boundary decision examples, see online supplemental appendix D. Full-text reports were single screened using the safety-first approach (70%), with 30% double screening. The EPPI-Reviewer V.4 software's machine learning streamlined the process and efficiently removed clearly irrelevant studies.

All articles on the same intervention and population were linked to avoid over-representing interventions with multiple reports. For example, reports were linked when authors followed a group of participants over time, published multiple versions of the same study in different formats or updated an SR. Descriptive information was only included once for each group of linked publications. Therefore, the presented analysis is reported at the study level, rather than the publication level. However, if there was additional relevant data, such as outcomes, in the linked publications this was added to the record for the main study.

One person systematically extracted data and another person verified the data using a prespecified data extraction tool (online supplemental appendix E). General study characteristics, such as authors, publication date, study location, intervention type, outcomes reported and definition of outcome measures, population of interest and funders, were extracted. Methodological information, including the type of quantitative methods employed and whether any cost or cost-benefit analysis was conducted, was also extracted.

We critically appraised all included SRs using a standardised appraisal tool (online supplemental appendix F). We considered each review's search strategy, screening method, risk of bias assessment, data extraction and synthesis methods. SRs were rated as low, medium or high confidence, based on guidance provided in Snijlveit and colleagues.¹⁷ To ensure consistency in the quality appraisal process, a 5% sample of reviews was initially appraised by two researchers, then independently reconciled by an SR expert. Reviewers were provided with feedback. Subsequently, one person appraised each SR, and the SR expert independently reviewed all completed appraisals. IEs were not critically appraised due to timescale and resources.¹⁷

Developing the interactive EGM

All included studies are presented in an interactive graphic on 3ie's EGM platform.¹⁹ This matrix presents the food systems interventions as rows and the food security and nutrition outcomes as columns. Within the matrix, grey circles represent IEs. Coloured circles represent SRs. The SRs follow a traffic-light system to indicate confidence in their findings: green for high confidence, orange for medium, red for low. Blue circles are ongoing studies. The size of the bubble indicates the relative size of the evidence base for that intervention-outcome combination. The interactive aspect of the EGM allows users to filter the results based on key characteristics, such as study design, intervention country and age of the

Table 2 Outcomes in the EGM framework

Stage of theory of change	Outcome group	Outcome sub-group
Intermediate	Economic	Income
		Assets
		Output value
		Prices received for goods
		Other SES indicators
		Tax revenue
		Purchasing behaviour
	Agricultural	Water related
		Animal husbandry
		Plant/crop production
		Land related
		Quality of agricultural inputs
		Agricultural cooperatives
	Nutritional outcomes	Food nutrient content
		Caloric requirements
		Nutrient bioavailability
	Advertising and labelling	Exposure to advertisement
		Advertisement topics
		Accuracy of advertisement
	Food distribution	Import/export
		Movement of food
		Location of foods in stores
		Food distribution centres
	Environmental impacts of the food system	Climate impact
		Non-food waste produced
	Food loss	Time food remains unspoiled
		Food spoilage
		Food loss
	Intrinsic motivators	Consumer preferences
		Perceptions
		Knowledge
	Women's empowerment	Decision making
		Ownership
		Control of resources
		Self-esteem
		Time use
		Other women's empowerment outcome
	Regulations	Violations
		Fines
		Other regulation outcome
	Economic, social, and political stability	Economic, social, and political stability
	Time use	Time use
	Behaviour change	Behaviour change
	Other steps taken due to non-compliance	Other steps taken due to non-compliance

Continued

Table 2 Continued

Stage of theory of change	Outcome group	Outcome sub-group
Final	Anthropometric	Linear growth
		Weight
		Relative weight
		MUAC
		Birth outcomes
		Anthropometric other
	Developmental outcomes	Physical
		Other developmental outcomes
	Micronutrient status	Iron
		Iodine
		Vitamin A
		Zinc
		Other micronutrient status outcome
	Diet quality and adequacy	Breast feeding
		Dietary diversity
		Insufficient diet
		Micronutrient intake
		Other diet quality and adequacy
	Food safety	Food toxins
		Food borne illness
		Other food safety outcome
	Food affordability and availability	Food access
		Food availability and supply
		Affordability
		Food insecurity measures
		Food stressed households

EGM, evidence gap map; MUAC, mid-upper arm circumference; SES, socioeconomic status.

participants, thereby facilitating efficient, user-friendly identification of relevant evidence.

RESULTS

We identified 142 849 articles through the academic database search; we found an additional 1590 through the grey literature search (figure 2). Studies with high similarity that potentially could be duplicates were identified by EPPI Reviewer software. Identical studies were automatically assigned as duplicates and the rest of the studies were manually compared by consultants. After removing duplicates, 111 641 studies were screened using title and abstract, and 10 323 screened using full text. Finally, 2477 papers were included, which correspond to 2016 unique studies (1838 IEs and 178 SRs) (online supplemental appendix G).

The results show a significant growth in literature over time (figure 3). In 2000, there were 17 IEs and 0 SRs, while in 2020 there were a total of 1838 IEs and 178 SRs. Growth in the literature base was especially high for IEs

of food supply chain and consumer behaviour interventions. Half of the IEs were published between 2015 and 2019.

Characteristics of the evidence base

Interventions

There was an uneven distribution in the frequency with which interventions were evaluated. Certain nutrition-specific interventions were evaluated in over 100 IEs and 20 SRs: provision of supplements (SR 67; IE 369), fortification (SR 23; IE 245), direct provision of foods (SR 24; IE 205) and peer support and counselling in the consumer behaviour domain (SR 22; IE 130; figure 4).

Although at least one IE was identified for most of the interventions in the framework, we did not identify any IEs of interventions related to advertising regulations, food waste education or the packaging of food. Several intervention types had fewer than five evaluation studies: food safety regulations (1), cold chain initiatives (1), composting education (3), labelling regulations (3), door-to-door behaviour change communication campaigns

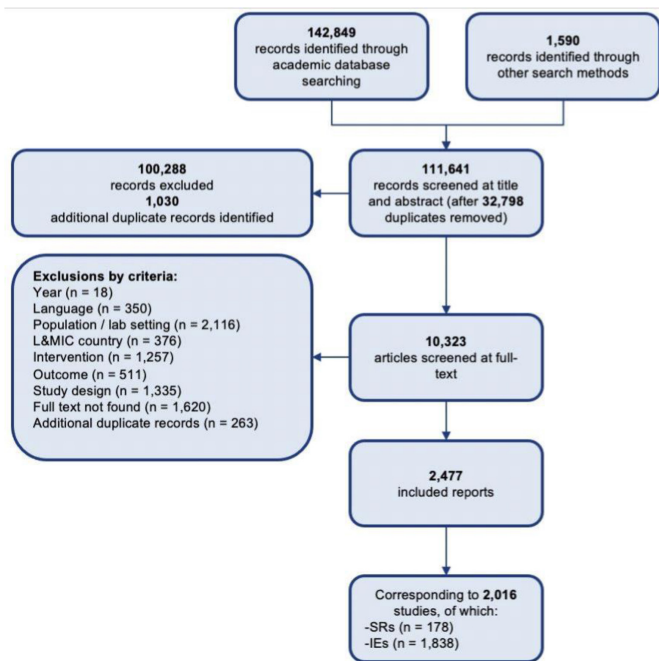


Figure 2 PRISMA diagram. IEs, impact evaluations; L&MIC, low-income and middle-income country; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SRs, systematic reviews.

(4), provision of goods and/or services to support food processing (4), on-farm and post-harvest processing (4); and access to pesticides (4).

Many interventions were associated with multiple IEs but only one or no SRs: agricultural extension (SR, 1; IE, 112), provision of free or reduced cost access to other/unspecified agricultural inputs (SR, 1; IE, 65), agricultural information provision (SR, 0; IE, 27), government manipulations of price (SR, 1; IE, 22) and agricultural insurance (SR, 1; IE, 22).

Some evaluations considered programmes with multiple components that spanned the interventions in the framework. Common groupings of interventions that were implemented and evaluated jointly in at least five IEs included: fortification and the direct provision of food, nutrition classes and healthy food marketing campaigns, and peer support and nutrition classes. In addition, 11 IEs considered multicomponent programmes with

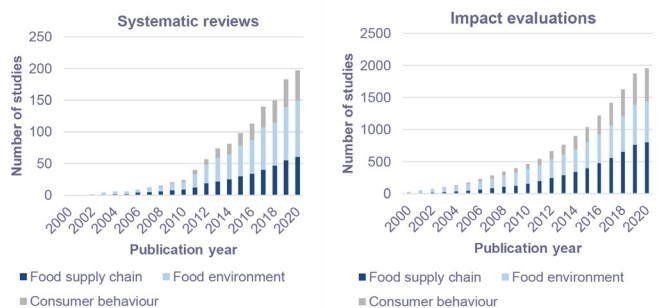


Figure 3 The cumulative distribution of included studies by year reflects a rapid growth in the literature base.

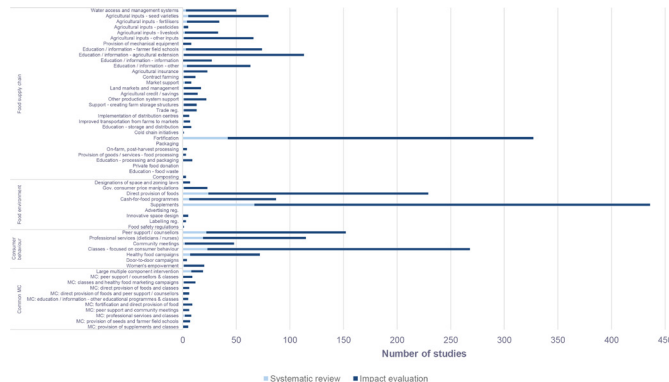


Figure 4 There is considerable heterogeneity in the frequency with which interventions are evaluated.

activities that fell into five or more interventions. Most of these included at least one food supply chain intervention. Eight SRs considered interventions that fell into five or more categories. Evaluations of common intervention packages are represented in the corresponding intervention package (eg, fortification and direct provision of food) while less common intervention packages are represented alongside each intervention component they implemented.

Outcomes

Almost three-quarters of studies evaluated at least one final outcome (SR 170; IE 1,353; figure 5). The most common final outcomes were anthropometry (SR 111; IE 671), micronutrient status (SR 78; IE 530) and diet quality and adequacy (SR 51; IE 555). The specific final outcomes that were most commonly examined in IEs were linear growth (433), weight (395) and relative weight (377).

Less than half of all included studies evaluated at least one intermediate outcome (SR 38; IE 848). The most common intermediate outcome categories were economic (SR 18; IE 350), agricultural (SR 13; IE 309) and intrinsic motivational outcomes (SR 16; IE 302). The specific intermediate outcomes that were most commonly examined were behaviour change (269), knowledge (238), income (225) and plant production (222).

The location of foods in stores, climate impact, non-food waste produced, import/export, agricultural cooperative performance, women's self-esteem, food spoilage

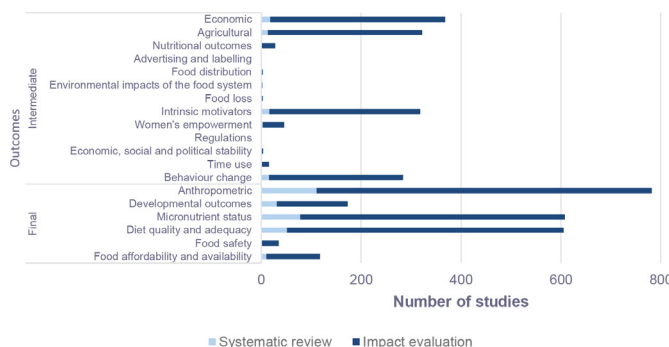


Figure 5 Research focuses on final outcomes without considering evidence along the theory of change.

or loss and economic, social and political stability were each considered in fewer than five studies.

Intervention-outcome combinations

The most common interventions (fortification, supplementation, the direct provision of food and nutrition classes) tended to be evaluated against iron status and various anthropometrics. Evaluations of the impacts of fortification considered iron status (170), linear growth (118), weight (100) and relative weight (78). Evaluations of supplementation programmes considered iron status (150), linear growth (125), weight (117) and relative weight (88). Evaluations of the direct provision of food also measured linear growth (81) and weight (74). While the evaluations of nutrition classes followed a similar pattern in outcome measurement as the others, they also tended to evaluate impacts on knowledge (91).

Other characteristics

IEs were primarily located in Sub-Saharan Africa (648), South Asia (367) and East Asia and the Pacific (324). IEs have been conducted in 25 (out of 36) fragile and conflict affected countries, as defined by the World Bank: mostly in sub-Saharan Africa (87) and the Middle East and North Africa (15).²⁵

IEs mostly included both sexes and populations with a wide age range; however, few considered those over 60 years old (59). The most commonly isolated age group was infants (497). Among studies evaluating infant outcomes, 14% (70) also looked at outcomes for mothers. About 25% (405) of included studies focused on women of reproductive age, most commonly pregnant women (214), postpartum (86) and lactating women (68). Over half of the interventions were conducted in rural areas. Most interventions were implemented locally (1401). Only 175 interventions were conducted and evaluated at the national or transnational level. The most common intervention setting was in the household (627). Over 1300 of the included studies did not specify the programme funding agency type or name.

About three-quarters of the IEs were randomised controlled trials (RCTs) (1390). Quasi-experimental studies mainly used statistical matching (242) and difference-in-differences (136). Just over 10% of the IEs adopted mixed methods approaches (186). There were 173 IEs that reported cost data or presented cost analysis in some form; 103 of these presented detailed budget information or attempted to make some comparison between the costs of a programme and the associated benefits.

In total, 95 of the reviews were appraised as low confidence, 46 were rated medium confidence and 34 were rated high confidence. The high confidence SRs were mostly published more recently, with 75% published in or after 2015 (26), compared with 60% of low and medium quality reviews published in or after 2015. Reviews rated with high confidence predominantly focused on synthesising the effects of the provision or use of supplements

on birth outcomes (10), iron or anaemia status (7) and the effect of fortification on iron status (6).

DISCUSSION

There is significant variation in the intensity of research by intervention and outcome type, in addition to other characteristics of interest such as setting, population and research method. The most well-researched interventions are nutrition-specific and include fortification, supplementation, the direct provision of food and nutrition classes. These interventions easily lend themselves to experimental IE designs. Positive impacts are consistently observed in short times scales using easily quantified metrics. Key evidence gaps included the evaluation of national level policies and efforts to support women's empowerment.

However, not all evidence gaps must be filled in our framework. In some cases, there is no theoretical reason to expect a relationship between an intervention and an outcome. In others, relationships may already have been (dis)proven. In both instances, additional research is not needed. For example, an evaluation of the impacts of breastfeeding peer-support groups on environmental outcomes is not theoretically sound. While the re-evaluation of certain interventions in new contexts may be necessary for external validity,²⁶ additional evaluations of the impacts of established interventions, such as fortification and supplementation interventions, are not necessarily beneficial unless they consider unique context. The generalisable impacts of these interventions were established as far back as the 2013 Lancet series on Maternal and Child Nutrition.²⁷ However, the evaluation of intervention-outcome relationships that are theoretically sound and not well established represent valuable practical contributions to the adoption of evidence supported interventions and policies.

Interventions which are difficult to evaluate due to long time frames (eg, land markets and management interventions), inability to randomise (eg, trade regulations or a national food policy) and difficulty in outcome measurement (eg, efforts to increase women's decision making) are not often evaluated. As a result, multicomponent interventions, national policies and agricultural interventions are understudied. There has been a shift in the rhetoric surrounding the evaluation of these interventions in recent years, but this is not yet apparent in the literature base.²⁸ The field of economics has taken on the challenge of identifying causal impacts in difficult contexts and developed new approaches for the evaluation of policy. In 2019 and 2021, the Nobel Prize in economics was awarded to researchers who developed innovative approaches to evaluate these difficult to study interventions.²⁹ There have been recent advancements in measuring benefits that happen far down the causal chain,¹⁵ which could be useful in considering the impacts of agricultural interventions on final outcomes. The synthetic control method is becoming more widely

accepted and allows for the evaluation of national policies (eg, labelling regulations) and other interventions with only one treatment group (eg, designations of space and zoning).¹⁶ Other approaches, such as adaptive trials, factorial designs and qualitative comparative analysis, for evaluating complex interventions are also being widely adopted.³⁰ Mixed-methods approaches for evaluating complexity-informed interventions are now well established.³¹ Complexity-informed evaluation designs may be of particular interest to evaluators in the food system seeking to untangle the web of dependencies and driving forces that act on the complex system.

Opportunities for future research

Mixed-methods approaches and cost evidence are under-represented in the literature base and could provide valuable insights to the field. In both cases, the higher costs of these evaluations can prevent them from being implemented. Differences between qualitative and quantitative research approaches can make cohesive mixed-methods evaluations challenging. Many 'mixed-methods' evaluations more closely resemble two separate evaluations (one quantitative and one qualitative) than a single, cohesive evaluation where each component is integrated within and builds off the other. One potential explanation for the limited cost evidence is that it is not, and should not be, conducted for evaluations that show null results. In addition, economic analysis can be challenging for studies that have heterogeneous effects (eg, only work for the poorest participants) as it is difficult to determine how participant selection could affect future cost-effectiveness.

We have identified several widely implemented interventions that have not been well studied and, therefore, provide promising opportunities for future research. Taxes on sugar-sweetened beverages and labelling regulations for unhealthy foods have not been evaluated for their impacts on weight, yet more than 40 countries (many L&MICs) have implemented these interventions to fight the obesity epidemic.^{32 33} Mexico has successfully evaluated the impacts of their tax on some intermediate outcomes, implying that it is possible to conduct these evaluations, even if challenging.^{34–40} Many stakeholders are supporting post-harvest processing initiatives, but have not yet established how far down the causal chain these interventions provide impact. Evaluations of these interventions have the potential to impact policies that affect the lives of millions of people worldwide. As the reach and resource requirements of an intervention increase, so does the ethical imperative to evaluate it.

The 400 studies that used 'other dietary quality and adequacy' outcomes represent an exciting gap for evidence synthesis. Often, these outcomes were the intakes of specific foods or food groups. While providing a wealth of information, the variation in outcomes makes drawing conclusions across studies challenging. By developing novel synthesis methods, the evidence across these different metrics could be used in new ways, reaching new

conclusions and adding rich detail to existing work. There have been some recent efforts to collate the available methods for measuring diet, such as the INDDX Project's Data4Diets tool and IMMANA's Innovative Metrics, Tools and Methods Evidence Gap Map.^{41 42} However, tools for synthesising across metrics are not yet available.

Traditionally, women are significant actors within food systems; however, relatively few studies examined interventions supporting women's decision-making or measured outcomes regarding women's empowerment. The studies we identified typically viewed women as cooks and mothers rather than independent actors within the food system. One-quarter of studies focused on women of reproductive age, especially perinatal women. More interventions including women as independent actors within the food system could lead to promising new avenues to address Sustainable Development Goals 2 and 5 at the same time.

Implications for research and policy

This review of the evidence base highlights some ways that policy and research could be adopted to make the most of limited resources. Efforts need to move away from re-evaluating the impacts of established interventions, such as fortification, supplementation, the direct provision of food, and nutrition classes, to considering scaling and sustainability through process evaluation and implementation research. Now that these interventions are widely adopted,^{43 44} we must consider how to implement them effectively at population level and in diverse contexts. Future studies could provide new insights by incorporating process evaluations, mixed-methods approaches and cost evidence to understand the mechanisms through which changes may occur and how limited resources can be best allocated.

The adoption of standardised measures of diet quality and adequacy would aid comparison and improve evidence synthesis efforts. Policy-makers, implementers and researchers must continue working together to develop measures of diet that balance ease of use, linkage to disease and standardisation across context in order to allow for the effective comparison of results. A new diet quality questionnaire may represent a productive way to systematised diet data; however, due to its novelty, it is unclear as of yet if it will be adopted.⁴⁵ Although measures of dietary diversity are relatively common (150 studies in our map), these metrics do not always capture sufficient information for detailed nutritional analysis.⁴⁶ A recent synthesis of metrics found that among 19 common dietary metrics, most were not validated against health outcomes and none were designed to measure the double burden of malnutrition.⁴⁷

Decision-makers and practitioners are encouraged to use relevant existing high-quality SRs as identified through this mapping exercise. They may consider funding studies in under-researched areas and exercise caution and consideration prior to implementing under-researched interventions. However, because only IEs and SRs of



IEs were included in this EGM, policy-makers should strengthen any decisions made using this map with the following information sources:

- ▶ Existing or planned research and interventions by government agencies and development partners.
- ▶ Other forms of evidence, including implementation research, process evaluations, qualitative studies and programming administrative and monitoring information.
- ▶ Existing theories of change and logical frameworks.
- ▶ Formative work and local knowledge.

Strengths and limitations of research

There are several strengths and limitations of this research. Strengths include having a broad scope, considering a range of intermediate outcomes and reviewing a vast amount of the food security and nutrition intervention literature. The review protocol was developed and implemented in a 9-month period drawing on the latest advances in synthesis project management. Another strength is that this map was commissioned by a global health donor (GIZ), indicating a direct policy and planning need in the field.

Due to the high volume of included studies, forward citation checking was beyond the scope of this EGM. Only studies published in English were included; however, research has found that synthesis results are not affected when the effect sizes from non-English studies are removed from the analysis.⁴⁸ This decision was meant to limit scope, but some studies may be omitted.

EGM do not provide synthesis of the findings of IEs, rather they are intended to make these more easily available. Users of the map are expected to reference the included articles to make this judgement based on their unique interests and needs or use the EGM as a starting point for syntheses that do make these judgements.

CONCLUSION

Addressing the triple burden of malnutrition in a way that also considers the interactions of the food system with the ongoing climate crisis is one of the major challenges of our era. Increasing, but still limited, funding is dedicated to addressing this challenge it is important that decisions about policies and programmes are informed by the best available evidence. This EGM highlights a significant and growing evidence base on food systems and nutrition that could and should be used to support effective strategies. Decision makers and practitioners can use the EGM to access existing evidence on interventions. Commissioners of research and researchers themselves can use the EGM findings to prioritise the funding and conduct of new research

The findings show that there is a substantial imbalance in evidence on this topic, with interventions that lend themselves to RCTs being studied more frequently than interventions that cannot be randomised or take a long time to realise results. Researchers and policy-makers may

consider the evaluation of national, widely implemented interventions with limited evidence and studies focusing on women as decision-makers. Future research should also assess the examine the intermediate steps in a theory of change.

Twitter Thalia Morrow Sparling @SparlingThalia

Contributors All authors contributed to study conception and design. ME created the search strategy and conducted the search. CL, NM, TMS, BS and IS contributed to the acquisition of data, analysis and interpretation of data. All authors drafted this manuscript or revised it for important content and provided the final approval of this version of the manuscript. IS is the guarantor.

Funding The research was funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Competing interests Funding for the submitted work by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) as a part of the K4N programme and IMMANA donated their time to contribute to the delivery of the EGM.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data can be made available on request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Ingunn Gilje Storhaug <http://orcid.org/0000-0003-4112-2197>

Charlotte Lane <http://orcid.org/0000-0002-7730-6687>

Mark Engelbert <http://orcid.org/0000-0002-3665-1257>

Thalia Morrow Sparling <http://orcid.org/0000-0002-8071-3232>

REFERENCES

- 1 UNICEF. *The State of the World's Children 2019. Children, food and nutrition: Growing well in a changing world*. New York: UNICEF, 2019.
- 2 FAO, IFAD, UNICEF, WFP and WHO. *The state of food security and nutrition in the world 2021. transforming food systems for food security, improved nutrition and affordable healthy diets for all*. Rome: FAO, 2021.
- 3 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet* 2017;390:2627–42.
- 4 WHO. Overweight and obesity – key facts, 2020. Available: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> [Accessed 11 Nov 2020].
- 5 Development Initiatives. *2020 global nutrition report: action on equity to end malnutrition*. Bristol, UK: Development initiatives, 2020.
- 6 Ruel MT, Quisumbing AR, Balagamwala M. Nutrition-sensitive agriculture: what have we learned so far? *Glob Food Sec* 2018;17:128–53.
- 7 Cliffer I, Masters WA, Trevino JA. Food systems and nutrition: emerging evidence and research opportunities. *Nutrition Innovation Lab* 2019 https://pdf.usaid.gov/pdf_docs/PA00W5W7.pdf

- 8 Fiorella KJ, Gavenus ER, Milner EM, *et al.* Evaluation of a social network intervention on child feeding practices and caregiver knowledge. *Matern Child Nutr* 2019;15:e12782.
- 9 Sharma IK, Di Prima S, Essink D, *et al.* Nutrition-Sensitive agriculture: a systematic review of impact pathways to nutrition outcomes. *Adv Nutr* 2021;12:251–75.
- 10 Timler C, Alvarez S, DeClerck F, *et al.* Exploring solution spaces for nutrition-sensitive agriculture in Kenya and Vietnam. *Agric Syst* 2020;180:102774.
- 11 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;382:536–51.
- 12 Haddad L, Hawkes C, Waage J. *Food systems and diets: facing the challenges of the 21st century*. London, UK: Global Panel on Agriculture and Food Systems for Nutrition, 2016.
- 13 Fanzo J, Hawkes C, Udomkesmalee E. 2018 global nutrition report: shining a light to spur action on nutrition. development initiatives, 2018. Available: https://reliefweb.int/sites/reliefweb.int/files/resources/2018_Global_Nutrition_Report.pdf
- 14 Jones AD, Ejeta G. A new global agenda for nutrition and health: the importance of agriculture and food systems. *Bull World Health Organ* 2016;94:228–9.
- 15 Kremer M, Miguel E. Networks, social learning, and technology adoption: the case of Deworming drugs in Kenya. *Natural Field Experiments* 2003:003212.
- 16 Abadie A. Using synthetic controls: feasibility, data requirements, and methodological aspects. *J Econ Lit* 2021;59:391–425.
- 17 Snilstveit B, Bhatia R, Rankin K. *3ie evidence gap maps: a starting point for strategic evidence production and use, 3ie working paper 28*. New Delhi: International Initiative for Impact Evaluation (3ie), 2017.
- 18 Snilstveit B, Vojtkova M, Bhavsar A, *et al.* Evidence & Gap Maps: A tool for promoting evidence informed policy and strategic research agendas. *J Clin Epidemiol* 2016;79:120–9.
- 19 3ie. Development evidence portal. Available: <https://developmentevidence.3ieimpact.org/18>
- 20 HPLE. Nutrition and Food Systems. *A report by the high level panel of experts on*. Rome: Food Security and Nutrition of the Committee on World Food Security, 2017. <http://www.fao.org/3/i7846e/i7846e.pdf>
- 21 De Brauw A, Brouwer ID, Snoek H. *Food system innovations for healthier diets in low and middle-income countries. IFPRI discussion paper. No.01816*. Washington, DC: Intl Food Policy Res Inst (IFPRI), 2019.
- 22 Swinburn B, Dominich CH, Vandevijvere S. *Benchmarking food environments: experts' assessments of policy gaps and priorities for the New Zealand government*. Auckland: University of Auckland, 2014.
- 23 Panel G. *Policy actions to support enhanced consumer behaviour for high quality diets. policy brief No.8*. London, UK: Global Panel on Agriculture and Food Systems for Nutrition, 2017.
- 24 Shemilt I, Khan N, Park S, *et al.* Use of cost-effectiveness analysis to compare the efficiency of study identification methods in systematic reviews. *Syst Rev* 2016;5:1–13.
- 25 World Bank. FY18, 2018. Available: <https://bit.ly/31QoJxl> [Accessed 28 Oct 2020].
- 26 Pritchett L, Sandefur J. 'Validity Claims and Development Practice Don't Mix' Working Paper 336. Center of Global Development, 2013.
- 27 The Lancet. Maternal and child nutrition. *The Lancet* 2013 <https://www.thelancet.com/series/maternal-and-child-nutrition>
- 28 Cedil. Evaluating complex interventions in international development, 2021. Available: <https://cedilprogramme.org/events/evaluating-complex-interventions-in-international-development/>
- 29 Athey S, Imbens GW. The state of applied Econometrics: causality and policy evaluation. *Journal of Economic Perspectives* 2017;31:3–32.
- 30 Cedil. N.d. Evaluating complex interventions. Available: <https://cedilprogramme.org/funded-projects/programme-of-work-1/>
- 31 Bamberger M. Introduction to Mixed Methods in Impact Evaluation. *InterAction*, 2012. Available: <https://www.interaction.org/wp-content/uploads/2019/03/Mixed-Methods-in-Impact-Evaluation-English.pdf>
- 32 OEH (Obesity Evidence Hub). Countries that have implemented taxes on sugar-sweetened beverages (SSBs), 2020. Available: <https://www.obesityevidencehub.org.au/collections/prevention/countries-that-have-implemented-taxes-on-sugar-sweetened-beverages-ssbs> [Accessed 2020 Nov 20].
- 33 Zhang Q, Liu S, Liu R, *et al.* Food policy approaches to obesity prevention: an international perspective. *Curr Obes Rep* 2014;3:171–82.
- 34 Taillie LS, Rivera JA, Popkin BM, *et al.* Do high vs. low purchasers respond differently to a nonessential energy-dense food tax? Two-year evaluation of Mexico's 8% nonessential food tax. *Prev Med* 2017;105S:S37–42.
- 35 Batis C, Rivera JA, Popkin BM, *et al.* First-Year evaluation of Mexico's tax on nonessential energy-dense foods: an observational study. *PLoS Med* 2016;13:e1002057.
- 36 Colchero MA, Rivera-Dommarco J, Popkin BM, *et al.* In Mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage Tax. *Health Aff* 2017;36:564–71.
- 37 Grogger J. Soda taxes and the prices of Sodas and other drinks: evidence from Mexico. *Am J Agric Econ* 2017;99:481–98.
- 38 Aguilar A, Gutierrez E, Seira E. The effectiveness of Sin food taxes: evidence from Mexico. *J Health Econ* 2021;77:102455.
- 39 Colchero MA, Popkin BM, Rivera JA, *et al.* Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ* 2016;352:h6704.
- 40 Campos-Vázquez RM, Medina-Cortina EM. Pass-through and competition: the impact of soft drink taxes as seen through Mexican supermarkets. *Lat Am Econ Rev* 2019;28.
- 41 INDDX Project. *Data4Diets: building blocks for diet-related food security analysis*. Boston, MA: Tufts University, 2018. <https://inddex.nutrition.tufts.edu/data4diets>
- 42 IMMANA. N.D. Evidence and gap map: innovative metrics, tool and methods in Agriculture-Nutrition research. Available: <https://www.anh-academy.org/immmana-egm.htm> [Accessed 13th Jan 2022].
- 43 United Nations. Action tracks, 2021. Available: <https://www.un.org/en/food-systems-summit/action-tracks> [Accessed 17th Dec 2021].
- 44 Nutrition Connect. N.d. food fortification. Available: <https://nutritionconnect.org/priority-areas/fortification> [Accessed 17th Dec 2021].
- 45 Herforth A, Martínez-Steele E, Calixto G, *et al.* Development of a diet quality questionnaire for improved measurement of dietary diversity and other diet quality indicators (P13-018-19). *Curr Dev Nutr* 2019;3.
- 46 Leroy JL. Measuring the impact of agriculture programs on diets and nutrition. IFPRI, 2020. Available: <https://ebrary.ifpri.org/utills/getfile/collection/p15738coll2/id/133954/filename/134170.pdf>
- 47 Miller V, Webb P, Micha R, *et al.* Defining diet quality: a synthesis of dietary quality metrics and their validity for the double burden of malnutrition. *Lancet Planet Health* 2020;4:e352–70.
- 48 Higgins JP *et al.* *Cochrane Handbook for systematic reviews of interventions*. 2nd edition. Chichester, UK: John Wiley & Sons, 2019.