FOOD SYSTEMS AS DRIVERS SUPPLEMENT

CURRENT DEVELOPMENTS IN NUTRITION

Food and Agricultural Sustainability

Food Systems as Drivers of Optimal Nutrition and Health: Complexities and Opportunities for Research and Implementation

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ABSTRACT

The Sustainable Development Goals (SDGs) are intricately linked to food systems. Addressing challenges in food systems is key to meeting the SDGs in Africa and South Asia, where undernutrition and micronutrient deficiencies persist, alongside increased nutrition transition, overweight and obesity, and related chronic diseases. Suboptimal diets are a key risk factor for mortality and 3 billion people cannot afford a healthy diet; in addition, food systems are not prioritizing environmental sustainability. Optimizing food systems and increasing agricultural productivity beyond calories, to nutrient-rich vegetables and fruits, legumes, and livestock, and sustainable fishing, are required. Strengthening of research around food systems—on pathways, value chains, and development and validation of metrics of diet quality—is required. The development of new technology in crop management and pest control and addressing natural resource degradation is key. Engaging with the public and private sectors, outreach to donors and policymakers, and strengthening cross-disciplinary collaborations are imperative to improving food systems. *Curr Dev Nutr* 2021;5:nzab062.

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Abbreviations used: DQ-Q, Diet Quality Questionnaire; GDR, Global Dietary Recommendations; GDQS, Global Diet Quality Score; LMIC, low- and middle-income country; MDD-W, Minimum Dietary Diversity for Women; NCD, noncommunicable disease; PDQS, Prime Diet Quality Score; SDG, Sustainable Development Goal.

Introduction

There is a renewed call to transform food systems and integrate efforts in nutrition, health, and agriculture to address malnutrition in all its forms (1). Understanding food systems, which encompass the actors (people and institutions) and activities relating to the production, processing, distribution, and consumption of food (2) and their role in nutrition, is critical (1). Food systems affect human health through their influence on food environments and effects on diet quality (1). Suboptimal diets are the number 1 behavioral risk factor for mortality globally, surpassing the risk for smoking, and the second behavioral risk factor for morbidity (3). Approximately 11 million deaths were attributed to suboptimal diets characterized by low intake of whole grains, fruits, nuts, and seeds and excess sodium intake in 2017 (3). Up to 3 billion people globally cannot afford to purchase a healthy diet (4). In addition, undernutrition affects 820 million people (5), and anemia affects 1.9 billion people (6), mainly in low- and middle-income countries (LMICs). Moreover, 149 million children are stunted, 49 million are wasted, and 40 million are overweight (7). Global food systems are a key factor in these poor outcomes, as they are failing to deliver nutritious and healthy diets in an equitable manner (8).

The 10th Annual Nutrition and Global Health Symposium on Food Systems as Drivers of Optimal Nutrition and Health, held on 20 November 2019, brought together researchers and students from the Harvard TH Chan School of Public Health, the Harvard Kennedy School, and the Tufts University's Nutrition Innovation Lab to discuss these global challenges. The conference was attended by >160 participants (in person and virtual). The conference sought to discuss priorities for re-

search and potential roles for researchers, students, practitioners, and other experts, in positioning food systems as drivers of optimal nutrition and health in LMIC settings. The half-day conference was composed of invited opening and closing remarks by technical agriculture and nutrition experts from the US Agency for International Development (USAID) and academia and 2 moderated panel discussions with invited technical experts, which were followed by plenary sessions during which students and participants raised questions for discussion.

The conference highlighted that changing food environments and dietary patterns and increased urbanization have resulted in nutrition transition globally and increased obesity and noncommunicable diseases (NCDs). Participants noted that this occurred concurrently with the persistent lack of availability, affordability, and accessibility of nutrient-rich foods. Addressing these challenges holistically requires moving beyond a traditional focus on single-nutrient deficiencies and undernutrition in LMICs. The meeting suggested this requires departure from a health systems–centered approach of provision of nutritional services and nutrition-specific interventions only (e.g., micronutrient supplementation), to an integrated approach that also encompasses nutrition-sensitive, food systems–based approaches to address nutrition as is advocated for by the UN and others (2, 9).

The main consensus of the conference was that a "food systems approach" is broader than the typical focus on agriculture and "providing more food" (i.e., a quantity focus). Such an approach would encompass strategies to achieve safe and nutritious diets, assess environmental impacts of production and the impacts of rapid environmental change on crop yields and quality, and would give consideration to the role of governance, along with engagement with different actors and drivers, and actions that are critical for ensuring an equitable and safe food system (10). This approach is required to capture the nuances of the agricultural sector's influence on diets and nutrition (11).

Next, the conference discussed challenges and gaps in food systems. The forum identified key challenges and gaps, including fragmented approaches and differences in definitions and concepts of food systems; critical gaps in appropriate tools, data, and indicators for the measurement of food systems and diet quality in LMICs; limited knowledge on effective food system interventions for improving diets and addressing sub-optimal nutrition in LMICs; and limited cross-disciplinary skills to tackle challenges in food systems research and practice. A further challenge highlighted by the conference was the impact of climate change, biodiversity loss, water and land scarcity, and other environmental changes on the quality and quantity of food produced. The forum also discussed solutions and next steps, and particularly considered metrics for measurement of diet quality, dashboards and other resources for tracking progress in food systems, innovative approaches to improve availability and affordability of healthy diets, and research priorities in these areas. We discuss these in detail in the following sections (**Table 1**).

Challenges and Gaps

Complexity of food systems

To understand the role of food systems in human health and determine appropriate responses, nutrition researchers and practitioners need to first understand how they function. One reason why food systems approaches have been neglected in the past is that they are very complex, highly diverse, and context-specific. While there is increased agreement on key constructs of food systems, there are differing views about whether it is most important to address *1*) calorie sufficiency and closing the yield gap, *2*) failure to produce food of sufficient diversity and nutritional quality to meet dietary needs, *3*) inequity in the distribution of food within countries, or *4*) negative impacts of food systems on the environment and natural resources (10). While there may be region- and country-specific differences in relative importance, the views expressed by many at the forum suggest that these priorities are falsely separated; in fact, all must be addressed to meet our shared aspirations for food security.

Food environments have gained increasing attention in the LMIC context, as the interface between people and the broader food system. Research has encompassed both *1*) the personal food environment (with dimensions including accessibility, affordability, convenience, and desirability) and *2*) external food environments (including food availability, prices and marketing, and regulation) and their effects on diets and nutrition (12), as well as the built, cultivated, and wild food environments. There does exist significant knowledge gaps around food systems and environments, given that research has historically focused on high-income countries, and there are significant methodological and conceptual gaps as they relate to LMICs. In addition, research to characterize food systems in LMICs involves complexity, but complex systems can be understood in smaller parts and by using mixed methods, including subjective and objective measurement. Analogously, health systems are complex, but due to decades of research, we are now more informed about how to improve them at the national and local levels, and also how to measure them. Therefore, it is critical that further research is conducted to increase our understanding of concepts and approaches in food systems.

Scarcity of data on food systems

The conference highlighted that there are gaps in knowledge on how to move from agriculture production to improved food consumption, and better nutritional outcomes, particularly for vulnerable groups such as women, children, and adolescents. Data are required to understand the local contexts and to identify points for intervention within food systems in LMICs. Agricultural interventions do not always show nutritional impact (13); therefore, an understanding of food systems, their pathways of impact, and entry points to improve diet and nutrition is critical (11). Intervening in and measuring food systems requires *1*) the identification of appropriate theories of change, and *2*) determining the metrics to track progress (14). For some of the most important elements of food systems, including diets and food environments, data are scarce.

From a programmatic perspective, impact pathways trace the links along a series of inputs, outputs, and outcomes that should translate into nutrition impact, while a program theory of change identifies the key assumptions for the links between these elements to occur (14). Many interventions within the food systems space are designed and implemented without clearly defined impact pathways and theories of change, and programs often do not have systematic monitoring and evaluation in place, thereby making key information on food systems often unavailable (15). For example, individual commodity value chains are an important intervention pathway to improve nutrition and link smallholder producers with higher-value markets that can provide additional

TABLE 1 Key challenges in food systems in LMICs and proposed solutions[1]

Challenges in food systems	Proposed solutions
1. Complexity of food systems	• Refinement of concepts and definitions through research and across specializations • Tools and metrics can be refined, simplified and standardized, and approaches developed to allow the collection of data at national and subnational levels
2. Scarcity of data on food systems	• Collection on data in systematic and simplified approaches across countries • Development of dashboards and other resources tracking progress in food systems
3. Lack of appropriate tools and indicators for the measurement of food systems, including diet quality, food affordability, and drivers of food choices in LMICs	• Development and validation of tools and indices for measuring diet quality, assessing both micronutrient adequacy and consumption of healthy and unhealthy foods • Development and validation of tools for assessing affordability • Increased research to determine the drivers of food choices
4. Knowledge gaps: Which food systems interventions are effective in improving diets and addressing suboptimal nutrition in LMICs	• Innovation and research in technology to increase the production of nutrient-dense food crops such as legumes and beans, small livestock production • Improvements in genetics and market linkages for nutrient-rich food crops, biofortification, small livestock production • Well-designed interventions to evaluate the effectiveness of agriculture and food systems approaches to improving nutrition, considering intermediary outcomes (e.g., dietary diversity, the role of markets) • Design and test innovative approaches for scale-up of effective interventions and conduct pilot studies and operations research
5. Environmental risks to nutrition	• Research on new technology and innovation in the areas of management practices and pest control, and actions taken to prevent natural resource degradation • Innovation in farm management practices (e.g., agro-ecological approaches, adopting pollinator-friendly practices to improve yields of fruits, vegetables, nuts, seeds, and legumes)
6. Interdisciplinary training and skills are lacking	• Interdisciplinary approaches in research and groups undertaking work on food systems (include economists, social scientists, behavior-change experts, agriculture experts) • Pre- and in-service training for agriculture, health, food science, and other groups (such as extension staff) to include nutrition training • Cross-disciplinary and multisector training through short courses, joint training, and learning approaches across various sectors

[1]LMIC, low- and middle-income country.

income to purchase nutritious foods. However, research on value chains rarely addresses nutrition or diet quality directly, and data on how they can impact nutrition are often unavailable (14).

Alternative approaches have focused on the identification of intermediary or short-term outcomes on the pathway between food systems and nutritional impact, such as diet quality, food access and markets. It is important to understand the influence of food systems on these outcomes and their resultant effects on nutritional impact. In many LMICs, there are no nationally available data on diet and access to nutritious food, and insufficient research has been conducted on how these relate to nutritional outcomes.

Measurement of diet quality and food affordability

There is a need for better data on dietary intake and improved methodological approaches for measurement of diet quality, access, cost, and affordability, and a better understanding of the associations of these factors with poor nutrition outcomes. The EAT-Lancet commission recommends that food systems shift to support diets that are healthier for people and the planet, composed of diverse plant-based foods, with low intake of animal-source foods and saturated fats, refined grains, highly processed foods, and added sugars (1). However, concerns have been raised that current food systems cannot provide these recommended diets for all at a global level. A recent study highlighted that healthy diets remain unaffordable for at least 3 billion individuals (4). Therefore the collection of data on affordability of healthy diets at national and subnational levels is important (4, 16) and will enable the design and targeting of policies that address existing gaps.

There are critical gaps in the availability of appropriate metrics and indicators for the measurement of diet quality in LMICs. While there is general agreement on what healthy diets should provide, there are different definitions of healthy diets globally (17), and their measurement in nutrition programs lags behind most other causes of malnutrition. Different extents of disease burdens (undernutrition/starvation vs. micronutrient deficiencies/e.g., anemia vs. overnutrition/metabolic issues) in different regions of the world make it hard to propose unified indicators. For ease of measurement, indices that do not require food-composition data may be easier to adopt in LMICs. Clear definitions of healthy diets would make it easier for policymakers and implementers to track the performance in their countries toward attaining the healthy diets.

The development of metrics to measure diet quality in LMICs and their validation is also critical towards improving our understanding of diets and food systems globally. Currently, the Minimum Diet Diversity for Women (MDD-W) indicator is commonly used as a measure of dietary diversity for women (18). However, the MDD-W has been validated for micronutrient adequacy only and does not assess overall diet quality (19). Research is ongoing globally to refine and validate metrics for the measurement of diet quality that consider the consumption of healthy and unhealthy foods concurrently and allow for the tracking of changing dietary patterns in LMICs. Several diet-quality indices have recently been developed, including food-based approaches such as the Global Diet Quality Score (GDQS) and its predecessor, the Prime Diet Quality Score (PDQS) (20, 21), and a suite of indicators on Global Dietary Recommendations (GDR) (22). The GDQS is currently being validated for associations with anthropometry, nutrient adequacy, clinical biomarkers, and NCDs in 5 regional contexts. The PDQS has been previously associated with diet-related chronic diseases including cardiovascular disease and diabetes in developed-country contexts (20, 21). A recent study found that prenatal maternal PDQS was associated with low birth weight, preterm birth, and fetal loss in urban Tanzania (23). Furthermore, another study found that food crop diversity and women's participation in income activities were associated with the PDQS in rural Tanzania, and there was evidence of effect modification by distance to markets (24).

The GDR score has been validated to reflect diet patterns that meet existing global dietary targets, such as meeting the WHO recommendations on adequate fruit and vegetable consumption, low sugar consumption, and avoidance of processed meat (22). These indicators have not yet been applied globally to quantify the extent of poor diets or to measure changes in diets related to the nutrition transition. However, there are efforts underway to scale up implementation of a food group–based Diet Quality Questionnaire (DQ-Q) within the Gallup World Poll, with the aim of collecting comparable dietary data across most countries globally (25). In addition, the Demographic and Health Surveys are now starting to collect MDD-W data, using part of the DQ-Q.

In addition, an understanding of the factors that influence dietary intake in LMICS, including personal preferences and desirability and access to healthy foods, is required if prevailing nutrition problems are to be addressed. To this end, the development of metrics and methods to measure food environments and to evaluate the drivers of food choices and dietary intake is important, in addition to actions to improve them. The Cost of Nutrient Adequacy and Cost of Recommended Diet are 2 metrics that have been developed to determine the cost of nutritious diets (4, 16). Actions to improve food environments include the FAO Urban Food Systems Assessment, which promotes environmentally sustainable cities, and the Global Treaty for Food Systems (26), which seeks to influence food systems to promote healthful diets.

Outstanding issues in this area include *1*) the standardization and validation of diet quality and other scores globally, including for associations with poor nutritional outcomes; *2*) scaling up measurement; and *3*) considering issues of environmental sustainability. Issues of sustainability of food production systems are not currently being captured in dietary metrics, including the GDQS, although this is a future area of metric development. Standardization of scores globally allows for cross-country comparisons. In addition, the development of metrics to measure other areas of food environments, such as convenience, preference, and desirability, which influence food choices, will be important.

Implementation gaps/what works

There is limited evidence on which food systems interventions are effective in improving diet quality and addressing malnutrition in LMICs. While evidence is increasing for interventions such as the production of nutrient-rich crops and biofortification, homestead gardens, diversification of crop production, small livestock production, and aquaculture and their role in improving nutrient intake and nutritional outcomes (27, 28), many gaps remain. It is unclear which pathways from agriculture to nutritional outcomes improve dietary diversity most and how this varies across contexts, such as in subsistence agriculture versus commercial agriculture, and combinations thereof. A deeper examination of this question is necessary to improve nutrition outcomes in different locations (28). Furthermore, the role of women's empowerment in agriculture as a means to improving nutrition is yet to be rigorously evaluated (28).

Food systems interventions in LMICs have traditionally focused on addressing problems related to undernutrition and micronutrient deficiencies. However, many LMICs are undergoing nutrition transition, and dietary patterns are increasingly characterized by consumption of refined and ultra-processed foods and beverages (29, 30). This has been occurring in both urban and rural locations, with greater frequency in the former. With increasing globalization, some of these foods are imported, while local production of processed foods is also increasing in many LMICs. This has led to an increased prevalence of overweight and obesity, not only in the middle- and high-income urban households in these countries, but also among the poor urban and rural households (11, 31). Research on this topic, however, has not kept pace with rapidly changing dietary patterns in urban and rural locations in LMICs. In addition, there is limited knowledge on how people interact with food environments in LMICs to make food choices that influence their risk for micronutrient deficiencies, undernutrition, obesity, and NCDs (32). And, the interplay of global or regional food systems with local food systems in LMICs to influence nutrition transition and consumption behavior is also unclear. There is an urgent need to develop research to concurrently address these issues (12, 14). Moreover, from the farm and community levels to the regional and ministerial levels, there is a lack of integration of efforts and programs to address these issues concurrently.

Given the complexities of food systems, nuanced local considerations and actions are needed, and these can be explored through research and pilot studies. Efforts to develop appropriate solutions should be informed by an understanding of the multisectoral nature of problems in food systems and this complexity has to be reflected in the evaluation methods. However, evaluations of food systems interventions are few and far between, and when they have been done, they were often poorly designed (33). In addition, an issue that may also occur is publication bias, as occurs in other areas of public health, where positive findings are often reported compared to null findings. The strengthening of evaluation designs is essential for detecting program impacts and to inform programs and policy (14).

In addition, feasibility studies to pilot innovative food systems interventions and approaches are required (34). Delivery science and operations research that includes studies on the processes, contexts, and determinants of how to deliver effective food systems interventions at

scale to targeted groups is required, as is formative research and the use of both qualitative and quantitative approaches (mixed methods) to meet these gaps (14).

Environmental risks to nutrition

One of the major challenges for global nutrition is that rapid environmental change threatens food production. Rising carbon dioxide levels are making food less nutritious (35), and declines in pollinating insects are further reducing intake of critical food groups like fruits, vegetables, and nuts and seeds (36). In addition, ocean warming is reducing fishery sizes and altering their distribution, with impacts on who has access to fish and their nutrients (37), and climate change threatens crop yields—for example, due to increases in the occurrence of adverse weather events such as drought and flooding (38). Furthermore, global pollution of air, water, and soil impacts crop yields and quality, whereas water scarcity and arable land degradation impact production. All of these factors may have the effect of decreasing agricultural production, decreasing the availability of nutrient-rich foods such as fish, and decreasing the nutritional quality of fruits and vegetables for consumption (39–41). Therefore, it is imperative to factor in a deeper understanding of the interactions of food systems with environmental factors, in addition to the potential implications for health.

Interdisciplinary training and skills are lacking

A notable limitation in both research and practice related to food systems is that efforts are often siloed by discipline, with nutrition, epidemiology, agriculture, agricultural economics, and other fields having different approaches and priorities. While cross-disciplinary work is limited, the problems in food systems and nutrition are multidisciplinary, and solutions therefore require multisector approaches. For example, to achieve improvements in nutritional outcomes at scale from food systems interventions, practitioners and researchers must engage in new partnerships, including with agriculture and food science sectors, to develop new technologies for home or small-scale processing of nutrient-dense crops and preservation and storage to prevent losses through the value chain. Engagement with partners in economics, social sciences, and business can assist with developing food value chains that benefit small-scale farmers (14). Food systems researchers will also need to engage with policymakers in order to influence policies on trade that have significance for enhancing productivity for small-scale farmers (14). Without the transfer of knowledge and skills across disciplines and areas of expertise, it will be difficult to implement impactful food systems interventions at scale.

Solutions

The conference discussed potential solutions next, and these included actions in the following areas.

Tools and data availability

The refinement and validation of tools to measure diet quality, availability, and affordability of healthy diets and drivers of food choices are required across countries. Where tools can be refined and simplified to allow the collection of data at national and subnational levels, this will greatly enhance the tracking of these indicators and the use of data to inform programs and policies in LMICs. Increasing data collection and knowledge sharing on food systems is critical for enhancing knowledge of nutrition practitioners and ensuring informed design and implementation of food systems interventions.

Siloed responses and approaches to addressing challenges in the food systems within areas of expertise and limited knowledge sharing across disciplines are also a challenge. The collation of information on food systems, including tools and results from evaluations in central locations, will greatly improve access to those tools and resources and foster cross-discipline learning. It is also critical for the promotion and use of the same tools across countries and programs.

Currently, efforts to address these issues have led to the development of dashboards including the Food Systems Dashboard, which provides guidance on priority actions to improve food systems impact on diets and nutrition (42). This dashboard collates information from multiple sources and indicators for tracking food affordability and availability across countries. These efforts can be taken a step further by including more indicators and expanding on areas of food systems that are included as well as a higher geographic resolution (e.g., subnational data).

There is limited availability of data on which food systems interventions and approaches are successful in improving nutrition in LMICs. There is a need for the development of innovative interventions and pilot studies to evaluate the efficacy of interventions and policies to intervene in food systems, and the documentation and sharing of available knowledge are critical. Documentation of the scale-up of successful innovations and implementation processes through implementation research and well-designed evaluations is necessary. This will provide information that can be used to refine future programs, determine limitations of interventions, and provide valuable insights to policymakers. Finally, it is important to continue to strengthen oversight of research studies (randomized controlled trials and observational studies) and promote ethical research that will benefit the communities from whom data are collected.

Donors have a critical role to play, by availing resources for pilot studies and scaling-up of effective food systems interventions, as well as providing sufficient funding in intervention programs for evaluations and the collection, collation, and sharing of information. The costs for well-designed evaluations are high and have to be sufficiently accounted for during the program design phase.

Innovative approaches to improve availability and affordability of healthy diets

Globally, while there is a recognition of the importance of healthy diets, one of the factors that represents a bottleneck is insufficient production of nutrient-dense foods. This, in turn, affects the affordability of nutrient-dense foods such as animal-source foods and fruits and vegetables. Innovation and research are required in technology to increase the production of nutrient-dense food crops, including legumes and beans. This can include research into genetic improvements for nutrient-rich food crops and biofortification and small-animal agriculture. In addition, research on new technology, including labor-saving agricultural technology, and innovation in farm management practices, such as agro-ecological approaches or adopting pollinator-friendly practices to improve yields of fruits, vegetables, nuts, seeds, and legumes, is needed. Pest control to increase agricultural productivity, availability and

affordability of crops and livestock products is important. The production of equipment for home and small-scale processing and providing cold chains that will decrease food losses for perishable foods such as fruits, vegetables, and animal-source foods are also required. Research is also needed on innovations in storage and food safety across value chains, including treatment of aflatoxins. Finally, developing biosecure food systems, sufficiently segregated from wild animals that carry zoonotic disease, is critical. The funding of research in these areas by government and public and private sector players will be worthwhile investments towards transforming food systems in LMICs.

In addition, the promotion of processing of nutrient-rich foods is critical for enhancing dietary intake in both rural and urban areas. In many regions, the consumption of ultra-processed foods and drinks is increasing (43), contributing to poor diet quality. There is a need to increase research and investment to increase production of nutrient-rich processed foods to meet the demands for convenience and taste preferences for consumers. For example, increasing the availability of nutrient-dense processed complementary foods may help enhance nutrient intake and complement food-based approaches (44). Improving the availability of nutrient-dense foods is key for improving nutrition for many in LMICs.

Interdisciplinary training and responses

The conduct of policy-relevant research on food systems using an interdisciplinary systems approach—for example, to understand the drivers and determinants of food choices, as well as addressing gaps in evidence and practice—is critical (14). Several steps can be taken to rectify the siloed approach to understanding the problems and designing interventions, and these include encouraging cross-disciplinary and multisector training through short courses, joint training and learning approaches, and including multidisciplinary approaches and teams in conducting research and implementation of interventions on food systems.

The training of researchers and practitioners in the areas of nutrition, food science, agriculture, economics, and other sectors should include an understanding of the multidimensional nature of food systems, and incorporate tools and metrics from other sectors. The curricula and preservice training for health workers, such as nurses, agricultural development and extension agents, crop production and food science experts, should also integrate nutrition. In addition, experiential training opportunities and in-service training for these cadres should reinforce this. At the program level, teams designing, implementing, and evaluating nutrition and food systems programs should be multidisciplinary so as to incorporate methods, approaches, and tools from the various sectors. This is imperative if food systems interventions are to be effective.

Areas for Further Research

Finally, the conference highlighted the importance of research to address some of the noted challenges in food systems. Areas for food systems research and priority questions that are important for researchers, practitioners, and local governments were identified. These include the following: *1*) measuring the effectiveness of food systems interventions on nutrition, aligned with theories of change and impact pathways; *2*) validating indices for measurement of healthy diets and diet quality; *3*) engagement with private and public sectors to address bottlenecks in food systems in LMICs; and *4*) understanding how rapidly changing global environmental conditions might constrain production and distribution of, and access to, nutritious diets and developing interventions to address these challenges. Research around innovative approaches to improve food systems and to scale up proven interventions with appropriate implementation research were also identified as critical if food systems interventions are to be effective. We highlight several priority questions for research discussed by conference presenters and nutrition experts, students, and other attendees.

1. The role of women's empowerment and their effects on nutritional outcomes. The conference highlighted that given the critical role that women's empowerment has in improving nutritional outcomes for women and children, efforts to develop simpler tools to measure empowerment were required. In addition, innovation in designing proof-of-concept interventions in women's empowerment is critical, so that effective interventions can be easily identified and incorporated into development programs (45).
2. Cross-sectoral collaboration. Research into how multiple actors including consumers, producers, academicians, processors, and donors can collaborate with governments to address key challenges in food systems is required. While these efforts can be led by service organizations or academic institutions, the investment of resources by donors is critical for sustained solutions.
3. Public and private sector engagement. The role of the private and public sectors in innovation to improve nutrition and diet quality, and influence food systems in LMICs, is underresearched. Because the share of food purchased by consumers through the market has increased over time at all income levels, there is a need to engage the private sector (including agri-food businesses and retailers, medium-scale and small-scale processors, and the food service sector) to develop solutions to poor diets, and to more effectively consider the role of markets in efforts to improve nutritional outcomes (34). Identifying cases studies where the private sector has been effective in this regard would be valuable.
4. Policy approaches. The absence of policies and legislation to correct imbalances or to restrict advertising of unhealthy foods to children may be an important contributing factor to poor diet quality in LMICs (46). In addition, national policies are required that concurrently address micronutrient and calorie deficiencies that are still prevalent in urban and rural areas, as well as increasing obesity and NCDs in LMICs. There is limited experience in which policies can jointly address these issues, and innovation is required to adequately address this issue given limited government resources in many LMICs. Further study of approaches to improve food choices by consumers is needed.
5. Finally, research is also required to prevent natural resource degradation and address emerging issues, such as issues of climate change and biodiversity loss and food safety across value chains. Given competing challenges, these areas are often underfunded. However, it is imperative that they be addressed to secure future production of healthy and nutritious diets and to minimize adverse health outcomes while ensuring minimal environmental impact.

Conclusions

The Sustainable Development Goals (SDGs) specify targets to end hunger and ensure access by all people to safe, nutritious, and sufficient food by 2030 (47). They also target decreasing premature mortality from NCDs and include goals for reducing food waste. However, it is important to note that the SDGs do not include a target on diet quality. The SDGs are intricately linked to food systems, and addressing food systems is key to meeting the SDGs globally (17), specifically in Africa and South Asia. These regions face the worst of undernutrition and increasing risk of NCDs (48), the latter driven in part by transformations in food systems and diets as in other LMICs and the move towards unhealthy patterns of food production and consumption (49).

The challenges of food systems in LMICs are varied. They include poor agricultural productivity, characterized by rain-fed agriculture, limited public investment, and poor access to high-yielding seed varieties and low fertilizer input, leading to chronic food deficit, persistent rural poverty, and high food insecurity and limited availability and unaffordability of nutrient-dense fruits, vegetables, and animal-source foods (50–53). Combined with gender disparities and sociocultural factors, these challenges adversely affect nutrition for women and children in LMICs. In addition, poor food environments are increasing the availability and consumption of refined grains and processed and other unhealthy foods. Thus, food systems in LMICs are under threat.

Food systems in LMICs have the potential to address these system failures and prevent micronutrient deficiencies, child stunting, maternal underweight, obesity, and other related diseases. Addressing the problems within food systems requires taking a systematic approach and acting locally to address identified challenges. Harnessing the strengths of the public and private sectors, and strengthening collaborations across disciplines is imperative for improving food systems for nutrition. Strengthening of research around food systems—on pathways, value chains, diet quality, the development and validation of tools, and monitoring and tracking of progress—is required to develop informed responses. Research on new technology and innovation in the areas of management practices and pest control and actions taken to prevent natural resource degradation is also imperative.

The translation of research findings to policy is critical for food systems. Examples of successful policy implementation should be shared broadly and used widely to improve outcomes. Finally, financial investments by various donors and their engagement in the development of solutions are necessary to promote upstream work for diet quality and food systems. Collective and coordinated action by multiple stakeholders in science, practice, and funding agencies can contribute to enhancing food systems for the benefit of vulnerable women, children, and households in developing regions, and will lead to improved nutritional outcomes globally.

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