Micronutrient-sensitive food value chains: A systematic review of intervention strategies and impact pathways to nutritional outcomes

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Abstract

Knowledge and evidence on how food value chains can deliver nutrition, especially micronutrients, are limited. A deeper understanding of the food value chains as part of agri-food systems approaches addressing hunger and malnutrition through agricultural development may provide pathways for nutrition and health outcomes.. This systematic review was undertaken using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to assess the broad topic of value chains and micronutrients, focusing on interventions and their related impact pathways. Impact pathway interventions improving micronutrient delivery and consumption were classified as production, accessibility, marketing, income, knowledge and behavioral, and finally, women's empowerment pathways. However, the case study evidence on the micronutrient-sensitive value chains for nutritional outcomes is very scant. This review identified that making value chains micronutrient-sensitive requires a multi-stakeholder, integrated approach as a basis for concerted action among various stakeholders in terms of policy, research, strengthening partnerships and coordination, and information sharing. The review illustrates the scarcity of literature with a focus on the micronutrients in the context of food value chains and developing countries. The food value chain approach offers great potential to unpack the complexity of food systems and identify entry points and pathways for improving nutrition outcomes, especially the micronutrients. Additionally, this review identifies multiple entry points and calls for strong advocacy of nutrition-sensitive value chain approaches to combat hidden hunger.

Keywords: food value chains, micronutrients, interventions, impact pathways, malnutrition

Introduction

Developing country food systems have changed dramatically since the Green Revolution period. Despite economic growth and increased agricultural production in South Asia and Sub-Saharan Africa, malnutrition rates remain high due to the complexity of the problem [1]. Therefore, the sustainable development goals (SDGs) have been crafted to achieve food security and improve nutrition while promoting sustainable agriculture. Traditionally, the main focus of agricultural development and food security programmes has been on macronutrients ignoring the critically important micronutrients. The magnitude and profound consequences of micronutrient malnutrition on human health and well-being demand a new "greener" revolution [2]. Micronutrient malnutrition not only affects the health, well-being, and livelihood of all those individuals and families afflicted, but also adversely impacts programmes to control population growth, societal stability, and national development efforts.

Unfortunately, in many nations, the introduction of high-yielding cereal crops and trends towards less heterogeneous farming systems has resulted in reduced diversity of food available to low-income individuals and families, and therefore, decreased access to and increased cost of more diverse food sources in the marketplace especially for the poor [3–5] resulting in micronutrient malnutrition. The triple burden of malnutrition–undernutrition, micronutrient deficiencies, and over nutrition coexist in the same households. This review aims to learn from the understanding of intervention strategies and impact pathways to deliver micronutrients along the food value chains. Presently, there are at least 15 trace elements (i.e., micronutrient elements) and 12 vitamins known to be essential for human life [6–9].

Food value chains, being one of the core elements of a food system required to feed a population, comprise diverse drivers (e.g., political, economic, sociocultural, and environmental drivers) that affect all value chain actors, including consumers [10–12]. Building on our existing understanding of how food systems influence dietary patterns and nutrition [13–23], nutrition-sensitive approach to value chain development has been identified as a promising way to shape food systems for improved food security and nutrition outcomes [24–33]. However, changing the food systems at scale for better nutritional outcomes first requires changes in agricultural production among others, as the present composition of production does not provide sufficient quantities of micronutrients [10, 34]. Interventions through agricultural value chains can incorporate a range of value chain actors (input providers, traders, processors, and consumers) critical to providing more nutritious food. Functional value chains are necessary to widely distribute nutrient alternatives such as bio-fortified crops as well [7, 35–49]. Several past studies have suggested that value chain interventions can potentially play an important role in promoting more nutritious foods [15, 25, 50–53]. The research and development stakeholders have recognized that the value chain concepts can be useful in designing and promoting strategies to achieve nutrition goals [54, 55]. Identifying opportunities and incentivizing the chain actors involved in marketing of agricultural products with higher nutritional value would be vital to this approach. However, the value chain development efforts have largely focused on efficiency and economic returns among value chain transactions, and the nutritional content of commodities is generally not considered. The potential for value chain interventions to enhance nutrition though is part of the current food and nutrition security narrative, but so far there has been little documented experience. The evidence on factors that incentivize actors along the value chain to deliver more nutritious food is needed to design enabling policies [56, 57]. Evidence is also important on the potential impacts of the absence of appropriate policies that might lead to food value chains that result in undesirable nutritional outcomes. Moreover, the literature particularly illustrating the role of micronutrient-sensitive value chains and their impact on nutritional outcomes [4, 24, 25, 27–30, 38, 58–62] is further limited. Very few studies are available in the literature on micronutrient-sensitive value chains [15, 28, 29, 50, 63, 64], which are considered important to address the challenge of the hidden hunger both in the developed and developing countries. The use of value chain analysis to identify opportunities for targeted nutrition interventions in food systems is still an emerging method, and very little evidence has been documented for specific nutrients. Therefore, this review was intended to explore the perspective of improved nutrition concerning specific micronutrients in food value chains. The present review seeks a more in-depth exploration of value chains' role as a useful framework to unpack the complexity of food systems bringing a nutrition lens to the value chains, especially the micronutrients. The review is likely to be helpful to researchers and development stakeholder to develop pathways of nutrition-sensitive value chain interventions and design future studies to fill the critical evidence gaps.

Following this brief introduction, the subsequent section describes the study's methodology, followed by the next section on the analyzed literature review in the form of impact pathways, intervention analysis, and nutritional outcomes. Finally, the conclusions are presented in the last section.

Methods

Protocol and registration

We conducted this review using the guideline from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [65, 66].

Search strategy

We systematically searched published studies from the three most visited electronic bibliographic databases such as CABI, PubMed, and Web of Science in two steps. Firstly, we identified three search themes: nutrient, micronutrient, and food system. We then explored various sub-themes, for example, diet general, food general, micronutrient, vitamin, minerals, value chain, food system, and policy. We used different keywords in different themes and sub-themes. We used OR between words for intra-sub-theme search and finally, we used AND for all inter-sub-theme words to accumulate all the relevant results. Secondly, we applied two filters, namely publication time (from the year 2000) and language (English), to get more relevant results. Although this syntax may look complex, it allowed us to deep dive into several related and insightful articles.

Initially, we piloted our search strategy in the CABI database in April 2021 and replicated it in the other databases. All the relevant queries are reflected in Table 1. In total, we found about 8702 articles from these three databases based on our search terms. Apart from these articles, we also included another 55 studies from other sources.

Eligibility criteria and study selection

Our main objective was to find out the interventions that help in the reduction of micronutrient malnutrition or hidden hunger through a better understanding and

Table 1. Search terms in the review of micronutrient-sensitive value chains using electronic bibliographic databases.

Query no.	Theme	Sub-theme	Keyword	CABI	PubMed	Web of Science	Others (cross references and web search)
#1	Nutrition	Diet general	Nutrition OR diet OR dietary OR dietary diversity	1070963	1052128	806747	
#2		Food general	Food OR fruit OR vegetable OR milk OR meat OR egg OR cereals OR Oil OR Pulses OR Fish OR millets OR processed food OR fresh food	3153520	2491188	2772787	
#3		Nutrition total	#1 OR #2	3638312	3052018	3263625	
#4	Micronutrient	Micronutrient	Micronutrients OR vitamins or minerals	449534	1035238	600012	55
#5		Vitamin	Fat soluble vitamin OR water soluble vitamin OR vitamin A OR vitamin D OR vitamin E OR vitamin K OR vitamin B OR vitamin C OR pantothenic acid OR biotin OR folic acid	172687	293064	254804	
#6		Minerals	Macro minerals OR microminerals OR calcium OR magnesium OR phosphorus OR sodium OR potassium OR chloride OR sulfur OR iron OR copper OR iodine OR zinc OR fluoride OR selenium OR manganese OR chromium OR molybdenum	1000993	2209672	3131269	
#7		Micronutrient total	#4 OR #5 OR #6	1279438	2816023	3593321	
#8	Food System	Value chain	Food system OR value chains OR food value chain OR supply chains	32060	2796	19710	
#9		Policy	Food policy, biofortification, “nutritional intervention”	23065	6194	7007	
#10		Food system total	#8 OR #9	53593	8891	26516	
#11	Final Search_1	Nutrition + micronutrient + value chains	#3 AND #7 AND #10	4860	2002	2724	
#12	Filter	Publication time, language	From 2000 AND English	4152	1886	2664	
#13	Final		#11 AND #12	**4152**	**1886**	**2664**	**55**

developing micronutrient-sensitive value chains (MNSVC). As Table 2 shows, we used six criteria to determine the eligibility for inclusion of relevant articles out of 8757 search articles: topic related to MNSVC, publication type, interventions, comparators, inclusion for impact, and pathway analysis.

Results

The search from three bibliographic databases and web search retrieved 8757 studies, resulted in final inclusion of 98 articles that reported on the impact pathway and intervention analysis (n = 84) and their nutritional outcomes (n = 14). The detailed PRISMA flow diagram (Figure 1) shows step-by-step search terms and queries for undertaking the present study review.

Study characteristics

Country-wise distribution

Out of 98 relevant literatures, 70 studies were related to 42 different countries for either analyzing impact pathways and/or interventions or case studies. We found that the most studies were from lower middle-income economies (n = 68), followed by upper middle-income economies (n = 20), lower-income economies (n = 15), and high-income economies (n = 12). Figure 2 shows the country-wise detailed map for our selected studies.

Year-wise distribution

The concept of MNSVC is relatively new. In the earlier years (2000–2010), we found very few readings (n = 13) relevant to the concept of the present study. However, after 2010, increased interest and significance (n = 102) were observed among the research fraternity in understanding nutrition-sensitive value chains. We found the highest frequency of publications in the year 2018 (n = 17), followed by 2017 (n = 13) and 2016 (n = 11) and 2019 (n = 11). Details of the year-wise publication are shown in Figure 3.

Impact pathway-wise distribution

Most food value chain pathways are nonlinear, and there are several interactions among them. Our research includes 84 studies in pathway analysis. Here, we have reported six

Table 2. Screening process for micronutrient-sensitive value chain.

Screening phase	Criterion	Included	Excluded	Rationale
Title screening	Topic related to MNSVC	Topic relevant to MNSVC, such as nutrition, micronutrient, or nutrition-sensitive interventions	Irrelevant topics, such as disease conditions	Relevance
Title and abstract	Publication type	Peer-reviewed studies, discussion papers, significant gray literature from highly reputed International Bodies (FAO, UNICEF, USDA)	Meta-analyses and opinion papers, letters and editorials, conference abstracts	Peer-reviewed articles are robust in quality of content and methodology, and therefore, studies without peer review excluded
Abstract and full text	Interventions	Micronutrient interventions that incorporate specific nutrition objectives and actions and address the following domains of the value chain stakeholders: health, environment, education, and social and financial protection	Nutrition interventions alone, without micronutrient-specific objectives and actions, and that do not go beyond the laboratory	Included studies relevant to nutritional interventions aimed at domains of value chains
Abstract and full text	Comparators	Studies comparing outcomes between different groups and pre-and post-intervention within a single group	One-time cross-sectional studies not comparing the effects between different groups; or the same group before and after intervention	Excluded the articles that were not able to identify the effect of the intervention
Full text	Inclusion for impact	The impact analysis included outcomes measured on treatment or intervention effects and also the processes	Studies present proportion only, without studying significant effects and/or differences between groups	Descriptive analysis presenting proportions allows making outlines about the change and better understanding of impact
Full text	Pathway analysis	Studies reporting entry points of pathways of intervention of MNSVC for nutrition, such as food production, agricultural income, markets, women's empowerment, and knowledge on nutrition	Studies reporting on intervention only without pathways mainly improving the micronutrient content in the food	Impacts alone do not give insights into the pathways that allow improving value chains to deliver micronutrient-rich foods

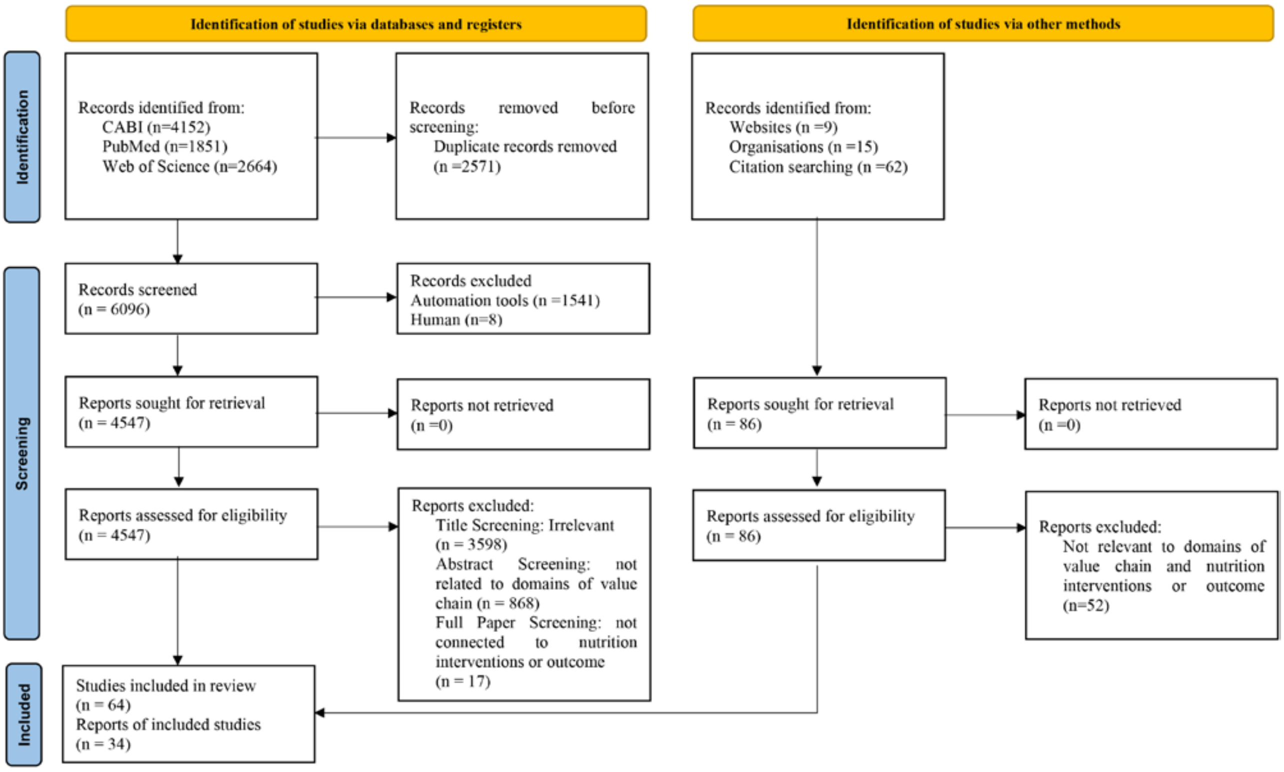

Figure 1. PRISMA 2020 flow diagram [67] for new systematic reviews which included searches of databases, registers and other sources.

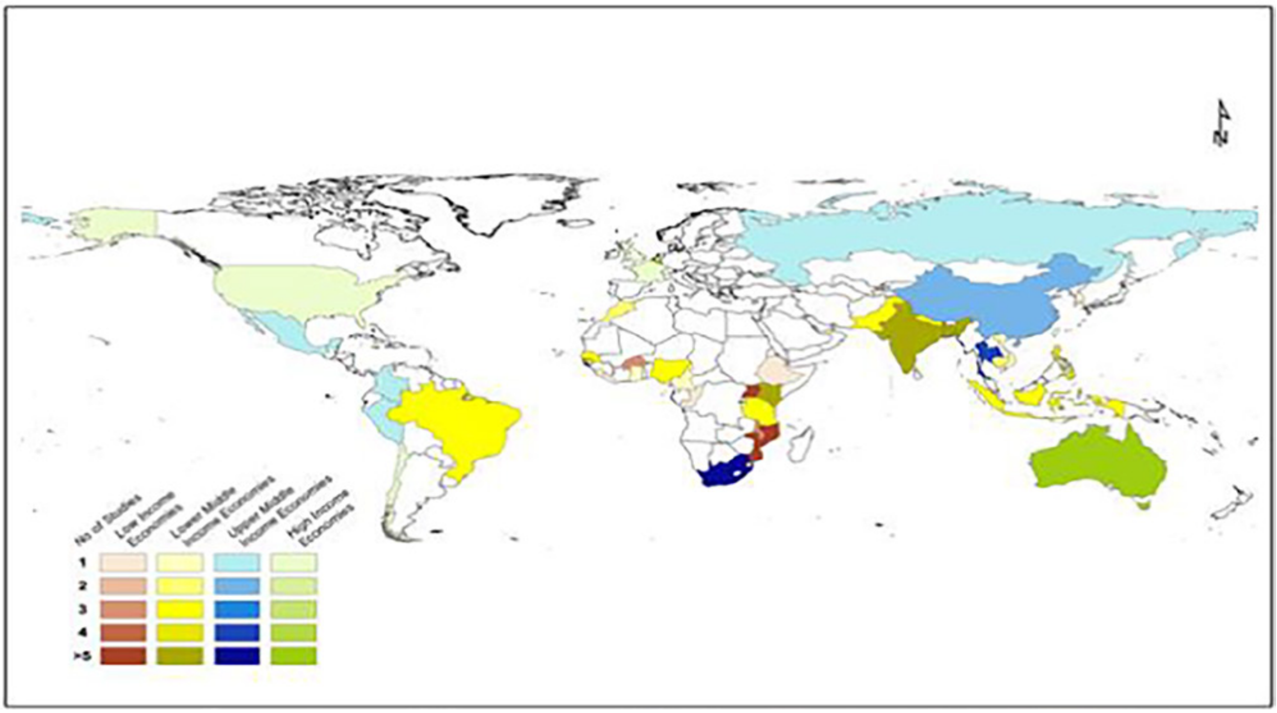

Figure 2. Distribution of relevant studies on MNSVC across the world.

pathways to improve micronutrient consumption. These six pathways were production pathway (n = 38), accessibility pathway (n = 38), markets pathway (n = 21), income pathway (n = 7), knowledge and behavioral pathway (n = 9), and women's empowerment pathway (n = 7). Along with these impact pathways, we found 14 studies on micronutrient nutritional outcomes through interventions. However, multiple combinations of these were often

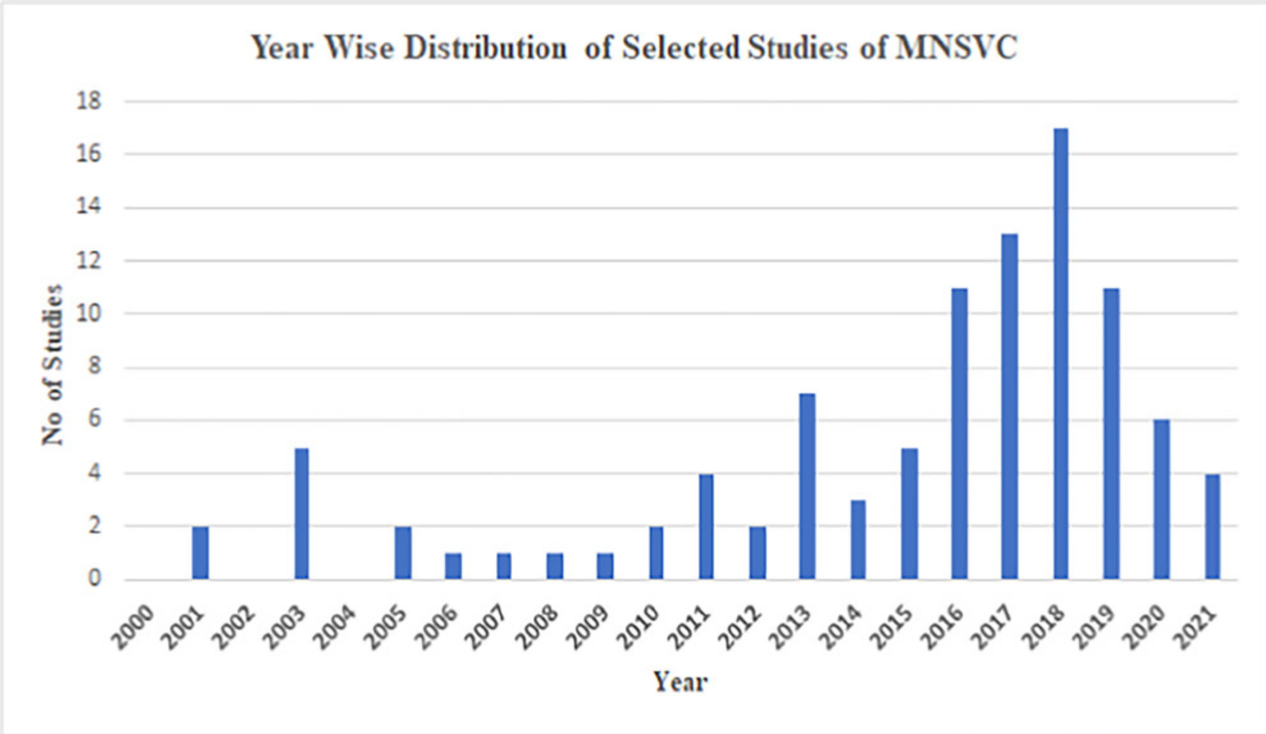

Figure 3. Year-wise distribution of selected studies on MNSVC.

reported within a single study. The largest number of studies reported only a single pathway (n = 77). The Venn diagram in Figure 4 shows the type of studies and interaction between impact pathways and the nutritional outcome studies.

Pathway and intervention analysis

Several recent studies have proposed pathways through which food systems could influence nutrition [24, 63, 68–71]. These seem to agree that food production for own consumption, food availability, incomes, prices, gender-specific time allocation, and consumer behavior provide important links between the food systems and household access to food and nutrition. In this study, we have followed six pathways of value chain interventions for delivering micronutrients, namely production pathway, accessibility pathway, markets pathway, income pathway, knowledge and behavioral pathway, and women empowerment pathway. The interventions introduced through these pathways have been discussed in detail in the following sections.

Production pathway

Thirty-eight out of 98 studies mainly relates to the production pathway. This pathway has two sub-pathways. The first sub-pathway discusses the improvement of micronutrient content in food through fortification. Fortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions [7, 35–49, 72, 73]. It can be done through two approaches: bio-fortification and fortification of food during processing. Bio-fortification of staple crops can help improve a poor-quality diet, especially where food choices are limited, and soils may be devoid of bioavailable micronutrients. Over 20 million people worldwide are currently consuming bio-fortified crops [7, 35]. Bio-fortification can be achieved in three ways [49]: (a) conventional bio-fortification—to change the genetic makeup of the plant for higher micronutrient content is the most sustainable bio-fortification approach [17, 37]; (b) agronomic bio-fortification—this approach includes fertilization of crop with micronutrient and exogenous application of micronutrients through the foliar application [17]; (c) transgenic bio-fortification—inserting genes needed for the accumulation of a micronutrient, which would otherwise not exist in that particular crop (either complete form or in a bioavailable form) [17, 74]. Another way of fortification of food is done during food processing either voluntarily through breakfast cereals, yoghourt, and sweet biscuits [59, 60, 73, 75–77] or through policies mandating blending of micronutrients in the flour, oil and salt, etc. [60, 73, 78].

The second sub-pathway is to increase the availability of micronutrient-rich food in communities. The consumption of micronutrient food by producer households either out of their production through home/school/community gardening [24, 79–86] or purchase from the market [29, 39] can be considered the most direct pathway to achieving changes in their micronutrient consumption. However, proper processing by increasing the shelf-life of whole

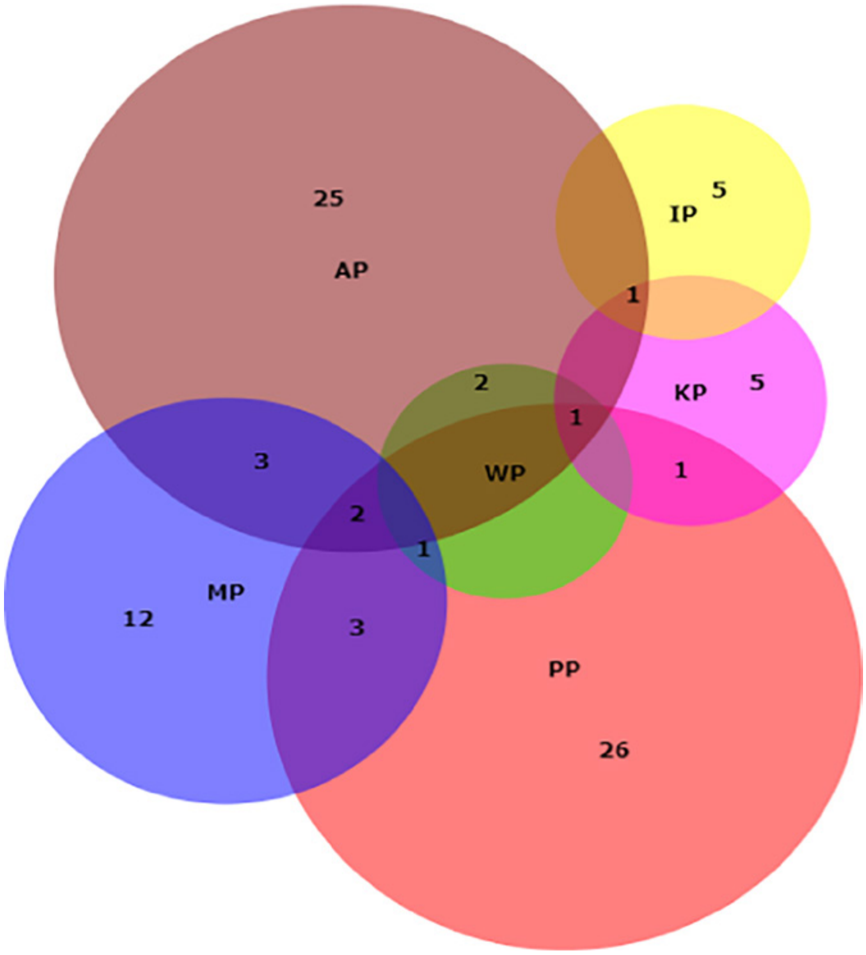

Figure 4. Number of studies along the impact pathways. AP—accessibility pathway; PP—production pathway; MP—market pathway; KP—knowledge and behavioural pathway; WP—women's empowerment pathway; IP—income pathway.

micronutrient-rich foods can be used year-round and can be distributed in a wider community, increasing the availability of micronutrient-rich food [39, 87]. The overall availability of nutritious foods might also be increased through interventions that increase seasonal availability. This might be achieved through staggered planting systems, or systems of planting in different climatic regions [87], or improved storage systems [81].

Accessibility pathway

The availability of micronutrient-rich foods in the local food environment is important; however, this alone does not necessarily translate into high-quality dietary patterns [88]. Economic and regular accessibility of micronutrient-rich food is equally important. An increase in accessibility of micronutrient-rich foods can be explained in two sub-pathways: direct and indirect pathways.

The direct pathway is easy accessibility to the micronutrient-rich foods to the end consumer through government and non-governmental programmes. Providing micronutrient-rich food through school meal programmes is one of the most important interventions of the accessibility pathway [1, 58, 61, 87, 89–92]. Public distribution system (PDS) providing subsidized food is another intervention pathway to increase access to micronutrient-rich foods by vulnerable populations [6, 8, 26, 69, 77, 93]. Subsidies/social transfers to facilitate consumption in lean season can also increase micronutrient-rich food consumption [25]. Community kitchens that provide the main meal at a low cost to impoverished families also influence access to micronutrient-rich foods [94–97].

An indirect pathway enables accessibility through strategic interventions across the food supply chain. In developed countries, significant quantities of food are wasted at the consumption level and lost early in the food value chain. In developing countries, significant quantities of food are lost during the production-to-processing stages of the food value chain; much less food is wasted at the consumer level [27, 98, 99]. Micronutrient-rich foods can be made relatively more affordable by reducing losses and waste [100–103] and through an integrated production process after harvesting [51]. The government's provision of subsidies also alters the affordability and accessibility of nutritious foods or specific micronutrient-rich foods/agricultural commodities [4]. Household and community production of micronutrient-rich food in the short and long value chains [29, 71, 79–81, 84, 85, 104–107] also affect the micronutrient consumption. In addition, the packaging and processing enhance the micronutrient consumption by increasing shelf-life and wider distribution [87].

Markets pathway

Commercial marketing for micronutrient-rich food not only motivates feasible behavior changes of the potential consumers but can also promote the rate of adoption of micronutrient-rich foods [24, 108]. In some cases, it will benefit maternal and child nutrition and health [41], promote the production and consumption of indigenous vegetable crops in vulnerable communities, and help meet the recommended intakes of micronutrients like vitamins A and C and iron throughout the year [6].

To ensure that value chain interventions have sustainable impacts on nutrition outcomes, the interventions must engage with the private sector throughout. The private sector may be engaged to integrate goals such as improved nutrition or sustainability; such interventions are more likely to be taken to scale if profit incentives can be aligned with nutritional outcomes [2, 77]. For this pathway, both public and private sectors need to engage to achieve the integrated goals of nutritional outcomes and sustainability.

Government programmes may better adapt the product's labelling to the local consumers and offer customized products for wider acceptability and utility. Through labelling in the local language, nutrition messaging can facilitate consumer compliance and are more likely to be popularly accepted in the communities [109], but it is also critical that the consumers understand and is aware about food products labelling A standardized small-packaged food product may fulfills the safety and micronutrient intake at the point of consumption and ensures easy availability for the lower-income populations [75,77,110,111]. Development of convenient packaging sizes is needed that suits a limited budget [1, 70, 75, 90, 109, 112, 113]. Another option, such as supplementation of micronutrients through capsules, needs more evidence base [62, 90] apart from the issues of the supply chain and adherence for Iron Folic Acid Supplementation (IFAS) for pregnant women. The development and promotion of ready-to-eat micronutrient-rich food products maybe encouraged through nutritious snacks at any time of day. However, the consumers should have choices to access this through various distribution channels like alternative retail outlets such as petrol stations, convenience stores, and schools [29, 114].

Nowadays, the concept of local food has gained traction in the media, engaged consumers, and offered farmers a new marketing tool [25, 61, 115]. Therefore, nutrient-dense, climate-resilient, economically viable, and locally available or adaptable food can be prioritized as Future Smart Food (FSF) and it can play an important role in combating hunger and malnutrition [115–117].

Income pathway

Household income has the high potential effect on nutrition, especially among the most vulnerable population. Changes in consumption patterns in response to price and income changes could impact nutrient intake with related positive or negative consequences [118]. Dietary quality is also associated with income, especially in developing countries. When people are very poor, they rely on dietary staples like cereals that tend to be poor sources of micronutrients [119]. Increasing and, where relevant, diversifying on- and off-farm income throughout the year are essential to improving food and livelihood security and meeting nutritional needs. The most important intervention in this pathway has been the introduction of improved dairy cow breeds resulting in higher milk yields per cow, higher milk sales, and greater market integration, and thereby, these households had higher expenditure on nutritious food [84, 120–122]. Besides that, crop diversification also increases and stabilizes the households' income and, henceforth, nutrition [123]; in addition, improved coordination and linkages with traders/markets also reduce costs of production and increase revenue and therefore improve the income of the farmers that may influence the nutrition [25].

Knowledge and behavioral pathway

Lack of knowledge, beliefs about food, customs, and poverty are the main factors preventing millions of people from eating enough micronutrient-rich foods [124]. Information campaigns and the promotion of nutrient-rich products increase the awareness among the value chain actors [25, 125]. Education on micronutrient-rich food enhances consumers' awareness on its importance for health and confidence in food safety and food quality [60, 126, 127]. The evidence on interventions to improve the iron content of the meals found community kitchens as a unique opportunity to develop and design nutrition education interventions to improve the consumption of micronutrient-rich foods. Simultaneously, a behavior change communication strategy targeted at women and adolescent girls to enhance awareness and knowledge about micronutrient deficiencies was looked upon as a long-term strategy for improving dietary intake among the communities [15, 94].

Women's empowerment pathway

There is compelling evidence of the fundamental role of women in food value chains [24, 27, 128–130]. Gender relations have been found highly relevant also in determining the effectiveness of food loss reduction strategies and interventions. These types of interventions, which aim for long-term adoption of technologies and shifts in production behaviors, require that gender relations and the different priorities, preferences, and bargaining power of women and men as actors of the food value chain are considered [27]. Gender affects health and nutrition outcomes, which may lead to micronutrient deficiencies, at least in some cultures, and where there is a difference in priority within the household, it is usually females who are disadvantaged [8].

Evidence suggests that knowledge transfer to women can lead to desirable changes in diets and there is greater potential to enhance nutrition knowledge and practices by targeting women [97]. A study reveals that a combination of strategies and formative research effectively improved women and adolescent girls' dietary iron intake and thereby improved their iron status [94].

Nutritional outcome through value chains

Value chain approach, which use supply chains to add value (usually economic) to products as they move from producers to consumers, can increase access to nutritious foods, especially micronutrient-dense foods, and improve nutritional status. There is an existing knowledge gap specifically, about how the value chains can be shaped to increase incomes and improve diets and nutritional outcomes. The dairy value chain was a successful strategy to distribute micronutrient-fortified yoghourt (MNFY) among pastoralists in Northern Senegal, and increase Hemoglobin concentrations among their children and reduce anemia [60]. Another study described that development, expansion, coalition, and strengthening consumer demand of new products or by modifying existing food products to address specific micronutrient deficiencies such as iodine fortification; vitamin-fortified yoghourt from Grameen Danone Foods for the Asian market; packaged foods rich in micronutrients and vitamin A-fortified cooking oil [59]. In Nigeria, school meals served in three rural schools were provided to meet a third of recommended daily energy and micronutrient intakes [58]. The large-scale interventions using integrated agricultural, demand creation/behavior change, and marketing components to introduce and promote Orange Fleshed Sweet Potato (OSP) were successfully incorporated it into the diets of women and children. It significantly increased the adequacy of vitamin A intake [38].

While in rural Bangladesh, children who participated in a community-based school meal programme using local foods with soybean showed significant improvements in height velocity and hemoglobin concentrations compared with children who did not participate in the school meal programme [61]. In another study, the supplementation method's delivery of multiple micronutrients through the food route was as efficient as the conventional method of supplementation through tablets among residential school children [62].

In India, a study found a negative effect on micronutrient intake in low-income families upon the exogenous increase in wheat and rice subsidy through a targeted food price subsidy programme [4]. This study reflects the unintended effect of selectively subsidizing certain food items, thereby lowering micronutrient intake among a population that suffers from high levels of micronutrient deficiency.

When adopted and put into practice, nutrition awareness can lead to improvements in nutrition outcomes across the life cycle [24]. Also, a case study that seeks to identify actionable options for leveraging local value chains for improved nutritional outcomes of poor rural consumers in Malawi calls for an integrated approach, starting from consumption to production [25]. The traditional food value chains often still predominate in low- and middle-income countries and can significantly influence nutrition outcomes by facilitating a year-round availability of a wide variety of foods [27]. There is little empirical evidence illustrating how food purchasing patterns and dietary outcomes change when smallholder farmers and rural participants are linked to higher-value market opportunities [28]. Another research focused on the fruit value chain-linking growers, processors, and retailers in South Africa, India, and Australia with its emphasis on identifying implications for end-consumption through nutrition-oriented value chains rather than economic outcomes within the chain [29, 131]. Utilizing locally available small fish has shown considerable potential as a cost-effective food-based strategy to enhance micronutrient intakes in Ghana, Malawi, Uganda [30], and Bangladesh [132, 133].

Conclusions and implications

Making food value chains micronutrient-sensitive requires a multi-stakeholder, integrated systemic approach as a basis for concerted action among various stakeholders in terms of policy, research, strengthening partnerships, coordination, and information sharing. To make such a system approach effective and sustainable, there must be specific incentives for every stakeholder involved in the micronutrient-sensitive value chains. The pathways and policies to make food value chains nutrition-sensitive would include (a) moving from a focus on supply opportunities and market demands to one which takes into consideration consumers' nutrition needs, and which may involve creating demand (e.g., through social marketing or nutrition education campaigns, behavior change communication strategies); (b) shifting from a commodity focus that addresses one value chain at a time to an approach that addresses various value chains including food loss and waste intending to improve diets in a holistic way; (c) transitioning beyond targeting economically active groups in a more inclusive way also to address the needs of nutritionally vulnerable and economically marginalized populations; and (d) broadening the concept of "value" from a purely economic focus on the one encompassing gender, nutrition, health, and environmental dimensions.

In this review, we have presented pathways to enable the delivery of micronutrients across the continuum of the food value chains to address the hidden hunger or triple burden of malnutrition, which is becoming a common problem for both developing and developed economies. However, the available literature has not yet deeply focused on the micronutrients in the context of the food value chain. More rigorous evidences are needed to identify leverage points for designing context-specific interventions to build (micro) nutrient-sensitive food value chains and enhance consumer awareness to attain improved intakes of nutritious foods, especially micronutrient-dense foods, to combat hidden hunger. The evidences are needed also to build strong narratives on the importance of (micro) nutrient-sensitive food value chains supporting healthy and sustainable food systems.

References

1. Maestre Morales M. Notes on contributors: Value chains for nutrition in South Asia: Who delivers, how and to whom? IDS Bulletin 2018;49(1):1-20. DOI: 10.19088/1968-2018.111.
2. Parasar R, Bhavani RV. Review of Agri-food value chain interventions aimed at enhancing consumption of nutritious food by the poor: India. LANSA Working Paper. Vol. 8. p. 42. Retrieved from: http://www.lansasouthasia.org/lansa-publications> [Accessed: 1 November 2016].
3. Arsenault JE, Hijmans RJ, Brown KH. Improving nutrition security through agriculture: An analytical framework based on national food balance sheets to estimate nutritional adequacy of food supplies. Food Security 2015;7(3):693–707. DOI: 10.1007/s12571-015-0452-y.
4. Muchomba FM, Kaushal N. Effect of food subsidies on micronutrient consumption. Indian Journal of Human Development 2016;10(3):317–335. DOI: 10.1177/0973703016685668.
5. Robinson E, Nwuneli N, Humphrey J, Henson S. Mapping value chains for nutrient-dense foods in Nigeria. IDS Evidence Report: Reducing Hunger and Undernutrition. 2014. p. 76.
6. Aphane J, Chadha ML, Oluoch MO. Increasing the consumption of micronutrient-rich foods through production and promotion of indigenous foods. FAO-AVRDC International Workshop Proceedings 2003;5-8(March):1–84.
7. Bouis HE. Micronutrient fortification of plants through plant breeding: Can it improve nutrition in man at low cost? Proceedings of the Nutrition Society 2003;62(2):403–411. DOI: 10.1079/pns2003262.
8. Darnton-Hill I, Webb P, Harvey PWJ, Hunt JM, Dalmiya N, Chopra M, et al. Micronutrient deficiencies and gender: Social and economic costs. American Journal of Clinical Nutrition 2005;81(5):1198–1205. DOI: 10.1093/ajcn/81.5.1198.
9. Schaetzel T, Sankar R. Effects of micronutrient deficiencies on human health: Its status in South Asia. Journal of Crop Production 2002;6(1–2):55–98. DOI: 10.1300/J144v06n01_06.
10. Anim-Somuah H, Henson S, Humphrey J, Robinson E. Strengthening Agri-Food Value Chains for Nutrition: Mapping Value Chains for Nutrient-Dense Foods in Ghana. Vol. 2. England: Institute of Development Studies; 2013. Retrieved from: https://opendocs.ids.ac.uk/opendocs/handle/123456789/2632
11. Chitima M, CôtéStLaurent A, Darkashalli H, Giorgis I, Isla E, Lizarraga A, et al. The case of Kenya: How can value chains be shaped to improve nutrition? In: Global Forum on Food Security and Nutrition (FSN). Human Development and Food Security. Italy: Roma Tre University; 2017.
12. Bamanyaki P, Muchunguzi P. Exploring gender-and nutrition-sensitive climate-smart agriculture value chains for Nwoya District, Northern Uganda. In: Information Note. CGIAR Research Program on: Climate Change, Agriculture and Food Security (CCAFS). Wageningen, the Netherlands: GIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); 2020.
13. Chibarabada TP, Modi AT, Mabhaudhi T. Expounding the value of grain legumes in the semi- and arid tropics. Sustainability (Switzerland) 2017;9(1):1-20. DOI: 10.3390/su9010060.
14. Conijn JG, Bindraban PS, Schröder JJ, Jongschaap REE. Can our global food system meet food demand within planetary boundaries? Agriculture, Ecosystems and Environment 2018;251(June 2017):244–256. DOI: 10.1016/j.agee.2017.06.001.
15. Gelli A, Donovan J, Margolies A, Aberman N-L, Santacroce M, Chirwa E, et al. The role of food systems and value chains to improve diets in low income settings: Diagnostics to support intervention design in Malawi (June). Washington, DC: International Food Policy Research Institute (IFPRI); 2018. 35 p. Retrieved from: http://cdm15738.contentdm.oclc.org/cdm/ref/collection/p15738coll2/id/132712
16. Hirich A, Rafik S, Rahmani M, Amira F, Azaykou F, Filali K, et al. Development of quinoa value chain to improve food and nutritional security in rural communities in Rehamna, Morocco: Lessons learned and perspectives. Plants 2021;10(2):1–27. DOI: 10.3390/plants10020301.
17. Miller BDD, Welch RM. Food system strategies for preventing micronutrient malnutrition. Food Policy 2013;42:115–128. DOI: 10.1016/j.foodpol.2013.06.008.
18. Pingali P, Mittra B, Rahman A. The bumpy road from food to nutrition security—Slow evolution of India's food policy. Global Food Security 2017;15(April):77–84. DOI: 10.1016/j.gfs.2017.05.002.
19. Sammugam L, Pasupuleti VR. Balanced diets in food systems: Emerging trends and challenges for human health. Critical Reviews in Food Science and Nutrition 2019;59(17):2746–2759. DOI: 10.1080/10408398.2018.1468729.
20. Tyagi S, Naresh RK, Garg AP, Moni M, Kumar A. Increasing the competitiveness of market value chains be shaped to improve nutrition for smallholder producers: A review. International Journal of Current Microbiology and Applied Sciences 2019;8(11):2034–2048 DOI: 10.20546/ijcmas.2019.811.236.
21. Van Pamel E, Cnops G, Van Droogenbroeck B, Delezie EC, Van Royen G, Vlaemynck GM, et al. Opportunities within the agri-food system to encourage a nutritionally balanced diet—Part I. Food Reviews International 2020;00(00):1–52. DOI: 10.1080/87559129.2020.1719504.
22. Williams PN, Lombi E, Sun GX, Scheckel K, Zhu YG, Feng X, et al. Selenium characterization in the global rice supply chain. Environmental Science and Technology 2009;43(15):6024–6030. DOI: 10.1021/es900671m.
23. Sangwan N, Shalander K. Empowerment effect of women's labour force participation and the household's health: Panel data evidence from SAT India. Food Policy 2021;102:102117. Available from: https://www.sciencedirect.com/science/article/pii/S0306919221000968

24. De la Pena I, Garrett J. Nutrition-sensitive value chains A guide for project design. Vol. I. Rome: International Fund for Agricultural Development (IFAD); 2018. Retrieved from: https://cgspace.cgiar.org/handle/10568/99242

25. Donovan J, Gelli A. Designing interventions in local value chains for improved health and nutrition: Insights from Malawi. World Development Perspectives 2019;16(November):100149. DOI: 10.1016/j.wdp.2019.100149.

26. Downs S, Fanzo J. Chapter 1.3 managing value chains for improved nutrition. In: Good Nutrition: Perspectives for the 21st Century. Basel, Switzerland: Karger Publishers; 2016. pp. 45–59. DOI: 10.1159/000452374.

27. Laub R, Van Otterdijk R, Rolle R. Gender and food loss in sustainable food value chains. A guiding note. In: Nutrition and Food Systems Division & Social Policies and Rural Institutions Division. Rome, Italy: FAO; 2018.

28. Gómez MI, Ricketts KD. Food value chain transformations in developing countries: Selected hypotheses on nutritional implications. Food Policy 2013;42:139–150. DOI: 10.1016/j.foodpol.2013.06.010.

29. Hattersley L. Agri-food system transformations and diet-related chronic disease in Australia: A nutrition-oriented value chain approach. Agriculture and Human Values 2013;30(2):299–309. DOI: 10.1007/s10460-012-9411-9.

30. Kawarazuka N, Béné C. The potential role of small fish species in improving micronutrient deficiencies in developing countries: Building evidence. Public Health Nutrition 2011;14(11):1927–1938. DOI: 10.1017/S1368980011000814.

31. McDermott J, Johnson N, Kadiyala S, Kennedy G, Wyatt AJ. Agricultural research for nutrition outcomes—Rethinking the agenda. Food Security 2015;7(3):593–607. DOI: 10.1007/s12571-015-0462-9.

32. Temu A, Waized B, Ndyetabula D. Mapping value chains for nutrient-dense foods in Tanzania. Institute of Development Studies. 2014;76. Retrieved from: http://mobile.opendocs.ids.ac.uk/opendocs/handle/123456789/4025

33. Hulsen T, de Vlieg J, Alkema W. BioVenn—A web application for the comparison and visualization of biological lists using area-proportional Venn diagrams. BMC Genomics 2008;9:488. DOI: 10.1186/1471-2164-9-488.

34. Allen S, de Brauw A. Nutrition sensitive value chains: Theory, progress, and open questions. Global Food Security 2018;16(November 2016):22–28. DOI: 10.1016/j.gfs.2017.07.002.

35. Bouis H. Reducing mineral and vitamin deficiencies through biofortification: Progress under harvestplus. World Review of Nutrition and Dietetics 2018;118:112–122. DOI: 10.1159/000484342.

36. Carvalho SMP, Vasconcelos MW. Producing more with less: Strategies and novel technologies for plant-based food biofortification. Food Research International 2013;54(1): 961–971. DOI: 10.1016/j.foodres.2012.12.021.

37. De Moura FF, Moursi M, Angel MD, Angeles-Agdeppa I, Atmarita A, Gironella GM, et al. Biofortified b-carotene rice improves Vitamin A intake and reduces the prevalence of inadequacy among women and young children in a simulated analysis in Bangladesh, Indonesia, and the Philippines. American Journal of Clinical Nutrition 2016;104(3):769–775. DOI: 10.3945/ajcn.115.129270.

38. Hotz C, Loechl C, De Brauw A, Eozenou P, Gilligan D, Moursi M, et al. A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. British Journal of Nutrition 2012;108(1):163–176. DOI: 10.1017/S0007114511005174.

39. Kyriacou MC, Rouphael Y, Di Gioia F, Kyratzis A, Serio F, Renna M, et al. Micro-scale vegetable production and the rise of microgreens. Trends in Food Science and Technology 2016;57:103–115. DOI: 10.1016/j.tifs.2016.09.005.

40. Lockyer S, White A, Walton J, Buttriss JL. Proceedings of the 'working together to consider the role of biofortification in the global food chain' workshop. Nutrition Bulletin 2018;43(4):416–427. DOI: 10.1111/nbu.12348.

41. Omari R, Zotor F, Tagwireyi J, Lokosang L. Advocacy for scaling up biofortified crops for improved micronutrient status in Africa: Approaches, achievements, challenges and lessons. Proceedings of the Nutrition Society 2019;78(4):567–575. DOI: 10.1017/S0029665119000521.

42. Prakash P, Kishore A, Roy D, Behura D, Immanuel S. Biofortification for reducing hidden hunger: A value chain analysis of sweet potato in Odisha, India. Agricultural Economics Research Review 2017;30(2):201. DOI: 10.5958/0974-0279.2017.00042.8.

43. Rhowell Jr NT, Fernie AR, Sreenivasulu N. Meeting human dietary vitamin requirements in the staple rice via strategies of biofortification and post-harvest fortification. Trends in Food Science & Technology 2021;109:65–82. DOI: 10.1016/j.tifs.2021.01.023.

44. Saini RK, Nile SH, Keum YS. Food science a1nd technology for management of iron deficiency in humans: A review. Trends in Food Science and Technology 2016;53:13–22. DOI: 10.1016/j.tifs.2016.05.003.

45. Titcomb TJ, Tanumihardjo SA. Global Concerns with B vitamin statuses: Biofortification, fortification, hidden hunger, interactions, and toxicity. Comprehensive Reviews in Food Science and Food Safety 2019;18(6):1968–1984. DOI: 10.1111/1541-4337.12491.

46. Van Der Straeten D, Bhullar NK, De Steur H, Gruissem W, MacKenzie D, Pfeiffer W, et al. Multiplying the efficiency and impact of biofortification through metabolic engineering. Nature Communications 2020;11(1):1–10. DOI: 10.1038/s41467-020-19020-4.

47. Vinoth A, Ravindhran R. Biofortification in millets: A sustainable approach for nutritional security. Frontiers in Plant Science 2017;8(January):1–13. DOI: 10.3389/fpls.2017.00029.

48. Viscardi S, Marileo L, Barra PJ, Durán P, Inostroza-Blancheteau C. From farm to fork: It could be the case of Lactic Acid Bacteria in the stimulation of folates biofortification in food crops. Current Opinion in Food Science 2020;34:1–8. DOI: 10.1016/j.cofs.2020.08.002.

49. Ul-Allah S. Combating hidden hunger in agriculture perspective. World Review of Nutrition and Dietetics 2017;118:161–166. DOI: 10.1159/000484511. Epub 2018 Apr 13.

50. De La Peña I, Garrett J, Gelli A. Nutrition-sensitive value chains from a smallholder perspective. IFAD Research Series. Rome: International Fund for Agricultural Development (IFAD); 2018.

51. Gelli A, Becquey E, Ganaba R, Headey D, Hidrobo M, Huybregts L, et al. Improving diets and nutrition through an

integrated poultry value chain and nutrition intervention (SELEVER) in Burkina Faso: Study protocol for a randomized trial. Trials 2017;18(1):1–16. DOI: 10.1186/s13063-017-2156-4.

52. Morgan EH, Hawkes C, Dangour AD, Lock K. Analyzing food value chains for nutrition goals. Journal of Hunger and Environmental Nutrition 2019;14(4):447–465. DOI: 10.1080/19320248.2018.1434106.
53. Olney DK, Rawat R, Ruel MT. Identifying potential programs and platforms to deliver multiple micronutrient interventions. Journal of Nutrition 2012;142(1):178S–185S. DOI: 10.3945/jn.110.137182.
54. Hawkes C, Ruel M. Value Chains for Nutrition. 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health. 2020 Conference Paper 4. Washington, DC: International Food Policy Research Institute; 2011.
55. Ruel MT, Alderman H, and the Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programs: How can they help to accelerate progress in improving maternal and child nutrition? The Lancet 2013;382(9891):536–551.
56. Maestre M, Robinson E, Humphrey J, Henson S. The role of businesses in providing nutrient-rich foods for the poor: A case study in Tanzania. IDS Evidence Report No. 52. Brighton, UK: Institute of Development Studies; 2014.
57. Robinson E, Nwuneli N, Henson S, Humphrey J. Mapping Value Chains for Nutrient-Dense Foods in Nigeria. Evidence Report No. 65. Brighton, UK: Institute of Development Studies; 2014.
58. Ayogu RNB, Eme PE, Anyaegbu VC, Ene-Obong HN, Amazigo UV. Nutritional value of school meals and their contributions to energy and nutrient intakes of rural school children in Enugu and Anambra States. Nigeria. BMC Nutrition 2018;4(1):1–12. DOI: 10.1186/s40795-018-0216-0.
59. Greenberg S. Corporate power in the agro-food system and the consumer food environment in South Africa. Journal of Peasant Studies 2017;44(2):467–496. DOI: 10.1080/03066150.2016.1259223.
60. Le Port A, Bernard T, Hidrobo M, Birba O, Rawat R, Ruel MT. Delivery of iron-fortified yoghurt, through a dairy value chain program, increases hemoglobin concentration among children 24 to 59 months old in Northern Senegal: A cluster-randomized control trial. PLoS One 2017;12(2):1–17. DOI: 10.1371/journal.pone.0172198.
61. Murayama N, Magami M, Akter S, Hossain IA, Ali L, Faruquee MH, et al. A pilot school meal program using local foods with soybean in rural Bangladesh: Effects on the nutritional status of children. Food and Nutrition Sciences 2018;09(04):290–313. DOI: 10.4236/fns.2018.94023.
62. Kumar MV, Rajagopalan S. Impact of a multiple-micronutrient food supplement on the nutritional status of schoolchildren. Food and Nutrition Bulletin 2006;27(3):203–210.
63. Ridoutt B, Bogard JR, Dizyee K, Lim-Camacho L, Kumar S. Value chains and diet quality: A review of impact pathways and intervention strategies. Agriculture (Switzerland) 2019;9(9):1–18. DOI: 10.3390/agriculture9090185.
64. Gelli A, Hawkes C, Donovan J, Harris J, Allen SL, De Brauw A, et al. Value chains and nutrition: A framework to support the identification, design, and evaluation of interventions. 2015.
65. Sharma IK, Di Prima S, Essink D, Broerse JEW. Nutrition-sensitive agriculture: A Systematic review of impact pathways to nutrition outcomes. Advances in Nutrition 2021;12(1):251–275. DOI: 10.1093/advances/nmaa103.
66. Moher D, Liberati A, Tetzlaff J, Altman DG, the PRISMA Group. Preferred items for systematic reviews and meta-analyses: The PRISMA statement. International Journal of Surgery 2010;8(5):336–341.
67. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372:n71. DOI: 10.1136/bmj.n71. For more information visit: http://www.prisma-statement.org/
68. Henson S, Humprey J. Review of agri-food value chain interventions assessing the effectiveness of agri-food value chain food by the poor: Conceptual framework. LANSA Working Paper Series 2015;2015(04):1-27
69. Hoddinott J, Ahmed A, Roy S. Randomized control trials demonstrate that nutrition-sensitive social protection interventions increase the use of multiple-micronutrient powders and iron supplements in rural pre-school Bangladeshi children. Public Health Nutrition 2018;21(9):1753–1761. DOI: 10.1017/S1368980017004232.
70. Maestre M, Poole N, Henson S. Assessing food value chain pathways, linkages and impacts for better nutrition of vulnerable groups. Food Policy 2017;68:31–39. DOI: 10.1016/j.foodpol.2016.12.007.
71. Olney DK, Talukder A, Iannotti LL, Ruel MT, Quinn V. Assessing impact and impact pathways of a homestead food production program on household and child nutrition in Cambodia. Food and Nutrition Bulletin 2009;30(4):355–369. DOI: 10.1177/156482650903000407.
72. Díaz-Gómez J, Ramos AJ, Zhu C, Martín-Belloso O, Soliva-Fortuny R. Influence of cooking conditions on carotenoid content and stability in porridges prepared from high-carotenoid maize. Plant Foods for Human Nutrition 2017;72(2):113–119. DOI: 10.1007/s11130-017-0604-7.
73. Lalani B, Bechoff A, Bennett B. Which choice of delivery model(s)works best to deliver fortified foods? Nutrients 2019;11(7):1-27. DOI: 10.3390/nu11071594.
74. Farre G, Twyman RM, Zhu C, Capell T, Christou P. Nutritionally enhanced crops and food security: Scientific achievements versus political expediency. Current Opinion in Biotechnology 2011;22(2):245–251. DOI: 10.1016/j.copbio.2010.11.002.
75. Hills G, Russell P, Borgonovi V, Doty A, Lyer L. Shared value in emerging markets: How multinational corporations are redefining business strategies to reach poor or vulnerable populations. In: FSG. United States: FSG; 2012. Retrieved from: http://www.fsg.org/publications/shared-value-emerging-markets
76. Nazeri P, Mirmiran P, Shiva N, Mehrabi Y, Mojarrad M, Azizi F. Iodine nutrition status in lactating mothers residing in countries with mandatory and voluntary iodine fortification programs: An updated systematic review. Thyroid 2015;25(6):611–620. DOI: 10.1089/thy.2014.0491.
77. Parasar R, Bhavani RV. Private business driven value chains and nutrition: Insights from India. IDS Bulletin 2018;49(1):21–38. DOI: 10.19088/1968-2018.102.
78. Diosady LL, Mannar MGV, Krishnaswamy K. Improving the lives of millions through new double fortification of salt technology. Maternal and Child Nutrition 2019;15(S3):1–9. DOI: 10.1111/mcn.12773.

79. Birdi TJ, Joshi S, Kotian S, Shah S. Possible causes of malnutrition in Melghat, a tribal region of Maharashtra, India. Global Journal of Health Science 2014;6(5):164–173. DOI: 10.5539/gjhs.v6n5p164.

80. Chadha ML, Oluoch MO. Home-based vegetable gardens and other strategies to overcome micronutrient malnutrition in developing countries. Food Nutrition and Agriculture 2003;32:17–23.

81. Fan S. Ending hunger and undernutrition by 2025: The role of horticultural value chains. Acta Horticulturae 2016;1126:9–20. DOI: 10.17660/ActaHortic.2016.1126.2.

82. Federici C, Detzel P, Petracca F, Dainelli L, Fattore G. The impact of food reformulation on nutrient intakes and health, a systematic review of modelling studies. BMC Nutrition 2019;5(1):1-21. DOI: 10.1186/s40795-018-0263-6.

83. Just DR, Okello JJ, Gabrielyan G, Adekambi S, Kwikiriza N, Abidin PE, et al. A behavioral intervention increases consumption of a new biofortified food by school children: Evidence from a field experiment in Nigeria. European Journal of Development Research 2021;0123456789:124-146. DOI: 10.1057/s41287-021-00363-7.

84. Kabunga NS, Ghosh S, Webb P. Does ownership of improved dairy cow breeds improve child nutrition? A pathway analysis for Uganda. PLoS One 2017;12(11):1–17. DOI: 10.1371/journal.pone.0187816.

85. Prutha S. Effective Tackling of Micronutrient Deficiency Through Kitchen Gardens—A Policy Memo to Help Bring Down Malnutrition in Melghat, Maharashtra. 2020. Retrieved from:https://mpp.nls.ac.in/blog/effective-tackling-of-micronutrient-deficiency-through-kitchen-gardens/

86. Vereecken CA, Bobelijn K, Maes L. School food policy at primary and secondary schools in Belgium-Flanders: Does it influence young people's food habits? European Journal of Clinical Nutrition 2005;59(2):271–277. DOI: 10.1038/sj.ejcn.1602068.

87. Laurie SM, Faber M, Claasen N, Foley JK, Michaux KD, Mudyahoto B, et al. Global regulatory framework for production and marketing of crops biofortified with vitamins and minerals. Food and Nutrition Bulletin 2017;1390(1):906–930. DOI: 10.1016/j.foodres.2017.09.016.

88. Pingali P, Sunder N. Transitioning toward nutrition-sensitive food systems in developing countries. Annual Review of Resource Economics 2017;9(March):439–459. DOI: 10.1146/annurev-resource-100516-053552.

89. Beintema JJS, Gallego-Castillo S, Londoño-Hernandez LF, Restrepo-Manjarres J, Talsma EF. Scaling-up biofortified beans high in iron and zinc through the school-feeding program: A sensory acceptance study with schoolchildren from two departments in southwest Colombia. Food Science and Nutrition 2018;6(4):1138–1145. DOI: 10.1002/fsn3.632.

90. Bhagwat S, Sankar R, Sachdeva R, Joseph L, Sivaranjani. Improving the nutrition quality of the school feeding program (mid-day meal) in India through fortification: A case study. Asia Pacific Journal of Clinical Nutrition 2014;23(November): S12–S19. DOI: 10.6133/apjcn.2014.23.s1.01.

91. Mehta B, Grover K. Nutritional contribution of mid day meal to dietary intake of school children in Ludhiana District of Punjab. Journal of Nutrition & Food Sciences 2013;3(1):1–4. DOI: 10.4172/2155-9600.1000183.

92. Prasad MPR, Benhur D, Kommi K, Madhari R, Rao MV, Patil JV. Impact of sorghum supplementation on growth and micronutrient status of school going children in Southern India—A randomized trial. Indian Journal of Pediatrics 2016;83(1):9–14. DOI: 10.1007/s12098-015-1782-7.

93. Rao S, Yajnik CS, Kanade A, Fall CHD, Margetts BM, Jackson AA, et al. Intake of micronutrient-rich foods in rural Indian mothers is associated with the size of their babies at birth: Pune maternal nutrition study. Journal of Nutrition 2001;131(4):1217–1224. DOI: 10.1093/jn/131.4.1217.

94. Creed-Kanashiro HM, Bartolini RM, Fukumoto MN, Uribe TG, Robert RC, Bentley ME. Formative research to develop a nutrition education intervention to improve dietary iron intake among women and adolescent girls through community kitchens in Lima, Peru. Journal of Nutrition 2003;133(11 Suppl. 2):3987–3991. DOI: 10.1093/jn/133.11.3987s.

95. Fudge A. The Effect of Food Donations on the Micronutrient Intake of Soup Kitchen. Clients. 2018. Retrieved from: https://opencommons.uconn.edu/srhonors_theses/579/

96. Ministry of Rural Development, India. Community Kitchens run by SHG Women Provide Food to the Most Poor and Vulnerable in Rural Areas during the COVID-19 Lockdown. PIB Delhi. 2020. Retrieved from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1613866

97. Poshan Outlook. Can A Mobile Teaching Kitchen Target Malnutrition? 2019. Available from: https://poshan.outlookindia.com/story/poshan-news-can-a-mobile-teaching-kitchen-target-malnutrition/338506

98. Häsler B, Dominguez-Salas P, Fornace K, Garza M, Grace D, Rushton J. Where food safety meets nutrition outcomes in livestock and fish value chains: A conceptual approach. Food Security 2017;9(5):1001–1017. DOI: 10.1007/s12571-017-0710-2.

99. Kruijssen F, Tedesco I, Ward A, Pincus L, Love D, Thorne-Lyman AL. Loss and waste in fish value chains: A review of the evidence from low and middle-income countries. Global Food Security 2020;26:100434. DOI: 10.1016/j.gfs.2020.100434.

100. Gustavsson G, Cederberg C, Sonesson U. Global Food Losses and Food Waste. Rome: Food and Agriculture Organization of the United Nations; 2011. Available from: http://www.fao.org/food-loss-reduction/news/detail/en/c/345300/

101. James A, Zikankuba V. Postharvest management of fruits and vegetable: A potential for reducing poverty, hidden hunger and malnutrition in sub-Sahara Africa. Cogent Food & Agriculture 2017;3(1):1312052. DOI: 10.1080/23311932.2017.1312052.

102. Opara IK, Fawole OA, Kelly C, Opara UL. Quantification of on-farm pomegranate fruit postharvest losses and waste, and implications on sustainability indicators: South African case study. Sustainability 2021;13(9):5168. DOI: 10.3390/su13095168.

103. Roberta Lauretti-Bernhard. Postharvest Loss is Equal to Nutrition Loss. 2015. Available from: https://publish.illinois.edu/phlinstitute/2015/12/04/postharvest-loss-lauretti/

104. Abel OB, Gor CO, Okuro SO, Omanga PA, Bokelmann W. The African indigenous vegetables value chain governance in Kenya. Studies in Agricultural Economics 2019;121(1):41–52. DOI: 10.7896/j.1818.

105. Aderibigbe OR, Ezekiel OO, Owolade SO, Korese JK, Sturm B, Hensel O. Exploring the potentials of underutilized grain amaranth (Amaranthus spp.) along the value chain for food and nutrition security: A review. Critical Reviews in Food Science and Nutrition 2020;0(0):1–14. DOI: 10.1080/10408398.2020.1825323.

106. Charoensiriwatana W, Srijantr P, Teeyapant P, Wongvilairattana J. Consuming iodine enriched eggs to solve the iodine deficiency endemic for remote areas in Thailand. Nutrition Journal 2010;9(1):1–5. DOI: 10.1186/1475-2891-9-68.
107. Nandi R, Nedumaran S, Ravula P. The interplay between food market access and farm household dietary diversity in low and middle income countries: A systematic review of literature. Global Food Security 2021;28:100484. DOI: 10.1016/j.gfs.2020.100484.
108. Henson S, Agnew J. Are market-based solutions a viable strategy for addressing micronutrient deficiency? Lessons from case studies in sub-Saharan Africa and South Asia. Development Policy Review 2021;39(2):233–249. DOI: 10.1111/dpr.12492.
109. UNICEF. Multiple Micronutrient Powders and Customised Packaging. 2016. Available from: https://www.unicef.org/supply/media/1446/file/Multiple%20micronutrient%20powders%20and%20customised%20packaging%20technical%20bulletin.pdf
110. Ortmann S. The role of businesses. Environmental Governance in Vietnam 2017;52:165–200. DOI: 10.1007/978-3-319-49760-0_6.
111. Rajasekaran A, Kalaivani M. Designer foods and their benefits: A review. Journal of Food Science and Technology 2013;50(1):1–16. DOI: 10.1007/s13197-012-0726-8.
112. Catalogue P. Multiple Micronutrient Powders and Customised Packaging Dispensing Instructions for Use and Pictogram Breast feeding Message. Vol. 21. Copenhagen, Denmark: United Nations Children's Fund (UNICEF), Supply Division; 2016. p. 5–7.
113. Jarvis M, Magarinos BB. Naandi and GAIN: A public–private partnership for delivering nutrition through fortification in India. In: Business Innovation to Combat Malnutrition Case study Series. Washington DC, United States of America: World Bank Institute; 2008. p. 1–16. Retrieved from: https://documents1.worldbank.org/curated/en/690581468326388037/pdf/607170BRI0P1051Naandi0Case01PUBLIC1.pdf
114. Adekunle A, Lyew D, Orsat V, Raghavan V. Helping agribusinesses—Small millets value chain—to grow in India. Agriculture (Switzerland) 2018;8(3):1-11. DOI: 10.3390/agriculture8030044.
115. Edwards-Jones G. Does eating local food reduce the environmental impact of food production and enhance consumer health? Proceedings of the Nutrition Society 2010;69(4):582–591. DOI: 10.1017/S0029665110002004.
116. Li X, Siddique KHM. Future smart food: Harnessing the potential of neglected and underutilized species for Zero Hunger. Maternal and Child Nutrition 2020;16(S3):1–22. DOI: 10.1111/mcn.13008.
117. Taillie LS, Jaacks LM. Toward a just, nutritious, and sustainable food system: The false dichotomy of localism versus supercenterism. Journal of Nutrition 2015;145(7):1380–1385. DOI: 10.3945/jn.115.212449.
118. Santeramo FG, Shabnam N. The income-elasticity of calories, macro- and micro-nutrients: What is the literature telling us? Food Research International 2015;76:932–937. DOI: 10.1016/j.foodres.2015.04.014.
119. Ames I, Bouis HE, Eozenou P, Rahman A. Food prices, household income, and resource allocation: Socioeconomic perspectives on their effects on dietary quality and nutritional status. Food and Nutrition Bulletin 2011;32:S14–S23.
120. Miller LC, Joshi N, Lohani M, Singh R, Bhatta N, Rogers B, et al. Head growth of undernourished children in rural Nepal: association with demographics, health and diet. Paediatrics and International Child Health 2016;36(2):91–101. DOI: 10.1080/20469047.2015.1133517.
121. Randolph T, Schelling E, Grace D, Nicholson CF, Leroy J, Cole D, et al. Role of livestock in human nutrition and health for poverty reduction in developing countries. Journal of Animal Science 2007;85(11):2788–2800. DOI: 10.2527/jas.2007-0467.
122. Nicholson CF, Mwangi L, Staal SJ, Thornton PK. Dairy cow ownership and child nutritional status in Kenya. In: Paper Presented at the 2003 Agricultural and Applied Economics Association Annual Meetings, Montréal. 2003.
123. SPRING. 2014. Understanding the Agricultural Income Pathway. Brief #3. Improving Nutrition through Agriculture Technical Brief Series. Arlington, VA: USAID/Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project. Retrieved from: https://www.spring-nutrition.org/sites/default/files/publications/briefs/spring_agriculturalincome_brief_3_0.pdf
124. Wanyama R, Gödecke T, Jager M, Qaim M. Poor consumers' preferences for nutritionally enhanced foods. British Food Journal 2019;121(3):755–770. DOI: 10.1108/BFJ-09-2018-0622.
125. Kraemer K, Cordaro JB, Fanzo J, Gibney M, Kennedy E, Labrique AS, et al. Ensuring good nutrition for vulnerable population groups such as elderly and hospitalized individuals in affluent societies. In: Good Nutrition: Perspectives for the 21st Century. Karger Publishers; 2016. p. 264–275.
126. Hoffmann V, Moser C, Saak A. Food safety in low and middle-income countries: The evidence through an economic lens. World Development 2019;123:104611. DOI: 10.1016/j.worlddev.2019.104611.
127. Jenkins M, Shanks CB, Brouwer R, Houghtaling B. Factors affecting farmers' willingness and ability to adopt and retain vitamin A-rich varieties of orange-fleshed sweet potato in Mozambique. Food Security 2018;10(6):1501–1519. DOI: 10.1007/s12571-018-0845-9.
128. McLachlan M, Landman AP. Nutrition-sensitive agriculture—A South African perspective. Food Security 2013;5(6):857–871. DOI: 10.1007/s12571-013-0309-1.
129. Ruel MT, Quisumbing AR, Balagamwala M. Nutrition-sensitive agriculture: What have we learned so far? Global Food Security 2018;17(September 2017):128–153. DOI: 10.1016/j.gfs.2018.01.002.
130. Said-Allsopp M, Tallontire A. Pathways to empowerment?: Dynamics of women's participation in global value chains. Journal of Cleaner Production 2015;107:114–121. DOI: 10.1016/j.jclepro.2014.03.089.
131. Thow AM, Verma G, Soni D, Soni D, Beri DK, Kumar P, et al. How can health, agriculture and economic policy actors work together to enhance the external food environment for fruit and vegetables? A qualitative policy analysis in India. Food Policy 2018;77(April):143–151. DOI: 10.1016/j.foodpol.2018.04.012.
132. De Roos B, Roos N, Al Mamun A, Ahmed T, Sneddon AA, Murray F, et al. Linking agroecosystems producing farmed seafood with food security and health status to better address the nutritional challenges in Bangladesh. Public Health Nutrition 2019;22(16):2941–2949. DOI: 10.1017/S1368980019002295.
133. Hicks CC, Cohen PJ, Graham NAJ, Nash KL, Allison EH, D'Lima C, et al. Harnessing global fisheries to tackle micronutrient deficiencies. Nature 2019;574(7776):95–98. DOI: 10.1038/s41586-019-1592-6.