Feature Article

Mind the gaps: how can food safety gaps be addressed in developing nations?

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Implications

- As the global food supply continues to integrate and develop, there is a great need to understand the role of foodborne hazards and food safety systems in global food system development.
- Food safety systems must be considered as more than an enabling environment for agriculture value-chain development, and should receive targeted investments as a key element of global agriculture development.
- Global food safety systems contribute to global agriculture value-chain development, and can lead to improvements in agriculture productivity, economic growth, and public health around the world.

Key words: agriculture development, agriculture value-chains, food safety, public health

Introduction

As global food systems integrate, to meet the demands of a growing global population, safe and healthy agriculture value-chains will be essential to maintaining public health worldwide. In many ways, the current global food production landscape is made up of "mice and men." Meaning that the food sector within and across most countries includes both large-scale corporate agriculture production and varying degrees of small-scale agriculture production; the variation being the interpretation of small scale, which is highly dependent upon the country. This structure presents challenges for the creation of effective food safety systems in many countries, and can contribute to deficiencies in monitoring and control of foodborne hazards within agriculture value-chains. These deficiencies can lead to outbreaks of foodborne disease, impact customer acceptability, and lead to food waste and loss. Recent estimates by the World Health Organization (**WHO**) have determined that "the global burden of Foodborne Disease is comparable to those of the three major infectious diseases, HIV/AIDS, malaria and tuberculosis" (Havelaar et al., 2015). This has solidified presumptions and indications that unsafe food production has major impacts on global public health, human and country productivity, and development outcomes. Furthermore, these findings pose the question: **What is the role of food safety in global agriculture value-chain development, and how can improvements to global food safety improve agriculture productivity worldwide?** The answer to this question may lead to innovative approaches to global food systems that will assist in producing enough safe and nutritious food to feed the world.

The purpose of this article is to explore key concepts pertaining to food safety and the development of effective, efficient, and equitable food safety systems on a global scale. As the authors, we recognize that there are numerous factors involved in the topic of global food safety systems and food security. Due to this complexity, we have chosen to focus on a few concepts that we view as holding the most potential for impact, as well as directly influencing food safety and public health outcomes. Furthermore, based upon the readership of this journal, the article will also highlight the role of animal production in global food safety, as well as in creating healthy agriculture value-chains and healthy people.

The role of food safety in country and agriculture value-chain development

According to the Food and Agriculture Organization (**FAO**), the number of chronically undernourished people in the world increased from 777 million in 2015, to 815 million in 2016 (FAO, IFAD, UNICEF, WFP and WHO, 2017). These numbers are staggering in their own right, but considering the lifelong impacts of undernourishment and poor nutrition on an individual's physical and cognitive potential, this increase in global undernourishment may strengthen the cyclical effects of poverty, reduced productivity, and malnutrition and disease for many vulnerable populations (de Onis and Branca, 2016). Research has demonstrated that, on average, repeated episodes of diarrheal illness, during the first 2 yr of a child's

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life, may prompt an 8 cm growth shortfall, as well as a reduction of 10 IQ points by the time the child reaches 7 to 9 yr of age (Guerrant et al., 2013). Further research has shown that a child's odds of stunting increase by 1.13 with every five diarrheal episodes prior to 2 yr of age (Checkley et al., 2008). These findings are critical, based upon the considerable consequences that childhood stunting has on multiple human health and livelihood outcomes in adulthood; this includes elevated chronic disease, increased risk of noncompletion of schooling, lower adult earning potential, and poorer productivity (Black et al., 2008; Martorell et al., 2010; Adair et al., 2013; Guerrant et al., 2013; Hoddinott et al., 2013). Moreover, the WHO estimates that a majority of foodborne illness and deaths are caused by diarrheal disease agents (i.e., *Campylobacter* spp., norovirus, and non-typhoidal *Salmonella enterica*; Havelarr et al., 2015). These findings highlight the importance of safe and healthy agriculture value-chains and the role of foodborne disease on global public health outcomes, and it clearly exhibits the impact of foodborne hazards on human capital and global development.

In 2015, The United Nations released their 2030 Sustainable Development Goals (Figure 1). Agriculture development will play a vital role in reaching these goals. Therefore, agriculture value-chain development has become a global initiative, particularly in Africa and Southeast Asia. Hence, major investments have focused on the intensification and diversification of agriculture production, in order to diversify human diets, reduce undernourishment, and improve nutrition worldwide. This investment includes heightened attention to sustainable intensification, increased production and consumption of horticulture crops and animal source foods (**ASF**), and improvements to postharvest handling and processing; food safety is relevant to each of these areas and will play a pivotal role in their successful growth. Therefore, food safety should not be considered solely as an enabling environment, but rather as a key pillar of agriculture value-chain development.

In terms of animal production, several influential factors contribute to human livelihoods on multiple levels, particularly human health and nutrition outcomes (Randolph et al., 2007). Animal source foods are excellent sources of protein and key micronutrients that are essential for physical and cognitive growth (iron, zinc, vitamin A, vitamin B_{12}, and calcium). In fact, human nutrition research conducted in Kenya demonstrated that children supplemented with meat performed better on cognitive assessments than children not receiving supplementation (Whaley et al., 2003). Additionally, research has shown the vital role of vitamin B_{12}—a vitamin only found in ASF—in brain development and health (Black, 2008; Dror and Allen, 2008); these findings in many ways support the need for investment in animal production systems worldwide. However, it is also important to recognize that ASF are also highly perishable and susceptible to safety and quality defects. Livestock are common carriers of foodborne pathogens and can be exposed to mycotoxins in feed and the environment; these hazards can contaminate ASF intended for human consumption. Furthermore, many countries lack appropriate resources and infrastructure to safely handle and process animal products

Figure 1. The 2030 Sustainable Development Goals for the United Nations. https://www.un.org/sustainabledevelopment/sustainable-development-goals/

(i.e., pasteurization of milk). Without proper control of food safety hazards, healthy livestock value-chains do not always exist, and poor food safety and hygiene practices can result in customer rejection; increased health costs to individuals and countries, contribute to food waste and losses, and compromise public health.

Global food safety challenges

Improvements in food safety systems, on a global scale, can help to provide healthier agriculture value-chains. In many cases, human health outcomes can be attributed to a variety of dynamic, complex interactions between human beings and their environment. For example, empirical evidence suggests that healthy livestock contribute to healthier smallholder farming households (Thumbi et al., 2015). This evidence could be extrapolated to conclude that healthy livestock value-chains also contribute to healthier global human populations; however, causal pathways are not fully defined. Although the first estimates on the global burden of foodborne disease have been published, much remains unknown about this burden around the world. Currently, what is known is that some of the major challenges, in terms of food safety, center around—but are not limited to—inadequacies, inconsistencies, inequities, and inefficiencies. The following discussion will seek to fully describe these challenges and how they influence food safety systems, as well as development.

Inadequacies in data. Data and knowledge gaps can create a true "chicken or the egg" scenario, where the lack of data and knowledge about food safety hazards creates misconceptions about what constitutes adequate food safety systems, and then ultimately inadequate food safety systems are unable to provide sufficient data and knowledge about food safety hazards. For example, unsafe water is commonly associated with diarrheal illness in developing nations, yet reviews of water, sanitation and hygiene (**WASH**) programs have reported varying (between 20% and 60%) findings on the percentage of diarrhea that can be attributed to unsafe water (Cairncross et al., 2007; Prüss-Ustün et al., 2011; Engell et al., 2013). This variability, without context, could lead to misinformed decision-making, and ultimately end in inaccurate conclusions or inferences.

In order to establish proper food safety systems, both the policy and operational levels of food safety management, at the national level, require a solid foundation of epidemiological data. Data include the prevalence of various foodborne pathogens in and across food value-chains, the incidence and distribution of foodborne illness within communities, as well as the

Vegetables for sale in a traditional wet market.

routes of transmission and risk exposure within populations. These data are rarely available outside of the industrialized economies and even these countries face multiple challenges collecting this information; which leads to estimates commonly being understated. However, without these estimates, it is impossible for governments and private sector actors to measure the impact of implementing food safety programs across agriculture value-chains.

The lack of data can also lead to confusion or misconceptions regarding foodborne hazards, resulting in inadequate or misguided control measures. For example, in many countries, municipal abattoirs base their food safety controls on conducting antemortem and postmortem inspections to identify animals carrying signs of zoonotic disease, such as bovine tuberculosis (**TB**) or Brucellosis. While this is an important measure, it is rarely coupled with controls for biological foodborne hazards that do not commonly elicit a visual response in livestock (e.g., *Salmonella* spp. and *Escherichia coli*). This is problematic, due to the role that the food sector should play in providing safe foods. Value-chain actors, particularly private industry, are responsible for establishing food safety management systems that ensure that foods present a minimal risk to the customer. If value-chain actors are not provided with the appropriate data, information, and training to base food safety decisions upon, then food safety efforts will be largely unsuccessful. Furthermore, data will help to drive informed decisions on food safety governance and investments in infrastructure, which are necessary elements of effective food safety systems.

Inadequacies in governance and infrastructure. Governance refers to how decisions are made, and the actions carried out in support of stated goals (Miralles, 2010). In this regard, it is evident that most developing and underdeveloped nations lack a systematic way to control food safety hazards. Even if governments have adapted *Codex Alimentarius* into their national health plans, there is a consistent lack of infrastructure for chemical and microbiological testing as well as little resources for routine monitoring and/or enforcement, e.g., properly trained inspectors. This lack of infrastructure extends into the private sector as well, in terms of both market structure and physical structure.

In contrast to industrialized nations, the food sector in many low- and middle-income countries is largely heterogeneous, and commonly includes a large informal sector (e.g., street foods, backyard slaughter, etc.; Grace, 2015). This combination of a huge market with multiple small-scale producers seriously complicates the government's possibilities to enforce food safety regulation (Bing and Jianjun, 2015). This type of market structure also presents challenges in terms of creating food safety programs that are adaptable enough to meet the needs of such a diverse food sector. For example, although Hazard Analysis Critical Control Points (**HACCP**) is the universal language of food safety, the level of implementation throughout the world varies tremendously. This is most likely because the adoption of HACCP by food producers/sellers is often driven by customer demands, especially if the product is to be exported. In heterogeneous markets, as well as in informal markets systems, the laws of customer demand and industry pressure may not be as persuasive. Particularly when considering the fact that informal markets largely serve the underprivileged, impoverished, and food insecure populations in a country. This is not to say that underprivileged, impoverished, and food insecure populations have a lower demand for food safety, but rather to suggest that they have reduced decision-making power when it comes to food safety (McDaniels et al., 1992).

Food safety implementation and governance is further complicated, in many developing economies, by the lack of potable water and electricity, isolation, war, and ethnic disputes. These factors can complicate or negate oversight of food production and routine monitoring of foodborne hazards. This is particularly evident in countries where subsistence agriculture persists

Fish being fried at a roadside vendor.

in rural, isolated regions. For example, the Afar and Samoli regions of Ethiopia are largely underdeveloped, lack sufficient transportation infrastructure, and are susceptible to violent conflict. These regions are home to pastoralist communities, as well as expansive livestock herds (Tolera and Abebe, 2007). The oversight of livestock production in these regions is a tremendous task that is often not prioritized. However, a majority of young cattle in Ethiopia are sourced from these regions, and therefore should require heightened attention to the monitoring of production and handling practices within those regions (AGP-LMD, 2013). In order for value-chain based food safety programs to be effective, they must have appropriate governance and infrastructure. Otherwise programs will not be fully implemented and monitored. This also clearly demonstrates a need for full engagement of all value-chain actors, as well as the need to create capacity in multiple sectors of food production throughout the world.

Inadequacies in value-chain engagement, laboratory capacity and training. Food safety is not the responsibility of a single stakeholder, but is a partnership between value-chain actors. The management of food safety should be considered as a concerted action that needs cooperation between the government, enterprises, customers, and civil societies. The primary role of the government, in regards to food safety, is to verify that the private sector is implementing appropriate food safety management systems. Additionally, the government has roles in defining what is safe, in establishing appropriate targets or metrics, in providing guidance to industry on ways to achieve safety, and in informing customers when breakdowns in the systems have resulted in unsafe foods (Waite and Yousef, 2010). While foodborne illness surveillance will be a government responsibility, monitoring for foodborne hazards will be the responsibility of both the government and private sector. Moreover, universities and research institutes should engage with both the government and private sector to provide informed recommendations and innovative ideas to support the development and evolution of food safety systems. Engagement of both the public and private sector within agriculture value-chains can often be limited, particularly in nations where the private sector is very small or heavily restricted. This can be detrimental to the acceptability and sustainability of food safety programs

Typical wet market meat counter.

and policies, particularly as food supplies move more toward a global value-chain.

Further, sustainability of food safety programs is highly influenced by human and institutional capacity within public and private sector entities. Depending upon the situation, technical capacity is often minimal within developing nations, particularly in regards to food safety testing laboratories. This capacity includes laboratories with the appropriate equipment to test for biological and chemical hazards, trained and competent laboratory personnel, availability of and access to reagents, test kits, and laboratory consumables, etc. Building research capacity in regional government agencies, universities, and the private sector will enable countries to develop the necessary science-based data and information.

Traditionally, investments for food safety and skill development and transfer have not been a priority in developing nations, except in major exporters for the western world. Agro-industrial production and modern retail have not demonstrated clear advantages in food safety and disease in these systems (Reardon et al., 2001). Public information, education, and communication are primarily the responsibility of government and university and research institutions, but industry will also play a role, with respect to specific products, especially when problems occur with a product (Waite and Yousef, 2010). Customers, the government, research institutions, and industry, need to participate in the food safety governance, as well (FAO, 2017). Capacity development—in regards to equipment, education and training, and the unifying of stakeholders—needs to be prioritized as a part of agriculture value-chain development. This is not only necessary, but may also be the path of most certainty in order to obtain measurable impacts in reducing the burden of foodborne disease, improving public health outcomes, and creating safer food systems worldwide. Capacity building should be combined with targeted global efforts to train and educate students and professionals about food safety principles and their application around the world. This should include bidirectional training and education programs that seek to empower and inform food and agriculture scientists around the world about global food production, and may create more consistency in how food is produced and regulated within and across nations.

Inconsistencies in standards, regulations, and certification. In regards to inadequate infrastructure and governance, this discussion has already introduced the role of market structures. However, market structure also contributes to inconsistencies in food safety systems worldwide (e.g., formal market vs. informal market standards and controls, and domestic food production vs. export food production). Inconsistencies exist both within a country, as well as across countries, and are highly influenced by trade agreements, customer willingness to pay, and government priorities.

Food safety programs and their implementation are driven by trade to the same extent that they are driven by the desire to protect public health. Trade is one the most common arguments used either for, or against, food safety standards, controls, and regulation. Underdeveloped nations often host inconsistencies in their approach to controlling foodborne hazards, usually on a larger scale than can be observed in developed nations. These inconsistencies include: numerous organizations with overlapping commissions, standards not based on country or value-chain context, conflicting standards or regulations often based on developed nation mandates, fragmented and/or missing legislation, food safety standards and controls for export market food production that differ from domestic (Grace, 2015). These inconsistencies can often increase the burden of compliance and add to confusion among value-chain actors.

Inconsistencies in standards and regulations, within and across countries, can arise from the pressure to meet global trade standards, often set by developed nations. Global standards can tend to favor established exporters and can lead to reduced access to export markets by developing nations (Unnevehr and Ronchi, 2014). In order to remedy this, national governments may seek to create stronger regulatory standards for food production. However, stronger regulations are not commonly combined with increased resources to help value-chain actors cope with new standards. If not managed, this can lead to poor producers being unable to meet standards, and ultimately dropping out of the market (Graffham et al., 2007). Contrastingly, as a country enters into more trade markets, new or increased levels of foodborne hazards may be introduced into a country's food supply (Hawkes et al., 2015). This can lead to previous control measures becoming overwhelmed or inadequate, and create inconsistencies in existing standards and regulations for foodborne hazards.

Inconsistencies can also be observed between countries, in their approach and access to communicating food safety certification to food sector stakeholders, as well as customers. For example, consider the role of certification programs in assuring food safety. In most cases, the buyer specifies the type of food safety management system that the supplier must have in place. Most programs such as the British Retail Consortium (**BRC**) or the Safe Quality Food (**SQF**) programs are based on HACCP but elaborate on more in-depth food safety requirements for specific sections of the food chain or for specific food and agricultural commodities. While the various standards are voluntary, demand by buyers essentially makes certification under these standards de facto mandatory for food companies that want to sell their product to major retailers (Hammoudi et al., 2015). This can basically guarantee access to consumers with high food safety standards, and large economic shares of the global food sector. However, these certifications can also represent a large economic burden on food industry actors, especially if they are a small farm or food manufacturer. Countries that are based primarily on subsistence farming hold little to no chance of meeting trade or certification body standards. Furthermore, large established food industry companies are not incentivized by these standards to purchase commodities or raw materials from nations lacking proper modalities to supply products that are guaranteed as safe.

Wet market vendor selling meats and vegetables.

In industrialized economies, food safety has been, for the most part, institutionalized, regulated, and enforced. In these industrialized countries, food safety is managed and communicated through a risk-based approach in cooperation with the diverse stakeholders, i.e., national governments, the food and agricultural industries, retailers, and customers, including customer advocacy groups. The risk-based food safety management framework is divided into a policy level (setting targets) and an operational level (meeting the targets). This is largely unachievable without consistent approaches to standards and regulations, as well as in efforts to fully communicate regulatory expectations to food industry stakeholders. Finally, global approaches to trade should ultimately be contextually appropriate and not seek to grow faster than a country's infrastructure (physical, political, and social) will allow. This is an important consideration not only for developing nations, but also for developed nations.

Inequities. Food security and the need to keep food prices affordable remain important issues for many developing nations. Affordability of food does not always translate into the affordability of food safety, and in many situations, one is left to ask the question: how much safe food can a customer purchase on less than $1/day? (Reardon et al., 2001). Food safety programs can have substantial negative impacts on equity in low- and middle-income countries. One of the main issues associated with the development of food safety systems is that global food safety standards can have harsh economic impacts on domestic agriculture production sectors, compounding poverty and food insecurity around the world. In order to see sustainable progress in global food safety system development, and avoid food sectors that are anti-poor, food safety programs must consider their influence on gender, youth, and poverty.

In this article, vulnerable populations, in terms of food safety and development are to be defined from two perspectives: 1) Vulnerable populations may be characterized by an individual's or group's ability to cope with the political, social, and economic pressures that can be influenced by food safety programs, regulations, and standards. 2) Vulnerable populations may be characterized by an individual's or group's susceptibility to negative health outcomes due to the consumption of

a foodborne hazard. Based upon this, vulnerable populations include women of reproductive age, children under the age of 5, the immunocompromised, the elderly, subsistence farmers, and families living below the poverty level (less than $1.90/day).

For the most part, governments establish public health goals, such as the 2020 Healthy People in the United States and define an appropriate level of protection for their populations, which translate into a maximum annual incidence for a given foodborne disease. Governments need to work jointly with the food industry and consumer advocacy groups to set food safety objectives in the form of performance standards, microbiological criteria, and others to achieve the desired level of protection for their population. However, it is critical that these objectives are designed to also protect and include vulnerable populations, and not perpetuate the concept of food safety as a luxury item. This pressure is magnified in developing nations; however, inequities and their influence on food safety systems can be observed worldwide.

It is critical that national food safety objectives, in order to be successful, recognize that value-chain actors often face different barriers, and that fundamental differences exist between groups (i.e., women vs. men, elderly vs. youth, wealthy vs. poor) in regards to access to assets and resources, social norms, leadership roles, financial capital, social capital, information, and education. Furthermore, these groups also tend to value certain activities and outcomes differently, and are motivated by different incentives. For example, Women in Africa and Southeast Asia have primary responsibilities in household activities (i.e., food preparation and consumption, and child healthcare), making them a key influencer of household hygiene and child health outcomes (Grace et al., 2015). It has also been noted that women are more likely than men to use their income for purchases that benefit the entire household, including the provision of nutritious foods and healthcare for children (Quisumbing et al., 1995; UNICEF, 2011). These findings indicate that women appear to be motivated by child health outcomes, and could inform food safety programs in their approach to food safety messaging for women.

There is need for deep understanding of the needs and roles of different value-chain actors when developing food safety systems, in order to create positive impacts on vulnerable populations and support the development of agriculture value-chains. In terms of equity, food safety programs should design objectives to include: 1) recommendations for creating inclusive agriculture-led economic growth; 2) strategies for youth engagement, entrepreneurship, and employment; 3) impact pathways for gender equity, maternal and child nutrition and health, and income generation; 4) strategies to strengthen and expand access to markets and trade for poor populations; 5) and strategies to help vulnerable populations adapt to physical, economic, and man-made shocks.

Inefficiencies. The previously highlighted gaps seem to all be driving toward the same point: current food safety systems, and agriculture value-chains, in low- and middle-income countries are largely inefficient. Overlap, misconceptions, inadequate or misplaced controls, lack of data for informed decision-making, etc. all lead to many food sectors around the world failing to achieve maximum productivity, and ultimately wasting or misusing resources. This inefficiency is costly to individuals, the food and agriculture sector, and to governments. Although accurate estimates on the cost of foodborne disease are not readily available on a global scale, it is assumed that economic foodborne disease is high. Estimates from the United States indicate that foodborne disease can cost as much as 80 billion U.S. dollars annually (Scharff, 2012; Hoffmann et al., 2015; Grace, 2017). Rolled into these estimates are costs associated with medical care, productivity losses, mortality, and quality-adjusted life years (pain and suffering values; Scharff, 2012). These costs would only increase if expanded to include costs associated with poor governance, costs associated with failure to meet trade standards, costs associated with food waste or loss associated, etc. In order to realize economic growth in agriculture on a global scale, inefficiencies that stem from food safety gaps must be addressed.

Conclusions

In many ways, global food safety system development "has a long way to go, and a short time to get there." However, with targeted investment, data generation, and prioritization, several of the current gaps associated with food safety around the world can be addressed. The purpose of this article is to highlight these gaps, as well as to offer areas of opportunity for global research institutions, development agencies, private industry partners, and governments to engage in creating measurable impacts in strengthening food safety systems in developing nations. The engagement of multi-sector partnerships around the world is key to the successful integration of the global food supply. Food safety, as a discipline, has the power to unite diverse groups of people in order to solve complex problems. This article is intended to foster critical thought on the gaps that exist in food safety systems worldwide, and to serve as a call for action in order to unify stakeholders and generate innovative approaches to address these gaps.

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