

Integrating nutrition and food safety in food systems policy and programming

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ARTICLE INFO

Keywords:
Nutrition
Food safety
Food systems

ABSTRACT

Food safety and nutrition are inextricably linked: to achieve optimal human health and wellbeing, people must be both well-nourished and free from foodborne disease. Despite these linkages, the connections between food safety and nutrition have been largely lacking from existing frameworks for food systems, which tend to treat food safety superficially, as only one sub-component, not integrated throughout. As a result, they do not highlight relevant pathways for integrated action and measurement related to food safety and nutrition. Policy and programming tend to be implemented from either a nutrition standpoint or from a food safety standpoint; the two groups of stakeholders are often non-overlapping, even though both are concerned with improving public health through the food system. This Perspective highlights a set of specific causal pathways through which food safety and nutrition are interlinked (across health and physiology, consumer behavior, supply chains and markets, and policy and regulation). We then build upon these underlying causal mechanisms to discuss areas for action on food safety and nutrition within the food system. Finally, we suggest ways in which better integration of the two issues could take place within policy and programming, including key barriers to doing so.

1. Introduction and motivation

To further human health, diets must consist of foods that are both nutritious and safe: they must enable people to meet (without exceeding) nutrient requirements and not expose them to foodborne illness. Currently, this is not the case for a much of the global population. Malnutrition in all its forms affects one in three people and is associated with economic costs of up to \$3.5 trillion USD per year (Global Panel, 2016), with diet-related risk factors responsible for about 22% of adult deaths (Afshin et al., 2019). At the same time, foodborne diseases (see Box 1 for definition) are estimated to annually cause 600 million illnesses, particularly among lower-income consumers and young children in lower-income countries (Havelaar et al., 2015; Kirk et al., 2015), with annual economic costs estimated at \$110 billion USD (Jaffee et al., 2018).

The food system must have a mandate to make nutritious, safe food accessible to all; it is currently failing to do so. Efficient and effective

food-systems action to improve nutrition and reduce foodborne disease requires synergies that seek to improve access to nutrient-dense foods while simultaneously improving their safety. However, the two issues are often addressed in isolation. They are not monitored, analyzed, or tackled jointly, be it in legislation, guidance, measurement, or research. In this perspective, we will examine how food safety and nutrition are inextricably linked and contend that these linkages deserve greater attention in nutrition, food security, and food systems research, policy, and programming.

2. Food safety and nutrition are closely interlinked

Bidirectional causal pathways exist between food safety and nutrition: food safety issues influence nutrition, and nutrition issues influence food safety. The two interact in determining health outcomes and impact societal outcomes, such as livelihoods. Fig. 1 offers a non-exhaustive visual summary of these linkages, which we categorize into four types:

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Box 1**Key Terms**

Foodborne disease: Any disease (acute or chronic) of an infectious or toxic nature caused by the consumption of food (including beverages) (WHO, 2008). Foodborne disease can be caused by microbial, chemical, or radiological hazards.

Food safety: Assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (Codex Alimentarius Commission, 1969). Food safety is not binary—food can rarely be seen as clearly ‘safe’ or ‘unsafe’—but rather a continuum spanning different levels of safety.

Malnutrition: Refers to “deficiencies, excesses, or imbalances in a person’s intake of energy and/or nutrients.” It encompasses undernutrition (including wasting (low weight-for-height), stunting (low height-for-age), and underweight (low weight-for-age)), micronutrient-related malnutrition (deficiencies or excesses of vitamins and minerals), overweight/obesity, and diet-related noncommunicable diseases (NCDs) (WHO, 2020).

Nutritious food: A food that, in the context where it is consumed and by the individual who consumes it, provides beneficial nutrients (e.g., vitamins, major and trace minerals, essential amino acids, essential fatty acids, dietary fiber) and minimizes potentially harmful elements (e.g., anti-nutrients, quantities of saturated fats and sugars). This definition thus encompasses both foods that can contribute to preventing undernutrition and those that can help prevent overweight/obesity and diet-related NCDs (GAIN, 2017).

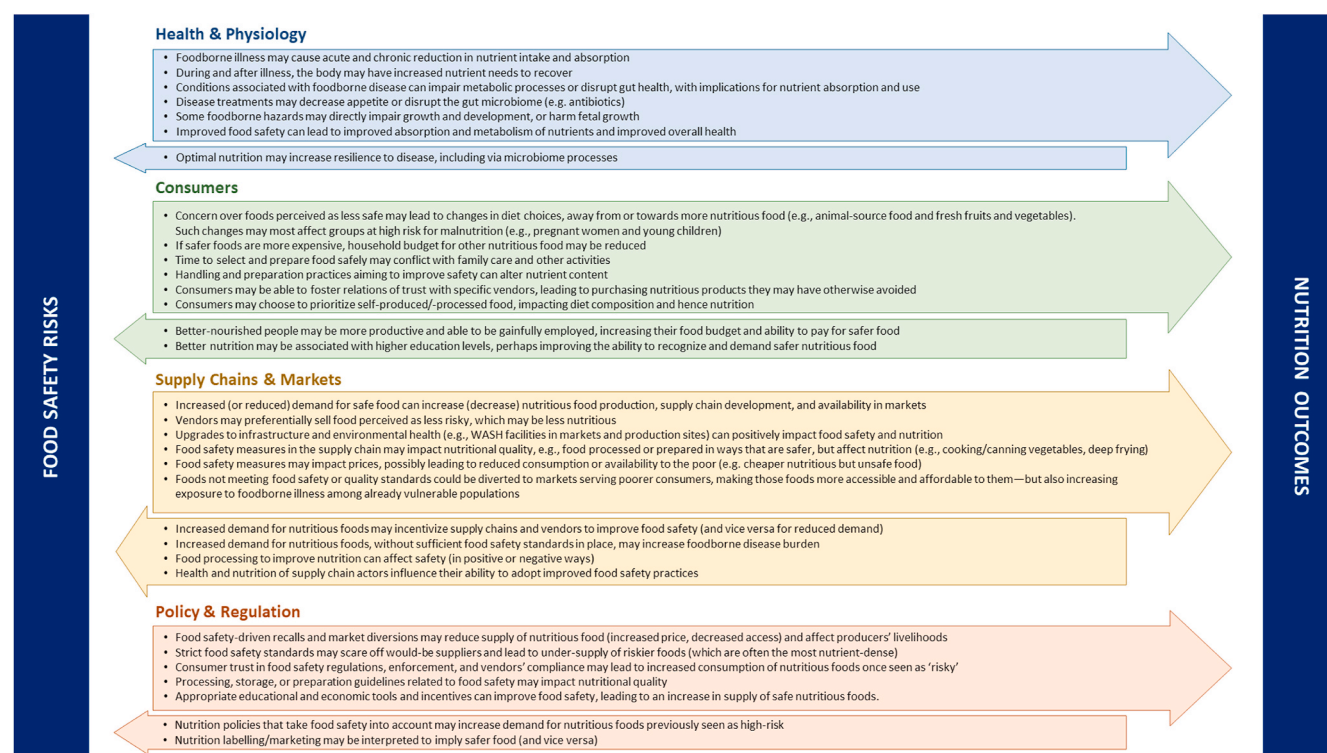


Fig. 1. Linkages between food safety and nutrition (Note: not weighted by impact or strength of evidence).

health and physiology, consumer behavior, supply chains and markets, and policy and regulation.¹ With the partial exception of physiological impacts, for which evidence is growing (GAIN, 2020), other impact mechanisms are more speculative, lacking rigorous evidence. We present them to illustrate a range of potential mechanisms, foster discussion, and highlight knowledge gaps.

Health and Physiology. The most obvious linkages between food safety and nutrition are physiological, beyond the chronic and acute effects of either foodborne disease or malnutrition alone. Certain mechanisms that have historically been described as either foodborne

disease mechanisms or malnutrition mechanisms can increasingly be understood as interconnected physiological responses within the human organism. For instance, foodborne disease can increase the risk of undernutrition. Many foodborne diseases involve acute gastrointestinal distress, including reduced appetite, vomiting, and/or diarrhea (Grace, 2015), which can lead to decreased nutrient intake and/or absorption, either acute or chronic (Checkley et al., 2008; Guerrant et al., 1992; Schaible and Kaufmann, 2007). Environmental enteropathy, a complex syndrome including intestinal inflammation and epithelial damage, has been associated with stunting (Budge et al., 2019; Harper et al., 2018). Acute foodborne disease depletes the organism and may increase nutrient needs during recovery. Exposure to certain foodborne hazards may impair metabolic processes responsible for properly utilizing nutrients or connected to developmental outcomes (Bahadoran et al., 2015; Cano-Sancho et al., 2017; Welch et al., 2019). Disease and

¹ This categorization is the perspective of the authors based on a review of the existing literature and feedback from a virtual workshop with over 30 experts in food safety and/or nutrition.

sub-clinical chronic exposure to microbes may also disrupt the gut microbiome, with potential implications for nutrient absorption and metabolism (Kho and Lal, 2018; Parekh et al., 2015). Finally, drugs used to treat foodborne disease may also disrupt the gut microbiome, impacting nutrient intake, absorption, or metabolism (Konstantinidis et al., 2020; Schwartz et al., 2020). Foodborne disease can also contribute to longer-term health outcomes. For example, certain foodborne diseases or exposure to hazards during pregnancy can impair fetal growth or survival (Lamont et al., 2011; Li et al., 2014; Tran et al., 2015), while aflatoxins may impair growth, although this is disputed (Kyei et al., 2020).

At the same time, nutrition also has physiological linkages with foodborne disease: optimal nutrition can strengthen the immune system and enhance resistance to infectious disease (Calder et al., 2020; Childs et al., 2019; Katona and Katona-Apte, 2008), including via microbiome processes and gut health (Kho and Lal, 2018). Similarly, poor nutrition, including overweight/obesity and diet-related non-communicable diseases can, over time, increase susceptibility to or severity of certain diseases (Calder et al., 2020; Katona and Katona-Apte, 2008; Kim et al., 2019; Liu et al., 2011). (No link between overweight and obesity and disease susceptibility has been identified for foodborne disease, specifically—an important gap in evidence).

Consumer Behavior. Food safety and nutrition are also linked through consumer behavior—which, compared to health and physiology, is malleable and shaped by perceptions and context. For example, fear that a food may be unsafe can lead to avoidance of that food (Cornelsen et al., 2016; Grace, 2016; Häslér et al., 2017, 2019; Nguyen-Viet et al., 2019); this is particularly relevant because some of the most nutritious foods also pose the greatest food safety risk (e.g., animal-source foods, fresh vegetables (Alonso et al., 2019; Grace, 2015)). Food avoidance can arise through personal experience with foodborne illness of oneself or a personal contact or through media coverage of disease outbreaks (Qiao et al., 2010). Worries over particular foods may also shift consumption to foods perceived to be safer, leading to either poorer or improved diet quality, depending on the nature of the shift (Trübswasser et al., 2021).

Other behavioral linkages between food safety and nutrition are less obvious, with less supporting evidence, but we can hypothesize several linkages. For example, if consumers choose to pay higher prices to ensure safer food (or avoid lower-priced options as ‘less safe’), this may impact their overall food budget, shifting diets towards more affordable foods—which are sometimes of lower nutritional value. Similarly, if consumers perceive foods as potentially less safe, they may increase the time spent choosing or preparing food to improve safety, reducing the time available for other activities—including health maintenance, exercising, and/or caring for young children, all linked to nutrition. Nutrition may also impact food safety issues through consumer behavior. Better-nourished, healthier consumers likely have more physical and mental energy to spend in food procurement and preparation, perhaps improving their ability to make choices regarding food safety, especially once basic food needs are met. They may also be more economically productive and thus face fewer constraints to purchasing safer foods. Over the long term, better nutrition in early life is associated with higher cognitive levels and educational attainment; this may lead to better informed, more literate consumers, with the income and ability to demand safer (and more nutritious) foods. While neither of these latter pathways are yet directly substantiated by evidence, they illustrate how food safety and nutrition may be linked.

Supply Chains and Markets. Food safety and nutrition may also impact one another through dynamics within supply chains and markets, though scientific evidence on this is also limited. For example, if consumers demand improved safety of a food commodity, market vendors may respond, either by improving safety at the retail stage (i.e., through actions under their control), or by sourcing safer products. This could result in positive effects (e.g., improved food safety across the value chains of nutritious foods), or negative effects (e.g., movement of

vendors towards foods for which it is easier to maintain safety, such as processed foods, decreasing the availability of fresh nutritious foods) (Grace and McDermott, 2015).

Storage, handling, and processing practices within a supply chain, aimed to improve safety, could affect nutrient levels—positively or negatively. For example, fermentation, high-heat treatment, drying, and preserving with salt are all processing practices aiming to improve safety or shelf life that can also affect nutrient content (Amit et al., 2017). Food safety measures in the supply chain may increase prices, impacting consumption (particularly among lower-income consumers) and producer or vendor profits and livelihoods (Focker and van der Fels-Klerx, 2020; Hoffmann et al., 2019). Finally, nutritious foods known to be contaminated could be diverted to markets serving poorer consumers, making those foods more accessible to them—but also less safe.

Considering linkages in the other direction, increased demand for nutritious (but risky) foods could incentivize supply chain actors to improve their food safety (and vice versa for reduced demand). Food processing aimed at improving nutrition (e.g., fortification) offers an easy in-road to simultaneously improve food safety (e.g., through equipment installation and process upgrading) but may also introduce poor quality ingredients and improper/hazardous dosage of fortificants that must be judiciously administered. Upgrades to market infrastructure and efforts to improve environmental health (e.g., installing improved sanitation facilities in markets), if properly maintained, can positively impact both food safety and nutrition. Finally, as with consumers, the health and nutrition of supply chain workers could influence their productivity and (in the long term) cognitive capacity/education, perhaps affecting their ability to adopt improved food safety practices.

Policy and regulation. Among these impact mechanisms, safety-driven market diversion of food products (e.g., condemning products, culling livestock) could reduce the supply of nutritious food (Hoffmann et al., 2019), increasing price and decreasing access. While context-appropriate and achievable food safety standards could incentivize greater supply of nutritious foods, strict standards could lead to reduced supply (Sirma et al., 2018), if producers decide to produce less. Recalls and market diversions may also affect the livelihoods of those whose product is rejected (Focker and van der Fels-Klerx, 2020), with implications for their food security and nutrition—while food safety certifications that allow producers and vendors to sell ‘certified safe’ products at a premium or access lucrative export markets could have the opposite effect (Hawkes et al., 2015). Consumer trust in food safety regulations, oversight, and compliance could increase their willingness to consume foods previously considered at higher risk, likely improving dietary quality.

Considering linkages from nutrition to food safety, nutrition-related interventions that increase demand for a food that is currently high-risk could increase foodborne disease burden if appropriate food safety measures are not also introduced or already in place. Poorly crafted nutrition labelling or marketing could be misinterpreted by consumers to imply safer food, when it in fact only relates to nutrient content. This hypothetically could alter the behavior of supply-chain actors and consumers (e.g., less careful cleaning/processing).

3. Food system approaches can help integrate food safety and nutrition

Using a framing focused on the food system, and designing policies/programming accordingly, allows for considering these interlinked food safety and nutrition processes, situated within a larger context of relevant forces. Food systems include all actors and activities that play a role in production, processing, distribution, preparation, and consumption of food (HLPE, 2017). They include food supply chains, food environments, and consumer behaviors. Food safety is mentioned in recent food system frameworks, but only partially, and its links to nutrition are often overlooked or left unexplained. For example, the widely used High-Level Panel of Experts’ food system framework mentions ‘safety’ only in

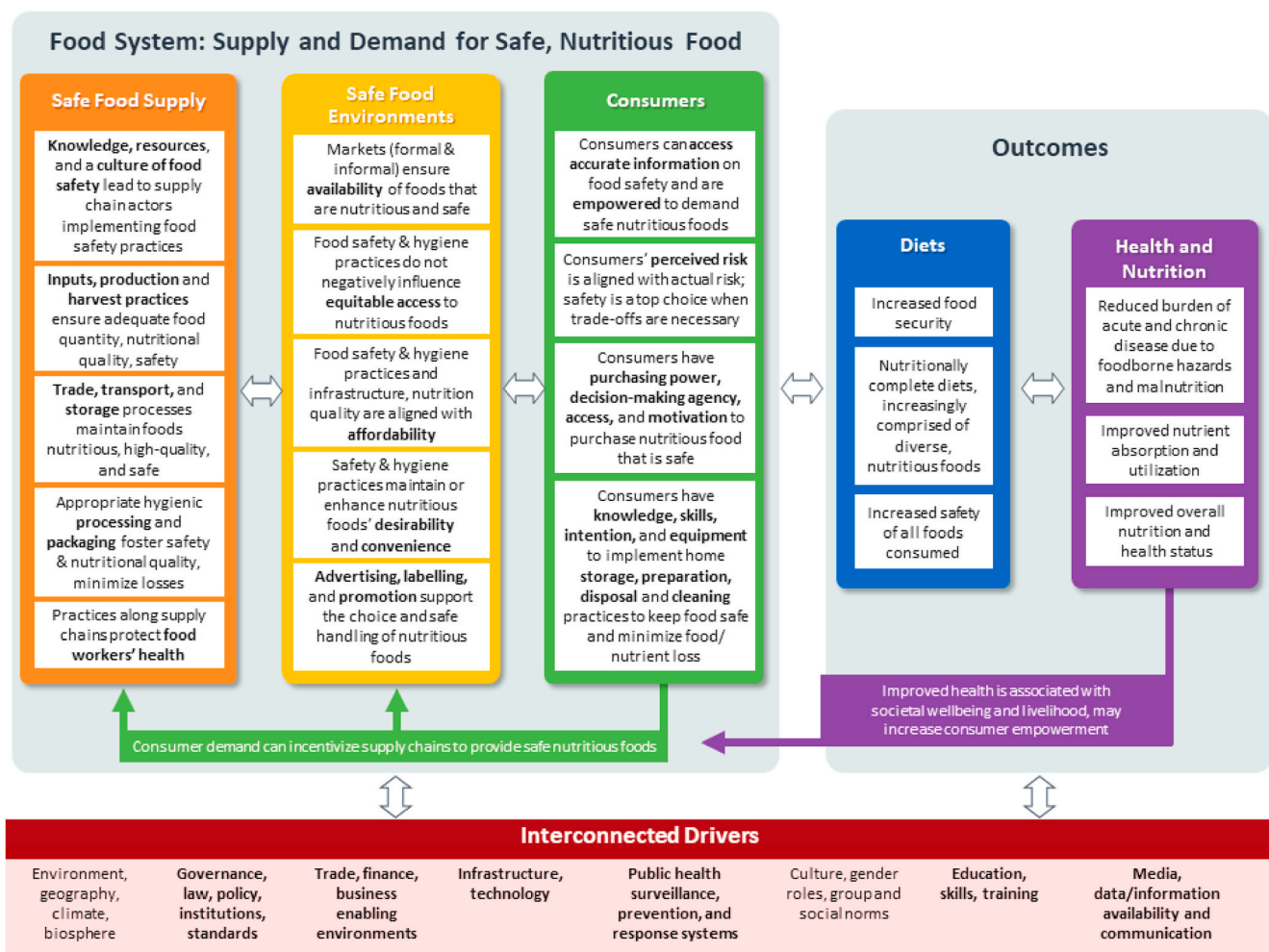


Fig. 2. The food system through an integrated “food safety and nutrition” lens.

Box 2

Areas for Integrated Action on Food Safety and Nutrition within Food Systems

Food supply chains must ensure nutritious foods are produced in sufficient amounts and with adequate controls on quality and safety, so that both safety and nutrition are considered and/or retained throughout. For example, at the farming input stage, soil additives can reduce contamination levels of soil-borne pathogens on nutritious groundnuts. At the processing and packaging stage, it is essential to ensure that processes to enhance safety (e.g., canning, smoking) do not reduce content of beneficial nutrients (e.g., temperature-sensitive vitamins) or increase that of potentially harmful ones (e.g., sodium).

Food environments (places where consumers acquire or consume food (Turner et al., 2018)) need storage, preparation, and disposal practices and adequate infrastructure to keep food safe and minimize food and nutrient loss, while balancing other desirable food properties such as affordability. Advertising and labelling should support the choice and proper handling of safe, nutritious foods, such as by providing information on safe cooking practices and nutrient content.

Consumers must have the information, purchasing power, decision-making power, access, and motivation to purchase safe nutritious foods. Potential trade-offs may exist between food safety and factors such as price, convenience, and desirability, and consumers often cannot easily identify whether a food is unsafe via sight or smell (USDA FSIS. Food Safety and Inspection Service, 2019); hence access to trustworthy information is key.

Food system drivers are interconnected forces that impact (and are impacted by) food systems (HLPE, 2020). For example, socio-cultural norms may determine who in a family decides what food to buy; governance, policy, and trade standards (e.g., inspection requirements) shape system incentives, while technology can spread information quickly (e.g., mobile apps could enable government to disseminate information on recalls). Information and education, such as disease surveillance data and consumer messaging, can empower citizens to recognize and demand safe, nutritious food.

relation to food environments and diets without making explicit linkages between the two or covering food safety in depth (HLPE, 2020, 2017). A recent framework on food systems for children mentions food safety in its background, but within the framework it appears only as an “influencer” within food environments and is not reflected in other areas, such as supply chains (UNICEF and GAIN, 2019). Relevant FAO guidance on food systems mentions safety as a cross-cutting theme but does not go into details on linkages with nutrition (FAO, 2018, 2017; Uccello et al., 2017). Finally, two influential recent global reports on sustainable food systems make little/no mention of food safety (Swinburn et al., 2019; Willett et al., 2019), and a recent review of food systems research identifies food safety as an important research gap (Cliffer et al., 2019). An exception to this general lack of integrated thinking is a pathways diagram, developed by Grace, that causally links food safety and nutrition (Grace, 2016).

Looking at the food system through a lens considering both food safety and nutrition, however, highlights the multifaceted role of food safety in all food system components and its dynamic links to nutrition processes and outcomes. This is illustrated by an adapted food system visual in Fig. 2. While food safety and nutrition processes must be contextualized within specific food systems, considering aspects such as the relative role of formal and informal sectors, key areas emerge as relevant for food systems across many contexts—these are highlighted in Box 2.

4. Taking a more integrated approach to food safety and nutrition in policy and practice

Given the linkages presented here, it is important to jointly account for food safety and nutrition in policy and programming, maximizing synergies and avoiding unintended negative impacts. Analyzing policy and programmatic decisions through the lens of the food system, as described in Section 3, can help guide such decisions because it allows processes, factors, and outcomes related to both food safety and nutrition to be mapped onto a common topography and systematically includes all system components in the discussion, reaching beyond subject-area ‘silos.’

How would policy and programming look different following such an integrated approach? First, approaches could focus on critical points for each domain, such as prioritizing the supply chains most in need of strengthening to close dietary gaps key to reducing malnutrition (in contrast to, for example, mycotoxin control in staples), then focusing on the parts of that supply chain most vulnerable to contaminant entry to implement supply-chain-strengthening approaches. Second, integrated policy and programming could identify critical points where food safety and nutrition processes are synergistic as positive levers or both in need of improvement – meaning that ‘win-win’ interventions could be easily identified. An example is promoting food preparation practices that encourage greater consumption of nutritious foods while reducing food safety risks—such as fermentation, which can improve absorbable nutrient content, extend shelf life, and increase microbiological safety (Hotz and Gibson, 2007). Third, integrated policy/program approaches could pay particular attention to potential trade-offs between nutrition and food safety and design policies to monitor and mitigate them. For example, a food safety policy that increased the cost of nutritious foods (e.g., by mandating milk pasteurization) could consider pairing this with supporting new packaging and distribution methods to allow consumers to purchase safe milk in small quantities at affordable prices. Recognition of such tradeoffs will make the policies/programs more effective at addressing overall public health goals (not only those related to one of foodborne disease or nutrition).

Such an integrated approach would need to be supported by appropriate monitoring and metrics for success. This could include tracking both food safety and nutrition indicators (e.g., gastroenteric disease occurrence and stunting) to better assess cross-impacts as well as developing integrated indicators that account for synergies and trade-

offs between outcomes (e.g., relative risks/benefits from increased egg consumption, accounting for potential increased exposure to *Salmonella*).² The definition of ‘safe food’ could even be adopted to reflect the nutrition content of the food – i.e., such that a food high in added sugars or salt would be considered ‘unsafe’ due to its long-term risk of causing non-communicable disease – thereby creating an integrated metric for monitoring. Such metrics should be viewed alongside other key indicators of food systems performance, such as environmental sustainability, to track progress on transformation towards food systems more holistically supportive of human (and environmental) health.

There are, of course, obstacles to taking such an integrated approach. The first, and perhaps largest, of these is disciplinary silos among researchers, practitioners, and policymakers. Nutrition and food safety are rarely studied in an integrated manner, and expertise in the two is often not overlapping within individuals. Policies and regulations on food safety typically make little mention of nutrition (and vice versa)—for example, while the work of Codex Alimentarius includes nutrition, e.g., through a committee on “Nutrition and Foods for Special Dietary Uses,” its standards and guidelines do not generally integrate food safety and nutrition. At the national level, most food safety policy frameworks do not explicitly include nutrition criteria, as seen in examples from Kenya and Vietnam (Kang’ethe et al., 2019). Promisingly, however, the same governmental agencies (e.g., EFSA in the European Union; Food and Drug Administration in the United States) can be in charge of both food safety and nutrition standards, offering one inroad for action.

A second obstacle to more integrated approaches is the paucity of evidence on the linkages between food safety and nutrition and how to jointly address them (Grace, 2017). While logically sound, much of what we put forward in Section 2 of this paper is based on hypotheses and anecdotal, not rigorous, evidence. There is a need to undertake further research that considers food safety and nutrition in a unified manner, to further support (or refute) and refine the initial ideas presented here. As the food community builds upon the 2021 United Nations Food Systems Summit, which targetted both food safety and nutrition concerns, the time is ripe for such an integrated approach.

Author contributions

SN conceived of the paper; SN and EL led the writing of the paper; all authors contributed to the development of the frameworks on which the paper is based and to the writing and reviewed and approved of the paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors thank the participants in a November 2020 workshop for their feedback on the ideas discussed in this paper and two anonymous reviewers for their useful feedback. This study was made possible through support provided by Feed The Future through the United States Agency for International Development (USAID), under the terms of the EatSafe Cooperative Agreement No. 7200AA19CA00010. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of USAID or the United States Government. This article is based on a report developed as part of the EatSafe project.

² Doing so would require improving disease surveillance systems, as food safety-related data in many LMICs is currently scarce.

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