# NUTRITIOUS *AND SAFE* FOOD FOR ALL

IMPROVING FOOD SAFETY THROUGH FOOD SYSTEMS ACTIONS


## GAIN Discussion Paper n°16

**May, 2024**

Stella Nordhagen, Teale Yalch, Richard Pluke, Genet Gebremedhin, Wendy Gonzalez, David Morgan

gain
Global Alliance for Improved Nutrition

## ABOUT GAIN

The Global Alliance for Improved Nutrition (GAIN) is a Swiss-based foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with governments, businesses and civil society, we aim to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable.

**Recommended citation**

Nordhagen, S, T Yalch, R Pluke, G Gebremedhin, W Gonzalez, D Morgan. Nutritious and Safe Food for All: Improving Food Safety Through Food Systems Actions. Global Alliance for Improved Nutrition (GAIN). Discussion Paper #16. Geneva, Switzerland, 2024. DOI: https://doi.org/10.36072/dp.16



**Acknowledgements**

We thank all of the current and former GAIN colleagues who have helped to develop food safety programming at GAIN, particularly the team behind the USAID Feed The Future EatSafe project, as well as the partners on the EatSafe project: Pierce Mill Entertainment, the International Livestock Research Center, and Busara. This document draws on the evidence, experiences, and insights emerging from that work. We particularly thank Caroline Smith DeWaal, Elisabetta Lambertini, Bonnie McClafferty, and Lynnette Neufeld for being part of the original thinking behind taking a 'food systems' approach to food safety, Abigail Reich for her work on the GAIN Food Safety Strategy that informed this paper, and Elisabetta Lambertini for her review. All photographs included in this document have been taken with consent for use in publications.

## GAIN DISCUSSION PAPER SERIES

The GAIN Discussion Paper series is designed to spark discussion and debate and to inform action on topics of relevance to improving the consumption of nutritious, safe foods for all, especially the most vulnerable.

The Global Alliance for Improved Nutrition
(GAIN)
Rue de Varembé 7
1202 Geneva
Switzerland
T: +41 22 749 18 50
E: info@gainhealth.org

www.gainhealth.org

## SUMMARY

Foodborne disease is a major global health challenge, causing millions of illnesses every year – mostly in low- and middle-income countries – and hindering achievement of other global goals, such as improved nutrition. Since contamination of food can happen at any point 'from farm to fork', reducing the burden of foodborne illness requires a whole-of-food-system approach: one that considers all actors and activities that play a role in production, processing, distribution, preparation, and consumption of food. The objective of this paper is to discuss how to enact such a food system approach to food safety, with a focus on LMICs. We describe entry points for food safety actions across the food system. We do this by drawing on the scientific literature on food safety as well as the programmatic experiences of GAIN, aiming to provide actionable examples of how food safety can be integrated into nutrition programming – as well as to help guide new directions for such integrated programming in the future.

Evidence and examples discussed here illustrate the need to support food system actors at all steps in the food supply chain, particularly in emerging middle-income countries and while considering and including small businesses as well as informal-sector actors. Simple technologies can help to improve food safety in storage and handling, while a number of best practices (applicable to various different types of companies) have been developed to support safe food processing. However, adoption of these technologies still lags. At the retail stage, support for traditional food markets is critical, and there have been a number of recent advances in understanding of how to do this in a way that recognises the constraints of these contexts. Engaging consumers emerges as an area where more innovation is needed, particularly in terms of moving beyond education to motivate action. Finally, all of these actions need to be supported by an enabling policy environment – including the use of right-fit approaches that align to what is feasible for a given country, given the resources available. By undertaking these types of integrated actions across food systems – and also the ways in which food safety interacts with other development goals – stakeholders can help to ensure access to safe food, for all.


## KEY MESSAGES

- Improving food safety is critical for reducing the large disease burden associated with foodborne disease – and for achieving other development goals.
- To do this most effectively, approaches that consider the entire food system, including how food safety actions interact with and effect other development goals, are needed.
- Opportunities for action exist in storage, handling, transportation, and aggregation; processing; retail; consumer behaviour; and supporting policies.
- While some proven approaches, best practices, and technologies have been identified, there is a need to further support their adoption, particularly by considering the incentives behind them and users' motivation to adopt and maintain that adoption.

## BACKGROUND AND OBJECTIVE

To further human health, healthy diets must be both nutritious and safe: they must provide the nutrients people need to thrive while not exposing them to foodborne illness (1,2). However, food systems are currently failing to deliver on this. While malnutrition in all its forms remains widespread worldwide (3), foodborne disease is also a major public health challenge. Foodborne disease contributes to an estimated 600 million illnesses and 420,000 premature deaths annually (4). Additionally, foodborne disease is associated with a substantial economic cost, due to sickness, loss of life, treatment expenses, and trade consequences, with annual economic costs estimated at $110 billion USD (5). Foodborne disease is also closely interlinked with malnutrition (6): it can directly increase the risk of malnutrition, and decisions related to nutrition (among consumers, policymakers, or food suppliers) can have implications for food safety (and vice versa). The greatest food safety risks are due to microbiological hazards most prevalent in nutrient-dense animal-source foods and fresh fruits and vegetables, all of which are critical to a healthy, diverse diet (7). Improving food safety is thus key to unlocking attainment of the Sustainable Development Goals (SDGs) and other development objectives.

As shown in Figure 1, the burden of foodborne disease is inequitably distributed. The highest per-capita burden of foodborne illnesses is observed in Africa, with levels approximately 27 times greater than in Europe or North America (4). Low- and middle-income countries (LMICs) comprise about 75% of deaths (compared to 41% of the global population) (8). This makes foodborne illness a public health equity issue.

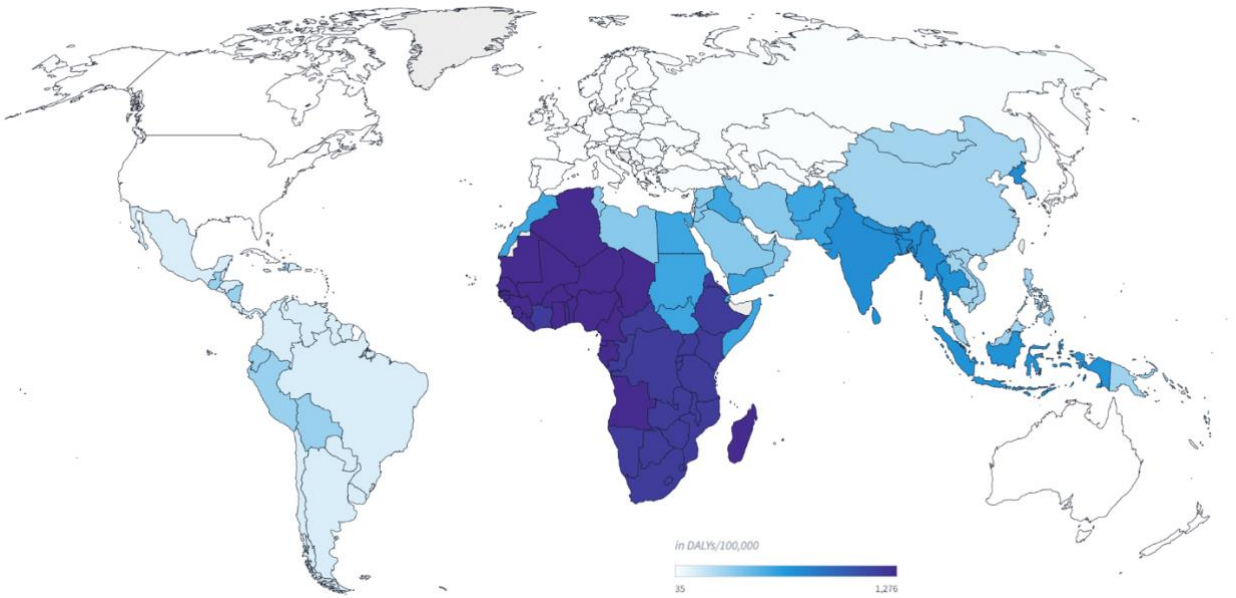


**Figure 1.** The global distribution of foodborne illness (measured in disability-adjusted life years (DALYs), a combined metric of mortality and illness. Made using 2010 data from Foodborne Disease Burden Epidemiology Reference Group (https://www.foodbornediseaseburden.org/ferg) via the Food Systems Dashboard (https://www.foodsystemsdashboard.org).

Contamination of food with the viruses, bacteria, moulds, protozoa, helminths (worms), or chemicals that cause foodborne disease can occur at any point from primary production (agriculture, livestock, and fisheries) up to the moment the consumer puts the food in their mouth (4). This includes all stages of the supply chain – production, transport, processing, storage, or wholesale, as well as the

point of sale itself, as well as household-level food preparation. Improving food safety[1] thus requires working across a whole supply chain to ensure food is kept safe as it moves from farm to fork (10–12). It also requires understanding and addressing food safety-related behaviours that occur at the consumer level, as well as the policies and regulations that shape food-related decisions and actions—whether by consumers or those who work in food supply chains.

Reducing the burden of foodborne illness requires a whole-of-food-system approach—i.e., an approach that considers all actors and activities that play a role in production, processing, distribution, preparation, and consumption of food (13). This is illustrated in the framework presented in Figure 2 (14).

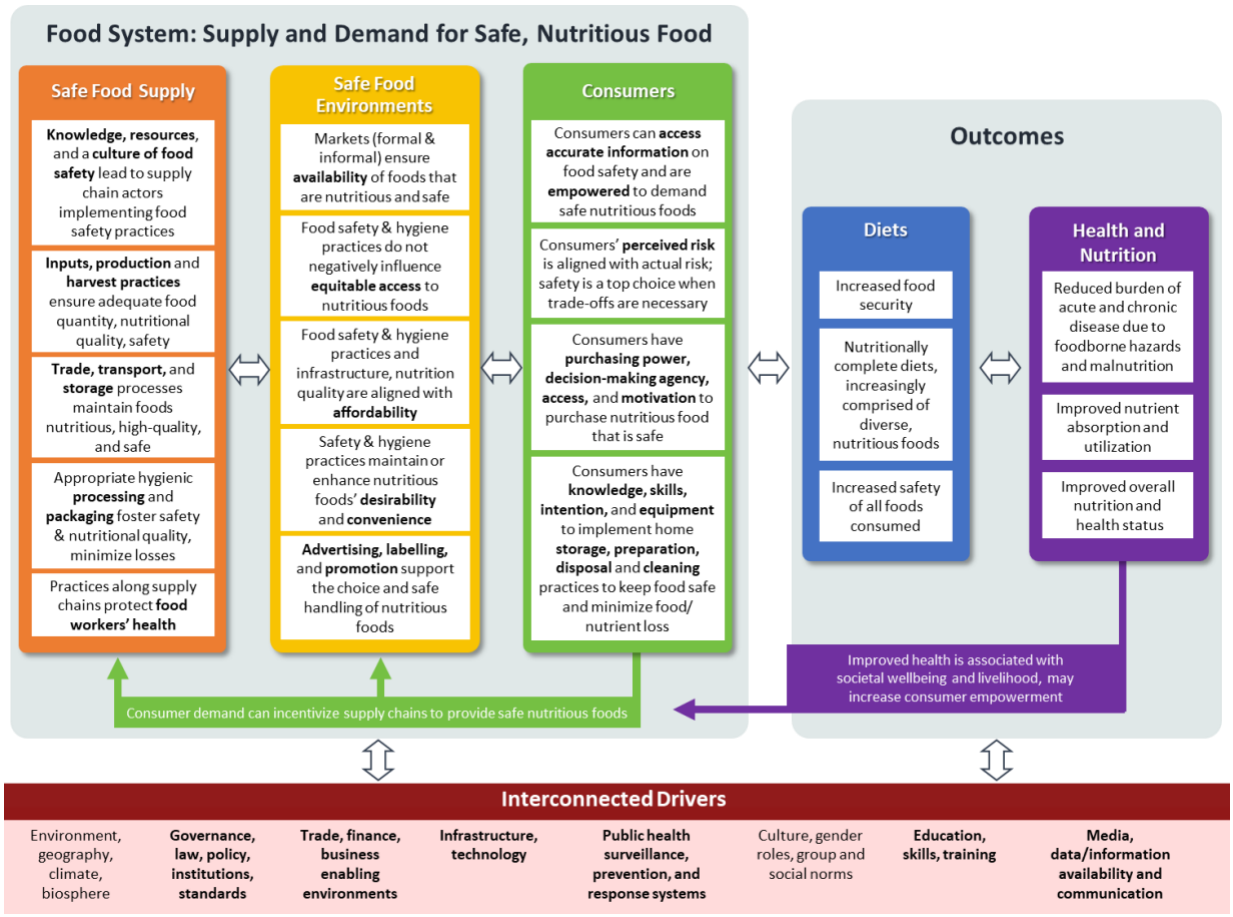


**Figure 2.** Opportunities for improving food safety (alongside nutrition) can be found throughout the food system. Reproduced from (14).

The objective of this paper is to discuss how to enact a food system approach to food safety by describing entry points across the food system, and how they can be strengthened, with a focus on LMICs. We do this by drawing on the peer-reviewed and grey literature on food safety as well as the programmatic experiences of GAIN, aiming to provide actionable examples of how food safety can be integrated into food system programming – as well as to help guide new directions for such integrated programming in the future. We organise our discussion according to different stages of the food system: food transportation, storage, and handling; food processing; food retail and markets; consumer behaviour; and food-related policy. We do not cover primary production, but instead refer readers to other papers on that topic (15,16).

[1] Food safety is the assurance that food will not cause harm to the consumer when prepared and eaten according to its intended use (9).

## FOOD TRANSPORTATION, STORAGE, AGGREGATION, AND HANDLING

Once food leaves the farm (or ranch or fishery), it must be transported (to and from warehouses, wholesale, and retail locations), aggregated (i.e., combined with food from other sources to create larger volumes and improve efficiency), and stored (either for brief periods while in transit or waiting for sale, or for longer periods to balance supply and demand in alignment with market dynamics)—and is constantly being handled by different actors. These supply chain services are essential for bringing food to consumers and also play an important role in supporting farmers' livelihoods (17,18). But each of these actions also opens the door for potential contamination or increasing levels of contaminants already in food. This can occur through multiple channels: handling food with unclean hands/equipment; storing/transporting it in unclean spaces/containers; long periods without proper cooling, leading to spoilage and the growth of bacteria; exposure to moisture fostering the growth of moulds and mycotoxins; or physical contaminants like rocks or glass being introduced into food from unclean surroundings.

As food systems develop, these parts of the food supply chain (as well as the processing stage) tend to become longer and more complex, with more actors involved (19). As a result, food safety hazards have more points of entry; food from different sources can be comingled and spread hazards more widely; and a food safety failure at a specific point in the supply chain can have widespread impacts at other points (20). For example, aflatoxin is a fungal toxin that is linked to liver cancer and may contribute to child stunting, though this is not well established (21). It commonly affects crops such as maize and groundnuts in LMICs, developing during storage and potentially spreading through aggregation and processing (e.g., milling of maize grain into flour) to contaminate large quantities of food. As it can be present without affecting taste, smell, or appearance, it is difficult to detect without explicit testing – which is often unavailable or not financially viable in LMIC contexts (22). But the development of these parts of the supply chain can also offer opportunities: for example, aggregation points can offer an occasion for food safety testing that would not be possible at the level of the individual producer (or eventual retailer).

In LMICs, these parts of the supply chain are often informal (i.e., not fully covered by existing regulation and enforcement systems) and dominated by small- and medium-sized enterprises (SMEs) (17,23). While dynamic and robust contributors to the local economy (17,24), SMEs often lack the skills, training, resources, and/or equipment needed to put in place best practices for food safety. This can be particularly the case in transportation, where transport services are often provided by individual operators who do not own the food in question and have limited incentives to ensure high quality is maintained; a study of value chain actors in Nigeria found transporters to be among the least engaged in food safety preventative behaviours (25).

Considering the informal sector of LMICs, a recent expert report identified two crucial factors necessary for ensuring safer food—which apply at all stages of the food supply chain. The first of these is *incentives* for food supply chain actors to implement and maintain food safety practices (26). Such incentives are often lacking and can be tricky to put in place (20,27). Food safety hazards are often invisible to consumers and, even after an outbreak has occurred, hard to trace to their original source. This is particularly the case in LMICs, which often have less-developed systems for testing and tracking foodborne disease hazards and outbreaks. Consumers also often have limited willingness to pay for safer food (due to lower purchasing power, limited awareness, and/or low trust). As a result, improvements in food safety are rarely rewarded financially, though they may come with costs. Moreover, enforcement capacity in LMICs is often weak, so the incentive to avoid fines or other negative consequences of noncompliance is also limited. These incentives are particularly weak in the storage, transport, and aggregation stages of the supply chain, which are often invisible to end consumers – and also under-recognised by policymakers (17). We do not know

of many strong examples of incentives being successfully put in place for these types of supply chain actors in LMICs; future work to develop and test stronger incentives for these actors is sorely needed.

The second critical factor for ensuring safer food via the informal sector in LMICs is *capacity* for food supply chain actors to implement and maintain food safety practices (26).[2] This relates to skills and knowledge; to equipment and infrastructure; and to access to financial resources to make and maintain needed changes in both those areas as well as in their operating processes (26). For actors in this part of the supply chain, skills and knowledge are often limited and not addressed; formal training in food safety is usually directed at food retailers and food service providers. To be useful, training for those working in transportation, storage, aggregation, and handling needs to be tailored to their specific needs and constraints – developing and implementing such approaches remains something of a gap in programming. In terms of equipment and infrastructure, there are also numerous gaps. Road quality in LMICs is often poor and transit delays - such as weigh bridges, taxation payment points, and police checks - are common (and extend transport times and increase physical damage to food, both increasing risk of contamination); warehouses and other storage facilities are often lacking; and access to cold chain services and the electricity needed to run them is limited (28). Access to appropriate storage, handling, and transport equipment can also be limited; this includes simple equipment like pallets, ventilated, well-drained storage spaces, high-quality storage sacks and crates, durable vehicles, and personal protective equipment as well as more sophisticated equipment like refrigerated trucks. This limited access is due to simple local unavailability, to poorly adapted technologies, to a lack of information about appropriate equipment, and to a lack of financial resources to purchase it. Indeed, a lack of financial resources constrains many of SMEs' actions related to food safety across all parts of the supply chain: in LMICs, inadequate access to finance is one of the biggest obstacles SMEs face in growing their businesses (29,30).

Encouragingly, there are a number of different technologies and interventions that have been developed to improve food safety within this part of the supply chain. For example, simple reusable plastic crates for storing and transporting fresh fruit and vegetables, which can reduce physical damage to these foods during transport and handling, helping to reduce the risk of contamination (31–33). Hermetic storage options that can reduce the risk of insect contamination offer a second example. For example, Purdue Improved Crop Storage (PICS) bags are a triple-layer hermetic sealed plastic bag that can be used to store grains or legumes, improving their quality and safety both by preventing infestation with insects and reducing the use of chemicals to prevent or treat such infestation (34,35). Many of these technologies also have benefits for reducing food loss and waste (and through it improving food availability and reducing the environmental impact of the food system (36,37)). GAIN has been working to support these types of technologies through its Postharvest Loss Alliance for Nutrition (PLAN) programme (Box 1). Additional work is needed on encouraging adoption and making sure each technology is supported by a strong business case that makes its use financially sustainable for the company or individual in question.

[2] Though capacity is also critical in the formal sector, it may be more easily achieved in that sector through employer- and state-provided trainings.

**BOX 1. COLD CHAIN SERVICES TO REDUCE NUTRITIOUS FOOD LOSS AND IMPROVE FOOD SAFETY**

Through its Postharvest Loss Alliance for Nutrition (PLAN), GAIN worked with SMEs to adopt improved technologies and practices to reduce food loss across nutritious value chains. Many of these technologies and practices also helped to reduce food safety risks. In Nigeria, PLAN co-invested in cold chain technologies that increased cold storage capacity for fresh fruits and vegetables from 6 tons to over 99 tons of storage space. One particularly innovative business strategy came from Alyx, a small business working to complete the cold chain system (from farm to market) for fresh fruits and vegetables using a 'hub and spoke' model. Alyx rents small cold room trailers (spokes) to farmers during harvest time and then transports the produce to their processing and cold storage aggregation centres (hubs). Alyx also participated in PLAN Nigeria's food safety training to improve handling practices and integrated the use of reusable plastic crates. Expanding access to cold chain services, improved technologies, and best food safety practices can help reduce the risk of spoilage and thus support improved food safety.

## FOOD PROCESSING & PACKAGING

While some foods (e.g., fresh fruits and vegetables) may be sold essentially unprocessed, many foods undergo further processing before reaching the consumer, such as the milling of grain into flour, and then the secondary processing of that flour into a baked good, pasta, or blended cereal. While certain types of food processing can be harmful for health (38), food processing is an important step in the food supply chain, as it can extend shelf life, improve safety, make food more nutritious, and make it more convenient and easier to prepare, and help improve palatability and desirability (39). Packaging can help to protect products, extend shelf life, make them easier to transport, and improve safety by reducing the risk of contamination. In LMICs, processing can be a highly varied sector: for certain foods, processing continues to be dominated by SMEs, while for others (e.g., production of wheat flour or cooking oil), large companies may play an important role (40). Packaging is usually integrated alongside processing and conducted by the same company, but some foods may be sold in bulk and repackaged later by a wholesale reseller or retailer.

Processing poses certain risks for food safety. For example, processing can introduce or increase the presence of foreign materials—such as glass, metal, plastic, or insects—in food products (20). These materials can come from the raw materials, processing equipment, packaging, or through handling and storage during processing. Food processing can also introduce or increase levels of harmful chemicals, such as pesticides, heavy metals, or mycotoxins, in food products. These chemicals can come from the processing environment, raw materials, or the processing equipment. Harmful substances can also be introduced deliberately, such as through adulteration or the use of harmful flavourings/colourings (41). Improperly practiced processing can also introduce microbial contaminants or foster their growth.

At the same time, processing can also do much to improve food safety (39). Certain methods, such as drying, salting, smoking, canning, and curing, can inhibit microbial growth; others, such as pasteurisation, sterilisation, and fermentation can reduce or eliminate existing microbial contamination; and proper processing can detect and remove physical contaminants already in food. If the food is kept at conditions that prevent subsequent contamination (potentially including well-implemented packaging solutions, like hermetically sealed containers), those improvements in

safety can be preserved through later handling and retail stages of the supply chain. Some of these processes also offer 'win-wins' for nutrition: for example, fermentation can increase microbiological safety while also improving absorbable nutrient content (42), while food packaging offers an opportunity for extended shelf life and the inclusion of nutritional information about a product.

Interventions to improve practices related to processing can thus help reap the benefits of improved safety (and potentially nutrition). A successful example of food safety measures related to large-scale food fortification, a proven approach to reducing micronutrient deficiency (43), is highlighted in Box 2.

### BOX 2. ENSURING SAFETY IN PROCESSING INPUTS

The GAIN Premix Facility (GPF) was established in 2009, specifically to address the challenges experienced by food producers and governments when sourcing micronutrients for use in industrial food fortification. The initiative was focused on strengthening access to safe, high-quality, and affordable sources of micronutrient premix. Such premix blends are often needed for the fortification of staple foods, such as oil, wheat flour, maize meal, and salt, which is done under voluntary or mandatory national programmes and is a proven way to address micronutrient malnutrition (39).

The GPF enabled access to safe, high-quality premix by first establishing an approved premix supplier list. In order to become listed, a premix blending site must be food-safety prequalified to a Global Food Safety Initiative (GFSI) certification standard, such as FSSC22000. Then the blending site is remotely assessed in terms of safety and quality management by supplying documents to demonstrate effective control. Following this, the site must be technically audited by a qualified food safety lead auditor who conducts a GAIN-specific on-site technical audit. For a successful company, this results in their blending site being formally approved by GPF, and the name and location of their site is then publicly listed as approved on the GPF-approved supplier webpage. Any food producer, agency, or government can then access the GPF approved-list and buy from a quality-assured blender or micronutrient manufacturer. Additionally, the GPF operates a tender platform that can supply micronutrient premix blends, sourced from GPF-approved sites at a competitive price to food producers, producer associations, governments, and international agencies. For some customers, credit terms can be made available, making the procurement of quality-assured premix more accessible. Today the GPF continues to maintain and publish an approved supplier list, which includes over 60 audited sites across 20 countries.

## RETAIL & MARKETS

Markets and retail outlets are where supply meets demand for food. Retail can include everything from large supermarkets and small shops, to traditional open-air markets, to mobile street vendors. Supermarkets, particularly when part of a major national or multinational chain, often have well-developed food safety procedures and typically benefit from stable electricity and water access, which facilitates food safety practices – though they are certainly not immune from contamination. However, in LMICs, the traditional sector tends to have much larger reach: over 70% of consumers purchase their food from traditional markets or retailers (26,44).

One area of particular focus for food safety in LMICs has been informal vendors of ready-to-eat foods or 'street foods'. Working in settings like street corners or transportation hubs, often in the direct sun and exposed to dust and traffic, many of these sellers lack access to the infrastructure and inputs (e.g., fresh water) needed to maintain best practices for food safety. Street food vendors' hygiene and food handling practices are often inadequate; foods for street vending may be prepared many hours in advance and stored without refrigeration; food may be displayed or sold on inadequate surfaces/containers; and utensils and plates may not be properly washed between clients (45). However, these vendors are important sources of food and nutrition for the working urban population, and there are promising approaches for supporting them to improve food safety practices, despite the constraints they face. For example, India's 'clean street food hubs' promote food safety and hygiene at popular street food-selling locations through training, resource provision, and certification; this has led to improvements in food safety practices and is being scaled up (46).

While most consumers use several different types of retail outlets to purchase food, traditional food markets (sometimes referred to as open-air, wet, or informal markets) remain the dominant food retail structure type in many LMICs (13,19,47). It is estimated that traditional markets provide fresh food to more than 70% of the population in LMICs (44). They are a particularly important source of nutritious foods such as fresh fruits and vegetables (47,48) and are often particularly relevant for lower-income consumers. Considered a key component of the food environment in many communities (49), markets are a unique combination of commerce, nutrition, social interaction, food safety and health. However, despite their importance to the community, traditional markets in LMICs are often unregulated and can pose serious food safety concerns. Recent studies suggest that foods sourced from the informal food sector contribute to between 50% and 60% of the foodborne disease burden in LMICs (26). In Nigerian markets/abattoirs, for example, studies have found prevalence of pathogenic bacteria and toxins in 15-60% of raw vegetables, 14-22% of beef, 2-10% of dairy products, and 100% of smoked fish (50). In Ethiopia, one study found about half of sampled vegetables to contain at least one parasite (51), while another detected *Salmonella* bacteria on 10% of sampled peppers and lettuce (52).


**Figure 3.** A Multifaceted Approach to Food Safety in Traditional Markets

These food safety risks are caused by a combination of inadequate policy, regulation, infrastructure, surveillance, and poor food handling practices (14,53). As such, improving food safety in traditional markets (and potentially other parts of the food system) requires a multi-faceted approach that considers positive best practices and appropriate technologies, behaviour change, and an enabling environment (54), as summarised in Figure 3.[3]

[3] In the figure, Hazard Analysis and Critical Control Points (HACCP) refers to a systematic process to identifying hazards arising in food production that could make the final product unsafe; Good Agricultural Practices (GAP) and Good Hygiene Practices

- **Practices and technologies:** Improving food safety in traditional markets involves the adoption of best practices and utilising appropriate technologies by vendors, consumers, and local authorities. Best practices for food safety in traditional markets can be summarised as '5 Cleans (Hands, Water, Tools, Surfaces, Clothes, and Cloths) and 4 Safes (Storage, Sorting, Separating, and Sanitising)'.[4] In markets and at retail, these practices can be as simple as vendors washing their produce and hands with clean water, keeping foods off the ground, and reducing cross contamination across commodities (e.g., ensuring fresh fruits and vegetables are not in close proximity to raw meat). For consumers, best practices can include purchasing foods from vendors who have adopted hygienic practices, transporting their purchased foods in a clean bag, and washing hands. Market authorities also need to ensure clean water is available in the market. Improved technologies at the market level can include cold storage, sensors for food safety assessment, and simple tools like color-coded cutting boards, trash cans, and gloves.

  The adoption of best practices and appropriate technologies requires capacity building largely via training and providing incentives through different communication channels. For vendors, incentives include leveraging improved quality and safety of the food to attract new customers and lead to more repeat customers; for consumers, the incentives largely lie in keeping their family safe from illness (and saving health costs that may result from it). For all actors, the adoption of new practices or technologies will require some behaviour change.

- **Behaviour Change:** Changing behaviour requires motivating and incentivising people to make new and/or different choices. For vendors, this focuses on the adoption of the best practices described above. However, training on best practices is not enough on its own; there needs to be a clear reason (or incentive) to put that knowledge into practice. Encouragingly, while incentives are difficult to apply in up-chain parts of the supply chain, as discussed above, they can be easier to leverage at retail level. Since food vendors' actions and consequences are more visible to consumers, consumer retention can serve as a powerful incentive for vendors, if consumers are motivated to make shopping decisions based (partly) on food safety. Consumer behaviour change is discussed in more detail in the next section, but in addition to general behaviour change and education campaigns, market-focused approaches have the potential to be impactful, as they focus on the place where consumers are actively making food purchasing decisions. Social networks - such as vendor associations, or commodity sub-committees, in traditional markets – can be powerful leverage points for making change in an efficient manner. Box 3 illustrates an approach to integrating behaviour change for vendors and consumers alongside vendor training.

  **Enabling Environment:** In LMICs, inadequate infrastructure often hinders vendors' and consumers' ability to adopt improved food safety practices, particularly in traditional markets. In most traditional markets critical infrastructure is lacking. This includes electricity, cold storage for perishable goods, and sufficient water, sanitation, and hygiene (WASH) facilities, like running water for handwashing and proper toilet facilities. Additionally, substandard vendor structures, inconsistent food waste management, and the presence of animals such as street dogs and cows in market areas further exacerbate the risk of foodborne disease transmission. Research suggests that upgrading and modernising

(GHP) refer to procedures to follow to ensure food is kept safe, covering primary production and the post-production stages as well as food service. More information on them can be found at: https://www.fao.org/good-hygiene-practices-haccp-toolbox/en.

[4] We thank Delia Grace for devising this useful phrase.

physical market infrastructure can have positive effects on food safety and nutrition at both individual and community levels (14).

The effective use of appropriate food safety regulations and policies (addressed in detail in a subsequent section) for retail and markets in LMIC is also an important aspect of the enabling environment. While there are clear lines of responsibility for food safety oversight in the formal food sector, this is lacking in the informal sector in many LMICs. Responsibility for overseeing local markets and the informal food sector is often unclear at the national and regional levels, leading to inconsistent regulation across different localities and states. This can result in differences in resource allocation, efficiency, and coordination among governing bodies and across local food systems. While some localities have established market management authorities, agencies responsible for food safety in the informal sector are generally underregulated and lack adequate resources (54). To address these challenges, relevant local stakeholders need to be brought together with municipal government officials to discuss the food safety and public health risks associated with traditional markets—and to drive momentum for change.

### BOX 3. A BRAND TO IDENTIFY SAFE FOOD

GAIN's EatSafe project focused on increasing consumer demand for safe, nutritious foods in traditional markets. To accomplish this, EatSafe developed a safe food brand in Nigeria. The brand was called Abinci Fes-Fes, which translates to 'Clean, Fresh Food' in Hausa. 'Fes-Fes' is a well-known Hausa slang that refers to cleanliness and is used colloquially to describe something that looks impressive. After successfully completing EatSafe's food safety training program, 270 fresh food vendors across two markets opted to join the Brand. In exchange for receiving a suite of branded food safety assets (e.g., tablecloths, aprons, caps, waste bins), Abinci Fes-Fes vendors agreed to monthly compliance checks with EatSafe's 10 food safety best practices. The branded assets served as visual cues for consumers to easily identify which vendors were part of the brand—and thus implemented food safety best practices. To generate awareness of the brand, EatSafe convened two month-long in-market campaigns of dramatic performances and games to engage consumers. As a result, 80% of branded vendors reported Abinci Fes-Fes had positively impacted their business by increasing their sales and attaining higher customer retention and referrals. Similarly, 96% of consumers that had patronised Abinci Fes-Fes vendors intended to continue doing so in the future due to their cleanliness and hygiene, good customer service, and high-quality products.

## CONSUMERS & HOUSEHOLDS

One key challenge with food safety is that, at any given point in the supply chain, the steps taken to prevent contamination may be undone by actions at the next level. This is particularly true at the consumer level: best practices all the way from production to retail are of limited use if they are followed by poor practices during food handling, storage, preparation, and consumption in the home. This makes consumers key actors in reducing the burden of foodborne disease: both in terms of demanding safer food at the retail level and in observing adequate practices once they bring that food home.

Considering the latter point, **common household-level practices or circumstances** that result in contamination of food with pathogenic microorganisms in LMICs are storage of cooked food at room temperature for extended periods, inadequate cooking and reheating of food (in terms of temperature and/or time), contamination from hands (linked to poor handwashing practices), use of raw food products with high pathogen content, contamination from utensils, and use of unclean water (55).

These openings for contamination can be closed through key actions: personal hygiene (particularly adequate handwashing before and during food preparation and before eating or feeding another person); appropriate initial cooking and reheating of food; avoiding cross-contamination (e.g., by separating raw and cooked food, maintaining clean or separate surfaces and adequate washing of utensils), keeping food at safe temperatures, using clean water, and avoiding foods from unsafe sources (55,56). The World Health Organization summarizes these actions as the 'five keys to safer food' (Figure 2). Food can also be contaminated by additional routes such as pests, chemicals, or physical hazards through poor storage practices, such as containers that are unclean or do not prevent access to rodents, insects, or dust, or improper preservation techniques.

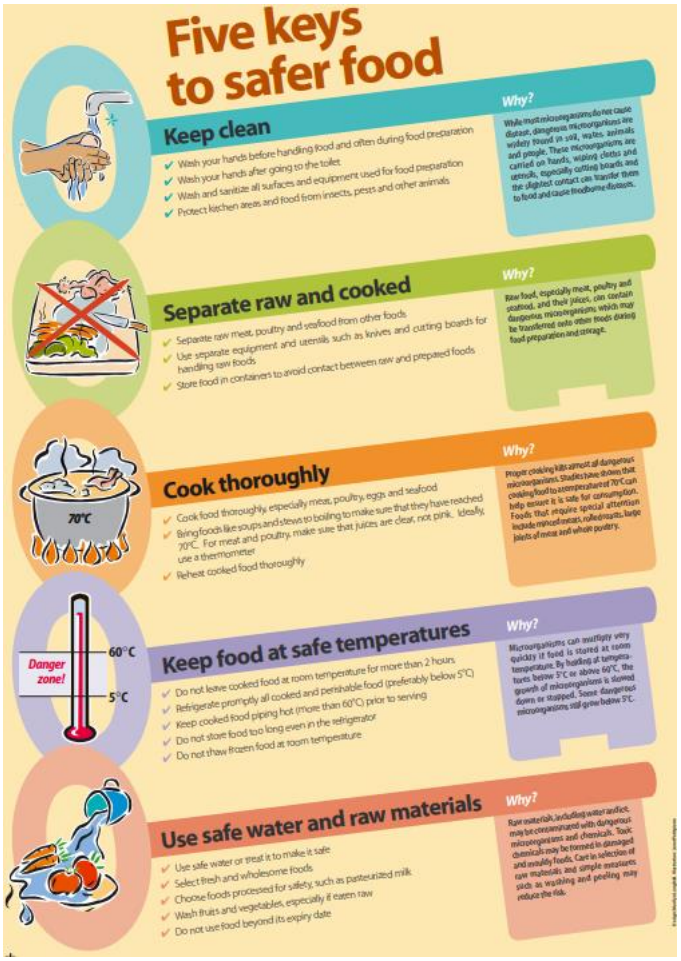


**Figure 3.** The WHO Five Keys to Safer Food. Source: WHO.

**Demanding safer food** at retail points is also important. For food eaten outside the home consumers have little control over the handling processes used when cooking it, and some foodborne hazards cannot be sufficiently lessened through home-based practices, meaning that consumers must source safe ingredients from their point of purchase. Consumer demand for safer food can also serve as an engine to drive improvement in other parts of the food system: by demanding stronger regulations and enforcement and by incentivising food supply chains to deliver safer foods. Indeed,

consumer demand was historically a major driver of safer food in middle- and high-income countries (57).

To choose to buy safe foods (whether ingredients cooked at home or ready-to-eat foods), consumers face numerous barriers: affordability, accessibility, and appeal (58). There may be trade-offs between food safety and food characteristics such as price, convenience, or desirability. Since consumers often cannot easily identify whether a food is unsafe via sight or smell (59), access to trustworthy information (potentially via labelling or certification) may be needed to facilitate an appropriate decision.

When it comes to both demanding safer food and keeping it safe in the home, there can also be a gap in knowledge, motivation, or concern about the issue, which can lead consumers to not take precautions to ensure that food is safe (25,60). In some contexts, even where consumers are aware of food safety, they may not see it as a highly salient issue that motivates their food choices (41,60–65). In others, they may be motivated and already acting to identify safer sources, based on their own heuristics (66,67). At the other end of the spectrum, consumers who fear that a food may be unsafe might avoid that food (68–72); this can have negative ramifications for nutrition, since some of the most nutritious foods also pose higher food safety risks (e.g., animal-source foods, fresh vegetables (73,74)).

Interventions to improve consumer-level food safety practices have often focused on education and communication, sometimes including hands-on practices (55). They are often delivered through schools, though often in community and home settings as well; communications messages can include interpersonal communication as well as mass media and social marketing (75). A 2022 review of the topic suggested that focusing on risk perception and using strategies that leverage emotion and trusted sources (e.g., respected community members) were likely to be useful strategies for future interventions. In LMICs, it is particularly important to ensure that such approaches are adapted to the local context, often based on local formative research (55).

While some communication-based approaches show promise, there is a need for more focus on increasing motivation to act, not just knowledge and information. A focus on caregivers of young children can be particularly relevant, as young children are particularly vulnerable to foodborne disease (27). (See Box 4 for an example of a creative way to engage caregivers on food safety-related behaviours.) There is also need for more rigorous evaluations to improve evidence in this area.

Labelling and certification can also help consumers to choose safer foods in markets. Still, there are key structural barriers that may prevent the implementation of best practices for food safety, even where consumers have both the knowledge and the motivation to act (27). These include a lack of time, income, cooking fuel, sufficient space, access to clean water, and access to refrigeration (and supporting electricity), as well as high ambient temperatures and close proximity to livestock.

**BOX 4: USING EMOTION AND SURPRISE TO CHANGE BEHAVIOUR**

Having clean hands is one of the five 'keys to safer food', and it is particularly important for those who prepare food for and feed infants and young children, who are particularly susceptible to foodborne illness. Through nutrition programmes in Indonesia and Mozambique, formative research identified better handwashing as a key behaviour for improving infant and young child feeding practices.

To convince caregivers of the importance of handwashing, the programmes utilised emotional demonstrations, known as emo-demos, as a community-level approach. Emo-demos are interactive group sessions focused on promoting one key behaviour (66). They aim to associate feelings with habits, generating a strong emotional response in participants and enhancing recall. Emo-demos are grounded in the Behaviour Centred Design framework, which emphasises that a behaviour change intervention must induce a change in the physical, social, or biological environment, acting as a stimulus (surprise), which in turn alters the brain or body of an individual, ultimately leading to the selection of the desired behaviour, which is then rewarded (67).

In Mozambique, the emo-demos involved a surprise game using glitter to represent germs. Participants observed how the glitter 'germs' transferred to the baby's food and practiced various handwashing techniques with and without soap for different durations. Through this exercise, participants came to realise that only handwashing with soap effectively removes the 'germs' (68). In Indonesia, the session used 'lumigerm' lotion to represent germs picked up by hands when in contact with items like groceries or money. Using UV light, participants observed how these germs were visible on caregivers' hands and learned that handwashing with soap is needed to eliminate them.

Although no evaluation has been conducted to assess the effectiveness of either programme in promoting handwashing with soap, research assessing other emo-demos found that participants enjoyed these sessions, understood the lessons taught, and expressed the ability to potentially change their behaviours accordingly (69). Emo-demos offer an example of using engaging and creative techniques to interest and motivate people to adopt better handwashing practices – a key step towards safer food.

## POLICIES & REGULATIONS

Food safety all along the supply chain, and at the consumer level, can be supported by appropriate policies and regulations. This includes a wider range of approaches, such as regulations on which types of chemicals/additives can be used in food production and processing; sanitary and phytosanitary standards applied to trade in food; foodborne disease surveillance and reporting systems; procedures for inspection and hygiene grading of food service outlets; and food recall and traceability systems (5,20). Some of these standards and regulations apply across all foods, while others are specific to the type of food (e.g., meat, dairy) or to the type of operator (e.g., a street seller, a school food service provider). Food safety issues can also be included in other policies and strategies, such as health/nutrition, trade, and agriculture policies; this can help support policy coherence and the achievement of multiple development goals in tandem.

The focus for developing food safety policies, systems, and regulations can vary depending on a country's (and a food system's) level of development (5). In less-developed food systems, this should often involve an initial focus on the informal sector, including traditional markets. Over time, this may

shift to more focus on improving capacity of SMEs and educating consumers, with an eventual goal of a strong private sector assuming considerable responsibility for food safety, supported by strong government regulation and enforcement (5). In some lower-income countries that lack widespread access to basic infrastructure, investments such as improving market drainage and ensuring food businesses have clean water access, may also be required. All policies and regulations must be supported by appropriate resources, both human and financial. For lower-income countries, this can entail a long-term investment in the education systems needed to strengthen skills required to eventually create a pool of qualified lab staff and other food safety professionals, which can then enable the development of capacity related to laboratory testing, inspections, and enforcement. Research programmes may also be needed to understand disease burden and causes.

At the global level, the Codex Alimentarius Commission, a joint programme of the UN Food and Agriculture Organization and the World Health Organization, sets standards related to food quality and safety, such as guidelines for food hygiene and standards for the maximum level of contaminants allowed in food. These can help guide national-level approaches and support harmonisation across countries (see Box 5).

Understanding that capacity and resources are limited in LMICs, policies and regulations must be designed accordingly. Regulations that are too difficult to follow in a local context and cannot be enforced can be counterproductive (20,76). For example, large shares of pork in India, beef in Nigeria, and maize in Kenya would be considered unfit for consumption according to stringent international standards (27). Identification of appropriate approaches and entry points is often based on a paradigm of risk assessment. Risk assessment aims to identify the most significant food safety risks to public health; such an assessment can be paired with value chain assessments to identify where in the value chain these particular risks are more acute (20). With this information, policymakers can target efforts and resources to focus on the biggest risks and the key places where they can be reduced.

**BOX 5. CODEX GUIDELINES FOR FOOD SAFETY IN TRADITIONAL MARKETS**

In 2022, GAIN examined four regional Codex Alimentarius (Codex) guidelines for street food vendors and considered their potential to inform international guidelines for traditional markets in LMICs. The results of the study were published in the *Journal of Food Protection* and spurred an international discussion around the need for Codex guidelines for traditional markets.

As an official observer organization of Codex, GAIN played an active role in facilitating a New Work proposal for the development of traditional market guidelines, which was formally accepted by the Codex Committee for Food Hygiene (CCFH) in December 2022. A working group led by Kenya and co-led by Bolivia and Nigeria, with GAIN providing technical inputs and guidance, was tasked with developing the guidelines. The working group then received inputs and suggested edits on their draft from numerous member states throughout 2023 and into early 2024. The proposed draft standards – **Guidelines for Food Hygiene Control Measures in Traditional Markets for Food** - were then submitted to the CCFH at their meeting in Kenya in March 2024 where the guidelines were accepted for submission to the Codex Commission. The Commission will consider the guidelines for formal approval at their next meeting in November 2024. The draft guidelines received strong support from multiple countries, the African Union, and other observer organisations. Upon final approval, the guidelines will be made available to country governments to adopt, implement, and comply with this new set of international food safety standards for traditional markets.

Key to targeting these efforts appropriately in LMICs is recognition of the informal and traditional food sector. This sector has often been left out of food safety policies to date, with many informal sector enterprises being virtually untouched by food safety regulators, giving them limited incentive to adopt enhanced food safety practices (26). Given the importance of these actors in ensuring food security and nutrition in LMICs, however, more inclusive approaches are likely to be needed. These should be designed to be more supportive of public health, as well as other development goals. For example, in LMICs, it is often more helpful to focus on capacity development to enable compliance, as opposed to punishment for noncompliance (27). Incremental formalisation of enterprises can be one route to doing so (26).

Improving food safety is a priority for many LMICs. For example, of the 126 countries that drafted food systems transformation pathway documents for the 2021 UN Food Systems Summit (UNFSS), 86 included references to food quality and safety. To date, however, many LMICs have lacked clear and comprehensive policy frameworks for food safety, which has hampered investment in and improvement of food safety systems (5). Others have improved policies but lack the regulations to support them, or the capacity to enforce those (26). There may also be issues with unclear responsibilities and limited coordination across agencies (26). However, there are outliers to this trend. For example, India's Food Safety and Standards Authority oversees a comprehensive national and subnational food safety programme, including creation of standards, licensing and inspections for food businesses, a testing system, training and certification, and behaviour change campaigns (5). GAIN is actively working to support the development of similarly ambitious policies and systems in other countries, such as in Ethiopia (Box 6).

**BOX 6. FOOD SAFETY POLICY AND STRATEGY IN ETHIOPIA**

Ensuring food safety to protect public health remains a significant challenge in Ethiopia, as in other LMICs. However, recognition of food safety as a public health priority is growing in the country. This is reflected in efforts to develop policy, strategies, regulation, and national standards. Ethiopia's 2018 Food and Nutrition Policy defined food safety and nutrition as being responsibilities of the government. One of this policy document's objectives is improving the safety and quality of food throughout the value chain.

Ethiopian policy also recognises the importance of food safety as a priority action embedded in a food system approach. The Ethiopian food system transformation pathway, developed through the UN Food Systems Summit process, outlined key steps to address food safety concerns in the country. One of its goals is to 'ensure availability and accessibility of **safe** and nutrient-dense foods', and it highlights food safety as fundamental to a successful food systems transformation. To achieve this, the document notes that Ethiopia's national food safety management and control system will need to be strengthened.

Ethiopia has also different strategies and regulations related to food safety, including the newly finalised and disseminated National Food Safety and Quality Strategy for Primary Agricultural Produce. GAIN, through the EatSafe project, reviewed Food Safety Policy and Legislation in Ethiopia in January 2022. This review is being used as input for making future food safety related strategies. The Ethiopian government's recognition of the importance of food safety is encouraging, but there is still more to do—namely, translating strategies into actions. In this way, Ethiopia can help promote food safety and reduce foodborne disease, ultimately saving lives and improving economic growth.

## DISCUSSION

This paper has reiterated the well-recognised importance of taking a food-systems-based approach to improving food safety, with a focus on LMICs – where the largest burden of foodborne disease is borne. While doing so, it has highlighted numerous opportunities for and examples of making food safety-supportive changes at different stages in the food system, such as in food processing, storage, and in retail outlets. Holistic approaches to food safety that consider the full supply chain are not a new idea, but we hope that this paper has helped to bring them to life and spark new thinking on their relevance.

While this paper was not able to examine system interactions in detail, part of the motivation for taking a food systems approach to food safety (as opposed to viewing the issue more narrowly or in isolation of others) is how interconnected it is with other development concerns. For example, there can be a potential trade-off between food safety and nutrition (27): low-income consumers need to be protected from unsafe food, but not in ways that make it more difficult for them to purchase nutritious meals. Similarly, there are potential trade-offs with economic outcomes: food supply chain actors need to be incentivised to enact stronger food safety practices – but not in ways that hurt their livelihoods. Yet enacting food safety measures in the supply chain can increase prices, impacting consumption (particularly among lower-income consumers, and particularly for highly nutritious foods) and producer or vendor profits and livelihoods (68,69). But there can also be many synergies: improved food safety and nutrition are often mutually reinforcing (14), and improved food safety practices can unlock access to new markets or higher prices for producers, supporting economic

outcomes. Actions to improve food safety must thus be designed and implemented with an eye to these wider interactions, trade-offs, and synergies.

Improving food safety is a long-term project. While the eventual goal can be strong systems of private-sector standards alongside government-led regulation and enforcement (5), interim solutions that can begin to reduce the burden of foodborne disease while working within short-term resource constraints are also needed. These types of solutions are particularly essential in transitioning low-middle-income countries: as rapid economic, demographic, and dietary change (like eating more meals outside the home and relying on increasingly longer supply chains) interacts with limited food safety regulation, management, and enforcement capacities, food safety concerns can be at their most critical (5). The need for creative interim solutions to food safety is growing in recognition. The African Union's Food Safety Strategy for Africa (2022-2036) (77), based on an assessment of food safety on the continent, noted that traditional approaches of 'official food control' are not well adapted for managing food safety risks in African domestic food chains—and thus unlikely to be effective.

While policy and regulation are being strengthened, complementary interim approaches need to focus at two levels simultaneously: consumer choice and food supplier actions. In the latter category, it will be important to first recognise that there are potential food safety actions available at all stages in the food supply chain – but that not all are equally important. To use scarce resources efficiently, the most important 'critical points' for ensuring safe food within a given value chain must be identified and prioritised for action. This category includes those who handle the foods most vulnerable to contamination: fresh fruits and vegetables and animal-source foods, particularly any that are not further cooked by the consumer prior to consumption. For many LMICs, as discussed above, it also encompasses many informal-sector actors: a significant share of the foodborne disease burden can likely be linked to informal channels, which are particularly important for low-income consumers (26). Next, it will be important to meet these supply chain actors where they are in terms of delivering the capacity-building activities that align to their needs, availability, and existing expertise. This will likely involve simplified, highly practical training that acknowledges the limitations of the context and finds ways to make improvements (even if marginal) within them.

Simultaneously engaging consumers is important not only to directly influence their actions related to food purchase and preparation but also to create an incentive – consumer demand – that can help motivate supply chain actors to act. As highlighted here, there is a need to develop creative new approaches to do this that can ensure 'food safety' is a topic that motivates attention and action. There is also a need to build evidence on which interventions actually work, to achieve which objectives, and under what conditions. Research on food safety interventions in LMICs is relatively limited and has considerable opportunity to grow and to become more rigorous (7,20).

One opportunity to support all these changes lies in broadening the group of 'food safety champions' to raise the issue on the development and policy agenda. This can be done by engaging with organisations that work to support other development goals (such as WASH, nutrition, or economic growth) and showing how improved food safety can align with that goal or the actions that support it. It can also be done by reaching out to stakeholders who are not always included in conversations about food safety actions. For example, municipal governments have good local understanding, personal incentives to reduce local food contamination, and the ability to coordinate the diverse actions needed to bring change in their communities. They, and others like them, are a critical partner waiting to be tapped.

## CONCLUSIONS

Foodborne disease remains a major global public health challenge – comparable in disease burden to malaria (7). While recognition of the issue has grown considerably, action in LMICs still lags behind what is needed to make a meaningful difference in reducing food contamination and with it the resulting illnesses and deaths. In this paper, we have elaborated opportunities for strengthening food safety action throughout the food system, providing examples of these in practice. The food safety landscape will continue to evolve. For example, climate change is expected to increase food safety risks in several ways (78), while technological developments will create new opportunities for reducing risks. To navigate these changes while protecting human health, food system leaders must be clear that a central part of well-functioning food system is making **safe** food accessible to all.

## REFERENCES


1. GAIN. GAIN's Definition of Nutritious and Safe Foods [Internet]. Global Alliance for Improved Nutrition (GAIN); 2021 Dec [cited 2021 Dec 24]. Available from: https://www.gainhealth.org/sites/default/files/publications/documents/gain-briefing-paper-series-8-gain-definition-of-nutritious-and-safe-foods.pdf

2. Neufeld LM, Hendriks S, Hugas M. Healthy Diet: A Definition for the United Nations Food Systems Summit 2021. In: von Braun J, Afsana K, Fresco LO, Hassan MHA, editors. Science and Innovations for Food Systems Transformation [Internet]. Cham: Springer International Publishing; 2023 [cited 2023 Apr 3]. p. 21–30. Available from: https://link.springer.com/10.1007/978-3-031-15703-5_3

3. Development Initiatives. Global Nutrition Report 2022. Bristol: Development Initiatives; 2022.

4. Havelaar AH, Kirk MD, Torgerson PR, Gibb HJ, Hald T, Lake RJ, et al. World Health Organization Global Estimates and Regional Comparisons of the Burden of Foodborne Disease in 2010. PLOS Medicine. 2015 Dec 3;12(12):e1001923.

5. Jaffee S, Henson S, Unnevehr L, Grace D, Cassou E. The Safe Food Imperative: Accelerating Progress in Low- and Middle-Income Countries [Internet]. The World Bank; 2018 [cited 2020 Mar 27]. 208 p. (Agriculture and Rural Development). Available from: https://doi.org/10.1596/978-1-4648-1345-0

6. Nordhagen S, Lambertini E, DeWaal CS, McClafferty B, Neufeld LM. Integrating nutrition and food safety in food systems policy and programming. Global Food Security. 2022 Mar;32:100593.

7. Grace D. Burden of foodborne disease in low-income and middle-income countries and opportunities for scaling food safety interventions. Food Sec. 2023 Dec;15(6):1475–88.

8. Kirk MD, Pires SM, Black RE, Caipo M, Crump JA, Devleesschauwer B, et al. World Health Organization Estimates of the Global and Regional Disease Burden of 22 Foodborne Bacterial, Protozoal, and Viral Diseases, 2010: A Data Synthesis. PLOS Medicine. 2015 Dec 3;12(12):e1001921.

9. Codex Alimentarius Commission. CAC/RCP 1-1969, Rev. 5 (2011). General Principles of Food Hygiene [Internet]. 1969. Available from: http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXC%2B1-1969%252FCXP_001e.pdf

10. Ortega DL, Tschirley DL. Demand for food safety in emerging and developing countries: A research agenda for Asia and Sub-Saharan Africa. Journal of Agribusiness in Developing and Emerging Economies. 2017 Jan 1;7(1):21–34.

11. Chamhuri N, Batt PJ. Exploring the Factors Influencing Consumers' Choice of Retail Store When Purchasing Fresh Meat in Malaysia. International Food and Agribusiness Management Review. 2013;16.

12. Aworh OC. Food safety issues in fresh produce supply chain with particular reference to sub-Saharan Africa. Food Control. 2021 May 1;123:107737.

13. HLPE. Nutrition and food systems. Rome: High Level Panel of Experts on Food Security and Nutrition (HLPE),Committee on World Food Security; 2017.

14. Nordhagen S, Lambertini E, DeWaal CS, McClafferty B, Neufeld LM. Integrating nutrition and food safety in food systems policy and programming. Global Food Security. 2022 Mar;32:100593.

15. Carvalho FP. Agriculture, pesticides, food security and food safety. Environmental Science & Policy. 2006 Nov 1;9(7):685–92.

16. Olaimat AN, Holley RA. Factors influencing the microbial safety of fresh produce: A review. Food Microbiology. 2012 Oct;32(1):1–19.

17. AGRA. The Hidden Middle: A Quiet Revolution in the Private Sector Driving Agricultural Transformation. Nairobi: Alliance for a Green Revolution for Africa (AGRA); 2019. (AGRA African Agriculture Status Report 2018).

18. Liverpool-Tasie LSO, Wineman A, Young S, Tambo J, Vargas C, Reardon T, et al. A scoping review of market links between value chain actors and small-scale producers in developing regions. Nat Sustain. 2020 Oct;3(10):799–808.

19. Gómez MI, Ricketts KD. Food value chain transformations in developing countries: Selected hypotheses on nutritional implications. Food Policy. 2013 Oct;42:139–50.

20. Unnevehr LJ. Addressing food safety challenges in rapidly developing food systems. Agricultural Economics. 2022 Jul;53(4):529–39.

21. Hoffmann V, Jones K, Leroy JL. The impact of reducing dietary aflatoxin exposure on child linear growth: a cluster randomised controlled trial in Kenya. BMJ Global Health. 2018 Dec 1;3(6):e000983.

22. Hoffmann V, Moser CM, Herrman TJ. Demand for Aflatoxin-Safe Maize in Kenya: Dynamic Response to Price and Advertising. American Journal of Agricultural Economics. 2020 Apr 16;ajae.12093.

23. Reardon T. The hidden middle: the quiet revolution in the midstream of agrifood value chains in developing countries. Oxford Review of Economic Policy. 2015 Mar 1;31(1):45–63.

24. Bertanzetti M, Mondal S, Nasir R, Teachout M. Why do SMEs matter? London: International Growth Centre, London School of Economics; 2024.

25. Nordhagen S, Onuigbo-Chatta N, Lambertini E, Wenndt A, Okoruwa A. Perspectives on food safety across traditional market supply chains in Nigeria. Food and Humanity. 2023 Dec;1:333–42.

26. Henson S, Jaffee S, Wang S. New directions for tackling food safety risks in the informal sector of developing countries. Nairobi: International Livestock Research Institute; 2023.

27. Hoffmann V, Moser C, Saak A. Food safety in low and middle-income countries: The evidence through an economic lens. World Development. 2019 Nov;123:104611.

28. Morris S. The case for increased investment in food systems infrastructure in low and middle income countries [Internet]. Global Alliance for Improved Nutrition (GAIN); 2023 Apr [cited 2023 Nov 22]. Report No.: Discussion Paper 13. Available from: https://www.gainhealth.org/sites/default/files/publications/documents/GAIN-Discussion-Paper-Series-13-The-case-for-increased-investment-in-food-systems-infrastructure-in-low-and-middle-income-countries.pdf

29. IFC. MSME Finance Gap: Assessment of the Shortfalls and Opportunities in Financing Micro, Small, and Medium Enterprises in Emerging Markets [Internet]. Washington, DC: International Finance Corporation (IFC); 2017. Available from: https://www. smefinanceforum.org/sites/default/ files/Data%20Sites%20downloads/ MSME%20Report.pdf

30. Wang Y. What are the biggest obstacles to growth of SMEs in developing countries? – An empirical evidence from an enterprise survey. Borsa Istanbul Review. 2016 Sep 1;16(3):167–76.

31. World Economic Forum. Enabling Trade: From Valuation to Action [Internet]. Geneva, Switzerland: World Economic Forum; 2014 Jan. Available from: http://www3.weforum.org/docs/WEF_EnablingTradeReport_2014.pdf

32. Kok MG, Groot JJ, Dastoum S, Plaisier C, Dijkxhoorn Y, Wagenberg CPA van. A Measurement tool on Food losses and Waste: Applied in a tomato value chain in Nigeria. Wageningen: Wageningen University & Research; 2019.

33. Benson OB, Ambee IA, Osegbo AN, Okonkwo EU. Re-useable plastic crates as a veritable tool for handling of fresh fruits and vegetables: Lagos State as a case study. Journal of Stored Products and Postharvest Research. 2020;11(1).

34. Moussa B, Abdoulaye T, Coulibaly O, Baributsa D, Lowenberg-DeBoer J. Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012. Journal of Stored Products Research. 2014 Jul 1;58:77–86.

35. Baoua IB, Margam V, Amadou L, Murdock LL. Performance of triple bagging hermetic technology for postharvest storage of cowpea grain in Niger. Journal of Stored Products Research. 2012 Oct;51:81–5.

36. Abbade EB. Estimating the nutritional loss and the feeding potential derived from food losses worldwide. World Development. 2020 Oct;134:105038.

37. FAO. Global food losses and food waste – Extent, causes and prevention. Rome: Food and Agriculture Organization; 2011.

38. Monteiro CA, Levy RB, Claro RM, de Castro IRR, Cannon G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr. 2011 Jan;14(1):5–13.

39. USAID Advancing Nutrition. Food Processing for Improved Diets. Arlington, VA: USAID Advancing Nutrition; 2022.

40. Demmler K. The Role of Small and Medium-Sized Enterprises in Nutritious Food Supply Chains in Africa [Internet]. Global Alliance for Improved Nutrition (GAIN); 2020 Apr [cited 2020 May 25]. Available from: https://www.gainhealth.org/sites/default/files/publications/documents/gain-working-paper-series-2-the-role-of-small-and-medium-sized-enterprises-in-nutritious-food-supply-chains-in-africa.pdf

41. Grace D, McDermott J. Reducing and Managing Food Scares. In: 2014-2015 Global food policy report. Washington, D.C.: International Food Policy Research Institute (IFPRI); 2015. p. 41–50.

42. Hotz C, Gibson RS. Traditional Food-Processing and Preparation Practices to Enhance the Bioavailability of Micronutrients in Plant-Based Diets. The Journal of Nutrition. 2007 Apr 1;137(4):1097–100.

43. Keats EC, Neufeld LM, Garrett GS, Mbuya MNN, Bhutta ZA. Improved micronutrient status and health outcomes in low- and middle-income countries following large-scale fortification: evidence from a systematic review and meta-analysis. The American Journal of Clinical Nutrition. 2019 Apr 17;109(6):1696–708.

44. GloPan. Food Systems and Diets: Facing the Challenges of the 21st Century. London: Global Panel on Agriculture and Food Systems for Nutrition (GloPan), UK.; 2016.

45. Alimi BA. Risk factors in street food practices in developing countries: A review. Food Science and Human Wellness. 2016 Sep 1;5(3):141–8.

46. Nemer L, Gorla I, Demmler K, Polack S. India's Clean Street Food Hubs: Working with vendors to improve food safety and strengthen urban food systems [Internet]. Global Alliance for Improved

Nutrition (GAIN); 2020 May [cited 2020 Jun 10]. Available from: https://www.gainhealth.org/sites/default/files/publications/documents/gain-working-paper-series-3-india-clean-street-food-hubs.pdf

47. Hannah C, Davies J, Green R, Zimmer A, Anderson P, Battersby J, et al. Persistence of open-air markets in the food systems of Africa's secondary cities. Cities. 2022 May;124:103608.

48. Wertheim-Heck SCO, Spaargaren G, Vellema S. Food safety in everyday life: Shopping for vegetables in a rural city in Vietnam. Journal of Rural Studies. 2014 Jul;35:37–48.

49. Turner C, Aggarwal A, Walls H, Herforth A, Drewnowski A, Coates J, et al. Concepts and critical perspectives for food environment research: A global framework with implications for action in low- and middle-income countries. Global Food Security. 2018 Sep 1;18:93–101.

50. Grace D, Alonso S, Mutua F, Roesel K, Lindahl J, Amenu K. Food safety investment expert advice: Burkina Faso, Ethiopia, Nigeria. Nairobi: International Livestock Research Institute; 2018.

51. Bekele F, Tefera T, Biresaw G, Yohannes T. Parasitic contamination of raw vegetables and fruits collected from selected local markets in Arba Minch town, Southern Ethiopia. Infect Dis Poverty. 2017 Dec;6(1):19.

52. Guchi B, Ashenafi M. Microbial Load, Prevalence and Antibiograms of Salmonella and Shigella in Lettuce and Green Peppers. Ethiop J Health Sci. 2010 Mar;20(1):41–8.

53. GAIN. Report on Normative Guidelines for Governments to Promote Safer Traditional Markets. Washington, DC: Global Alliance for Improved Nutrition (GAIN); 2021. (USAID EatSafe Project Report).

54. GAIN. Food Safety, Traditional Markets, and Consumer Demand: A Synthesis of EatSafe's Formative Research Across Low- and Middle-Income Countries. Washington, DC: Global Alliance for Improved Nutrition (GAIN); 2023.

55. Woldt M, Moy GG. Literature Review on Effective Food Hygiene Interventions for Households in Developing Countries. Washington, DC: FHI 360/FANTA; 2015.

56. Medeiros LC, Hillers VN, Kendall PA, Mason A. Food Safety Education: What Should We Be Teaching To Consumers? Journal of Nutrition Education. 2001 Mar 1;33(2):108–13.

57. Ortega DL, Wang HH, Olynk NJ, Wu L, Bai J. Chinese Consumers' Demand for Food Safety Attributes: A Push for Government and Industry Regulations. American Journal of Agricultural Economics. 2012 Jan;94(2):489–95.

58. Liguori J, Trübswasser U, Pradeilles R, Le Port A, Landais E, Talsma EF, et al. How do food safety concerns affect consumer behaviors and diets in low- and middle-income countries? A systematic review. Global Food Security. 2022 Mar;32:100606.

59. USDA FSIS. Food Safety and Inspection Service. Do spoilage bacteria make people sick? [Internet]. 2019 [cited 2021 Apr 20]. Available from: https://ask.usda.gov/s/article/Do-spoilage-bacteria-make-people-sick

60. Nordhagen S, Lee J, Onuigbo-Chatta N, Okoruwa A, Monterrosa E, Lambertini E, et al. What is safe and how much does it matter? Food vendors' and consumers' views on food safety in urban Nigeria. Foods. 2022;11(2).

61. Hoffmann V, Moser CM, Herrman TJ. Demand for Aflatoxin-Safe Maize in Kenya: Dynamic Response to Price and Advertising. American Journal of Agricultural Economics. 2020 Apr 16;ajae.12093.

62. Rheinländer T, Olsen M, Bakang JA, Takyi H, Konradsen F, Samuelsen H. Keeping Up Appearances: Perceptions of Street Food Safety in Urban Kumasi, Ghana. J Urban Health. 2008 Nov;85(6):952–64.

63. Behrens JH, Vedovato GM, Cervato-Mancuso AM, Bastos DHM. Social representations of safety in food services. Food Research International. 2015 Aug;74:324–8.

64. Nordhagen S, Lee J, Onuigbo-Chatta N, Okoruwa A, Monterrosa E, Lambertini E, et al. What is safe and how much does it matter? Food vendors' and consumers' views on food safety in urban Nigeria. Foods. 2022;11(2).

65. Grace D, McDermott J. Reducing and Managing Food Scares. In: 2014-2015 Global food policy report. Washington, D.C.: International Food Policy Research Institute (IFPRI); 2015. p. 41–50.

66. Wertheim-Heck SCO, Raneri JE. Food policy and the unruliness of consumption: An intergenerational social practice approach to uncover transforming food consumption in modernizing Hanoi, Vietnam. Global Food Security. 2020 Sep;26:100418.

67. Kendall H, Kuznesof S, Dean M, Chan MY, Clark B, Home R, et al. Chinese consumer's attitudes, perceptions and behavioural responses towards food fraud. Food Control. 2019 Jan;95:339–51.

68. 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 Sec. 2017 Oct;9(5):1001–17.

69. Grace D. Influencing food environments for healthy diets through food safety. In: Influencing food environments for healthy diets. Rome: Food and Agriculture Organization; 2016.

70. Cornelsen L, Alarcon P, Häsler B, Amendah DD, Ferguson E, Fèvre EM, et al. Cross-sectional study of drivers of animal-source food consumption in low-income urban areas of Nairobi, Kenya. BMC Nutr. 2016 Dec;2(1):70.

71. Häsler B, Msalya G, Roesel K, Fornace K, Eltholth M, Sikira A, et al. Using participatory rural appraisal to investigate food production, nutrition and safety in the Tanzanian dairy value chain. Global Food Security. 2019 Mar;20:122–31.

72. Nguyen-Viet H, Dang-Xuan S, Pham-Duc P, Roesel K, Huong NM, Luu-Quoc T, et al. Rapid integrated assessment of food safety and nutrition related to pork consumption of regular consumers and mothers with young children in Vietnam. Global Food Security. 2019 Mar;20:37–44.

73. Grace D. Food Safety in Low and Middle Income Countries. IJERPH. 2015 Aug 27;12(9):10490–507.

74. Alonso S, Dominguez-Salas P, Grace D. The role of livestock products for nutrition in the first 1,000 days of life. Animal Frontiers. 2019 Sep 28;9(4):24–31.

75. Bass SB, Brajuha J, Kelly PJ, D'Avanzo P, Lambertini E, Nordhagen S, et al. Changing Behavior, Attitudes, and Beliefs About Food Safety: A Scoping Review of Interventions Across the World and Implications for Empowering Consumers. Foodborne Pathogens and Disease. 2022 Jan 1;19(1):19–30.

76. Sirma AJ, Lindahl JF, Makita K, Senerwa D, Mtimet N, Kang'ethe EK, et al. The impacts of aflatoxin standards on health and nutrition in sub-Saharan Africa: The case of Kenya. Global Food Security. 2018 Sep;18:57–61.

77. African Union Commision. Food Safety Strategy for Africa: 2022 - 2036 [Internet]. Addis Ababa, Ethiopia; 2021. Available from: http://repository.au-ibar.org/handle/123456789/1405

78. FAO. Climate Change: unpacking the burden on food safety. S.l.: Food and Agriculture Organization; 2020.