

Food safety investment expert advice: Burkina Faso, Ethiopia, Nigeria

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Preface

This report summarises evidence and evidence gaps in order to help answer the following questions relevant to food safety investments in Ethiopia, Nigeria and Burkina Faso and more generally sub-Saharan Africa (SSA).

1. Why invest in food safety? What are the burdens of food safety?
2. Which sectors should be targeted to ensure food safety investments have greatest impact?
3. Which food safety hazards should be prioritised?
4. Which foods and value chains to invest in?
5. Which investments are most likely to succeed?

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Executive Summary

Take-home messages

- Donors and governments are massively under-investing in foodborne disease (FBD) management. While specific data is not available for the three countries, in SSA donor investment in food safety has been around £30-\$40 million a year. Meanwhile, the costs are at least \$16 billion per year, and disease of similar health impact receive hundreds of millions of dollars investment a year.
- Because of its health impacts – a global burden comparable to malaria, HIV/AIDs or tuberculosis – and because of its complicated relationship with several Sustainable Development Goals (SDGs), investing FBD is key to attaining SDGs.
- A lack of understanding of risk, and of risk-based approaches, as well as a lack of country-specific evidence underlies this sub-optimal investment. Current investments are skewed to issues of lesser health importance and impact: namely, export, formal markets and chemical hazards. A health-oriented focus would address domestic informal markets, informal trade and biological hazards.
- Investment in a small number of key hazards and foods would have large benefits. Consensus and stakeholder prioritisation is poor at identifying priorities and evidence-based approaches are better. Best evidence suggests that in each country around 5-7 pathogens are responsible for 90% of the burden.
- Hazard-based and country specific food safety management strategies offer a pragmatic best-bet for food safety interventions, but more evidence is needed on food safety management.
- Given the importance of the private sector in food safety, innovative financing instruments (IFIs) may have potential for addressing under-investment.

We propose the following ten-step investment **Road Map for food safety in LMIC** in general and the three countries in particular:

1. Expand the investment focus from public sector and exports to private sector and domestic markets.
2. Promote end-user driven approaches that rely on well-informed consumers to put pressure on both public and private sector to improve food safety. These will require:
 - a. Accurate information on hazards, risks and mitigation must be generated
 - b. Careful dissemination of information via social media and other routes
 - c. Targeting to different stakeholder groups and building capacity to advocate for food safety
 - d. Training and information provided via conventional and new media
 - e. Monitoring and information of outcomes and impacts.
3. Focus on food safety along the value chain and not just in the household. Build capacity in the formal and informal private sector to allow it to respond to consumer demand: for example, improving marketing skills, food safety management systems (FSMS), third party assurance.
4. Create institutions and incentives that do not only rely on government oversight to keep the private sector honest, for example, third party testing and dissemination of information to consumers.
5. Develop special initiatives for the informal markets which generate most of the health burden as well as massive livelihood benefits. The most promising approaches are market-based, light-touch, technically-innovative, incentive-driven and gender sensitive such as the training and certification of market traders.
6. Evaluate food safety investments ex ante on seven critical success factors: Efficacy, Enabling Environment, Frugality, Incentives, Capacity, Change (innovations) and Equity: the EFICACE model.
7. Change unhelpful policies that block helpful technologies from use (e.g. hydrogen peroxide) or that create unnecessary barriers for no health gains (e.g. medical certification).
8. Help the public sector broaden its current focus on standards, inspection, trade control and exports to include empowerment, co-regulation and co-ordination. Consider a single authority approach.
9. Remove barriers to intra-regional trade, including informal trade.
10. Develop innovative financing initiatives to raise resources for food safety activities. Invest in infrastructure such as electricity, access to water and access to the internet.

Why invest in food safety?

- FBD causes billions of illnesses each year, a health burden comparable to that of malaria or nutritional deficiencies. It also incurs costs of tens of billions of dollars annually.
- In addition, FBD results in significant costs to health systems and patients; is an important barrier to accessing markets; and, a growing and major concern of citizens

Which sector to invest in?

- However, food safety must be delivered by the private sector, with appropriate government oversight.
- Many food safety investments have been in formal sector exports. However, lack of food safety is not a priority constraint in the countries studied.
- The traditional sector dominates production, processing; although governments have been supporting “modernisation”, investments in the traditional sector may be more attractive.
- Informal, regional trade in food and livestock has been neglected or inappropriately managed. It comprises around half food traded: food safety issues undoubtedly exist but have not been addressed and are part of better managing informal, intra-regional trade.

Which food safety problems (hazards) to invest in?

- Most previous investments in managing food safety hazards have not been based on the contribution of the hazard or the food to health burden.
- A minority of hazards “the vital few” cause the majority of the health burden. Tackling these will be much more useful than devoting investments to other hazards (“the trivial many”).
- Most previous investments have been in pesticides and aflatoxins which are part of the trivial many not the vital few.
- Ten hazards are responsible for 90% of the health burden in the regions in which the three countries lie. Overall, the three priority hazards are salmonella, pig tapeworm, and toxigenic *Escherichia coli*. Priority hazards vary by country.
- In addition, hazards are influenced by environment and culture and country-specific hazards and value chains are likely under-invested in. These include hazards associated with raw meat in Ethiopia and food fraud in Nigeria.

Which foods and value chains to invest in?

- Best, but still weak evidence, suggests animal-source foods are responsible for most of the foodborne burden in sub-Saharan Africa. Vegetables are also important. More country evidence is needed.

Which investments are most likely to succeed?

- Food safety is best managed by a ‘farm to fork’ or ‘boat to throat’ approach that tackles food safety along the value chain. There should be multiple barriers (or redundancy) in the system so that if one barrier to contamination fails there are other opportunities to block contamination or decontaminate.
- Hazard-based management is recommended for at least the top three pathogens in each country.
- There is inadequate evidence on intervention options. Previous investments have mainly focused on training and technologies and ignored other critical factors (Efficacy, Enabling Environment, Frugality, Incentives and Equity). However, at least some benefits are proven from investments in: technologies, training and information, new processes, and population-based interventions.
- We propose a Road Map for food safety in LMIC based on consumer driven by creation of political will and empowering the private sector to deliver food safety while keeping public and private sector honest through checks and balances. Stroke of the pen policy reforms remove barriers to food safety and innovative financing initiatives will raise resources to support.

Other considerations

- FBD impacts are gendered and have positive and negative nutrition implications; interventions need to be designed with equity, nutrition issues in mind and tracked closely for impacts.
- Food fraud and informality contribute to lack of trust in food systems, economic losses and health burdens.
- Governments in the three countries are limited in capacity and also have governance issues. Relying on the public sector to deliver food safety will not work.

Food safety investment advice specific for the Three Countries

| | Burkina Faso | Ethiopia | Nigeria |
|---|--|---|---|
| Major hazards in terms of FBD burden | Non-typhoidal <i>Salmonella</i> Pig tapeworm Toxigenic <i>E. coli</i> Cholera Norovirus | | |
| Problematic value chains/systems According to burden | Pork, poultry Complementary food | Water Complementary food | Pork, poultry, beef Street food |
| Important problems from systematic literature review | Tuberculosis in beef/milk Dairy products <i>Listeria</i> in processed food Food handlers | Beef, poultry | Vegetables and fruit Beef Traditional foods |
| Risky foods highly consumed | Meat, eggs, maize | Milk | Vegetables, fish |
| Priority activities | Ground truth burden studies and identify high risk value chains/food systems Apply hazard-based management in high risk chains/food systems | | |
| Country-specific risky foods | Groundnuts | Raw meat Traditional dairy | Street food Cattle hides |
| Country-specific issues | Lack of water and poor sanitation | Substantial export of livestock | Relatively high proportion vulnerable groups High concern over fraud |
| Food system control deficits | Veterinary personnel | Residue testing | Food safety inspection |
| Opportunities | Small country, many development initiatives makes piggy-backing attractive | High coverage of government services makes public sector initiatives attractive | High urbanization, internet penetration, education make consumer led initiatives attractive |
| Risks | Lack of pre-requisites for food safety | Possible instability | Corruption and low transparency |

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Acronyms

| | |
|----------|---|
| B | Billion |
| BMGF | Bill & Melinda Gates Foundation |
| CDC | Centres for Disease Control and Prevention |
| COI | Cost of illness |
| DALY | Disability Adjusted Life Year |
| DFID | Department for International Development, United Kingdom |
| EAC | East African Community |
| EC | European Commission |
| FAO | Food and Agriculture Organization of the United Nations |
| FBD | Foodborne disease |
| FERG | Foodborne Disease Epidemiology Reference Group |
| FSPS | Food safety performance systems |
| GAFSP | Global Agriculture and Food Security Program |
| GAP | Good agricultural practices |
| GDP | Gross Domestic Product |
| GFSP | Global Food Safety Partnership |
| HACCP | Hazard Analysis and Critical Control Points |
| HICs | High income countries |
| HIV/AIDS | Human immunodeficiency virus/Acquired immunodeficiency syndrome |
| ICN | International Conference on Nutrition |
| IHR | International health regulations |
| IFPRI | International Food Policy Research Institute |
| IFI | Innovative finance instruments |
| ILRI | International Livestock Research Institute |
| IHME | Institute for Health Metrics and Evaluation |
| IPM | Integrated Pest Management |
| LMICs | Low and middle income countries |
| MRL | Maximum recommended limits |
| ODA | Official development assistance |
| OECD | Organisation for Economic Cooperation and Development |
| OIE | World Organisation for Animal Health |
| PACA | Partnership for Aflatoxin Control in Africa |
| PPP | Purchasing power parity |
| RCT | Randomised control trial |
| RTE | Ready to eat |
| SDG | Sustainable Development Goals |
| SPS | Sanitary and phytosanitary |
| SLR | Systematic literature review |
| SSA | Sub-Saharan Africa |
| STDF | Standards and Trade Development Facility |
| US | United States |
| USAID | United States Agency for International Development |
| VSL | Value of a statistical life |
| WASH | Water, Sanitation and Hygiene |
| WHO | World Health Organization |
| WTO | World Trade Organization |

Question 1a: Why invest in food safety?

1.1 Methodology

The report starts with some background information on foodborne disease (FBD) in developing countries. Thereafter, it focuses on three countries: Ethiopia, Nigeria and Burkina Faso. For each country, we gathered information to answer investment questions:

Which sector to invest? For this we gathered information on:

- The value and relative importance of the domestic food and export sector.
- The cost of illness due to food consumed domestically, and costs associated with FBD in exported foods.

Which hazards and commodities to prioritise? Which foods and value chains? We gathered information using:

- A landmark global assessment of FBD and a systematic literature review (SLR).
- Literature and experience on other considerations for prioritisation.
- Systematic literature reviews (SLR) for each of the three countries.

What are the most promising interventions to improve FBD?

- We present a conceptual framework to categorise interventions.
- We conduct a systematic literature review on food safety interventions.
- We develop a Food Safety System Performance Tool to guide investments.
- We summarise literature and our experience on interventions.
- We present a framework and road map for food safety investments along with country specific recommendations.

1.2 What are foodborne diseases and why do they matter?

Foodborne diseases (FBD) are illnesses caused by contaminated, or naturally harmful, food or beverages. A hazard is anything in food that can harm consumers' health. There are usually categorised as: biological hazards which are pathogenic organisms and the toxins they produce; chemical hazards which may be artificial or natural; and, physical hazards such as foreign objects in food.

The primary negative impact of FBD is its effects on human health and well-being. The best estimate of the global burden of disease resulting from food (which is highly conservative) suggests it is comparable to that of malaria, HIV/AIDS or tuberculosis. Nearly all of this burden (98%) is borne by poor countries and most of it (97%) is due to biological hazards, such as viruses, bacteria and parasites (Havelaar et al., 2015). Most of the burden is probably due to the consumption of fresh food (Hoffmann et al., 2017) sold in informal markets (Grace, 2015). FBD is most common and serious among vulnerable groups (the young, old, pregnant, immunosuppressed and malnourished) and is a major contributor to child stunting. The next chapter summarises information on the burden of FBD.

In addition, FBD results in significant costs to health systems and patients; it is an important barrier to accessing international markets and an emerging barrier to high value domestic markets such as supermarkets; and, it is a growing and major concern of citizens. Moreover, consumer and government responses to FBD can lead to development of agri-food systems in directions that are anti-poor and that are conducive to over or under nutrition and interventions to improve food safety often have un-intended negative consequences.

Some examples of unintended consequences are given in Grace (2015):

- Government control of avian influenza in Egypt likely led to reduced availability of poultry products and increased stunting.
- Attempts to enforce pasteurisation of all milk in Kenya, jeopardised livelihoods of smallholder farmers and small-scale value chain actors and decrease accessibility of milk to poor households.
- Largescale investments in upgrading slaughter houses likely increased contamination of meat by giving more opportunities for cross-contamination.
- Repeated scares associated with fresh foods in China may be shifting mothers' choices away from fresh foods and towards perishable foods.

1.3 Government and donor investment in foodborne disease prevention and management

Historically, FBD in developing countries has not been considered a development priority and has not been an area of substantial donor investment. There are several possible reasons for this:

1. Lack of information

- FBD is massively under-reported. FBD surveillance is weak or absent and, in many countries, there is no required reporting of FBD. Where compulsory or voluntary reporting exists, it commonly under-estimates FBD by orders of magnitude.
- Until recently, the global or regional health burden of FBD was not known. Assessing FBD in developing countries is not easy because many infectious diseases never receive a definitive diagnosis, that is, one which identifies the pathogen responsible. Even if a diagnosis is given, it may be difficult to know if the source was food, water, other people, animals or the environment.
- There is a misperception that foodborne hazards cause mild and short-term symptoms such as vomiting and diarrhoea. Although this is the most common manifestation of FBD, a minority of hazards produce severe and lasting symptoms including paralysis, epilepsy, arthritis and birth defects. As a result, about half the burden of FBD is comprised of very common relatively mild illnesses and the other half of less common but severe and dread illnesses.

2. Inappropriate focus

- Much of the efforts around food safety have focused on single hazards. This has led to an advocacy rather than evidence-based approach.
- Other major sets of efforts focus on upgrading value chains, assuming that this will automatically improve food safety. These interventions are unable to show health outcomes and it is possible that health outcomes are negligible or negative.

3. Lack of solutions

- There is little information on the range of interventions for FBD, their efficacy, costs and benefits. This is in contrast to other health interventions where there is better information (e.g. malaria or “water, sanitation and hygiene” (WASH) interventions).
- There is lack of agreement on approaches to solutions. Much of the public health community focuses on behaviour within households; much of the food safety community on farm and processing steps. Many believe that supporting agricultural transformation and the formal sector is necessary for food safety while a minority believe the informal sector can deliver safe food.

4. Lack of advocacy

- In contrast to other issues such as “the first 1,000 days” or WASH there is no strong research or development community organised around FBD. For example, on altmetrics (a measure of societal attention to science) the highest attention score for malaria is 1359 compared to 45 for FBD.
- Managing FBD is often seen as primarily a responsibility of the private sector, whereas managing other health problems is seen as more a responsibility of the public sector (for example, vector control or providing clean water).
- While several individual FBD are dread diseases associated with stigma (e.g. epilepsy caused by cysticercosis), FBD as a category are often (wrongly) perceived as having minor health impacts.

5. Complexity of FBD

- Managing FBD may be more difficult than managing some other health problems. For example, vaccinating infants or providing potable water is less technically demanding than ensuring safe food.
- FBD is context specific and the problems and solutions appear to vary greatly by context: this makes solutions to FBD less scalable.

6. A “new” problem

- FBD appears to, in general, become more problematic as value chains lengthen and complexify; as more people live in cities and towns; and, as more risky foods (primarily animal source foods and vegetables) are consumed. Many health programs are more adapted to dealing with “old” problems: such as maternal and child health, WASH, or malaria.
- There is often a lag between discovery of the importance of an issue and getting it onto donor, research and national agendas.

1.4 Why invest in food safety now?

Scientists at ILRI have worked on food safety in informal markets for the last 15 years, and we have noticed much more interest in food safety investments in the last two years than the ten before. Attention scores (altmetrics) also indicate raising interest.

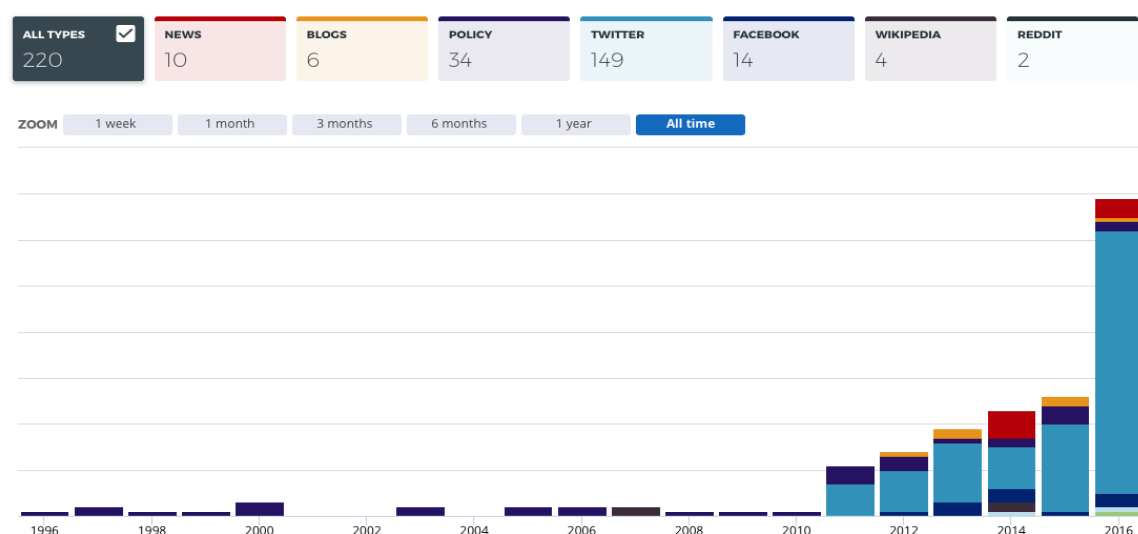


Figure 1: increasing attention on foodborne disease (source Altmetrics: 2017 not included as attention lags behind publication)

This appears to be driven by:

- The first global assessment of the health burden of FBD developed by the World Health Organisation indicating the burden was comparable to malaria, HIV-AIDs or tuberculosis (Havelaar et al., 2011).
- Increasing concern over food safety, especially among citizens of urbanising and rapidly developing countries. For example, in China and Vietnam, FBD ranks among the top societal concerns, higher than education or transport infrastructure (World Bank, 2016).
- Unlike other infectious diseases, FBD appear not to be trending down as development trends up (higher income, less hunger, less stunting, better schools, roads, hospitals, urbanisation). Some aspects of food system transformation mitigate FBD, but others exacerbate, and food safety often worsens before it gets better (Grace, 2015).

Recent years have seen major international initiatives on food safety in developing countries. ILRI is a partner in all of these:

- Global Food Safety Partnership (GFSP) initiating a study on food safety capacity
- The World Bank leading an investment study to generate evidence on food safety
- Food and Agriculture Association including food safety in the post-ICN2 process (Second International Conference on Nutrition held in 2014)
- African Union initiative on food safety
- Partnership for Aflatoxin Control in Africa (PACA)
- Department for International Development (DFID), USAID, and BMGF commissioning papers on evidence around foodborne disease in developing countries
- USAID considering funding a new Feed the Future Innovation Lab on food safety
- CGIAR research program on Agriculture for Nutrition and Health initiating a theme (flagship) entirely devoted to food safety
- The Standards and Trade Development Facility (STDF) undertaking new studies to understand the spill-over benefits of investments in food safety standards for trade on domestic food safety.
- Modernisation of food safety legislation in several countries including China, India and Vietnam.

1.5 Current investment in foodborne disease management

It is difficult to obtain comprehensive information on investment in FBD management in developing countries. Investments may occur in the agri-food system or in the health sector. Within the agri-food system they may occur at different points from farm to fork. Many investments may be partially motivated by food safety: for example, Farmer Field Schools (FFS) often aimed to improve productivity and farm income but also to reduce risk from pesticides to farmers and consumers. Investments may be made by the private sector, national governments, or development communities. Investments in initiatives on post-harvest losses, upgrading

infrastructure (e.g. roads, electricity), child feeding and care, business development may all be relevant to food safety but will not be classified as food safety investments.

Official development assistance is relatively easy to track. It is reported through the International Development Statistics databases of the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD DAC). In 2016, official development assistance for health was \$37.6 billion USD (IMHE, 2017). Around one third of this was targeted to malaria, HIV/AIDS and tuberculosis.

Between 2005 and 2015, official development assistance (ODA) for agriculture averaged 2.6 billion USD a year (OECD, 2016). The livestock and fish sectors, which produce the most hazardous foods from a food safety perspective, received around 3% of ODA each, again suggesting under-investment.

FBD spread easily across borders. Trade in food and feed as well as international travel are increasing and there are many examples of FBD pathogens spreading between countries and continents. As a result, FBD management requires global co-ordination and action. However, this, as for other global health public goods is likely under-invested in (Schäferhoff et al., 2017). This may indicate a lack of investment in global public good relative to the importance of global risks and the high return to global public health goods. For instance, Hallegatte (2012) estimates that early warning systems in developing countries would yield benefits of between \$4 billion and \$36 billion a year, with less than \$1 billion investment.

Our survey, found that the single most important activity of public food safety officials in headquarters was drafting and harmonising policy, regulation and standards. Yet there is little capacity to enforce these and little evidence of benefits. According to one expert *“The East African Community (EAC) has mixed legitimate health and safety concerns (aflatoxin) with attributes that merely determine value (grain size and color) and made every aspect mandatory thus contradicting the World Trade Organisation Agreements. Fortunately, most border inspectors turn a blind eye to this (or extract a bribe for turning a blind eye)”*.

“When 5% of milk samples fail to meet standards, you have a problem with your milk, but when 95% fail to meet, you have a problem with your standards”. ILRI research shows that it is not unusual for the majority of food sold in domestic markets in LMIC to fail to meet standards (Grace, 2015). In these cases, drafting and harmonising more and more rigorous standards is not a useful activity for national control systems.

The EAC dairy standards are not only excessively high, inappropriate but also unnecessary and harmful to the small-holder sector which dominates milk production in east Africa (Humphries, 2017).

Box 1: Strengthening National Food Safety Systems

We have also assessed coverage of food safety in the USAID funded Innovation Labs through review of material and interviews with the Lab leaders (Grace, 2017). Some preliminary conclusions from reviewing these development project investments are:

- Relatively few projects and programs focus uniquely on food safety. A much greater number claim that improved food safety may or will result from their activities. Almost none of these measure health outcomes in ways that would allow this claim to be tested.
- In projects where food safety is not the central aim, and which does not include staff with skills and expertise for food safety, it is very rare to find any measurable benefits in terms of food safety. (For example, Farmer Field Schools (FFS) often claimed that training would result in less pesticides in food, but a comprehensive evaluation found little or no evidence of health benefits to consumers). This is partly a problem of lack of appropriate monitoring; it is also likely food safety benefits are minor.
- Where projects do focus on food safety, the emphasis is most often compliance with standards for trade.
- Where projects do employ food safety experts, there is often a sectoral and technical perspective with little attention to gender, equity, livelihoods or nutrition.
- Projects mainly focus on processes rather than outcomes: for example, good hygienic practices or traceability. There is a smaller focus on presence of hazards in food, and very little work on risk, that is, the human health impacts of hazards in food.
- Many food safety initiatives seek to apply ‘best’ rather than ‘good enough’ practices. For example, trying to institutionalise processes which even in Europe is beyond the capacity of most small companies to implement (Taylor 2008).

- Initiatives intended to improve food safety can have unintended consequences on other sectors (e.g. making food less available; reducing livelihood options for women) and can even make food safety worse.
- Current investments are very poorly aligned with health burdens (table 1a, table 1b). They are mainly driven by export potential and perceptions of risk.
-

| What donors invest in | What makes people sick and kills them |
|---|---|
| Export trade | Food sold in domestic wet markets |
| Public sector standards, training, infrastructure | Private sector inability to deliver safe food Public sector inability to enforce regulations |
| Fruits and vegetables Cereals | Animal source food Vegetables |
| Aflatoxins and pesticides | Microbial hazards and worms |
| | Non-communicable disease associated with over-consumption Lack of consumer awareness |

Table 1: Donor investments compared to food-related health issues

1.6 Food safety and the Sustainable Development Goals

ILRI conducted a review to understand the relation between food safety and the Sustainable Development Goals (SDGs) for the GFSP. Food safety is little considered in the SDGs, probably because much of the negotiation occurred before the release of the first global burden study. However, the review found considerable connections between food safety and SDGs (annex 1).

Food safety is integral to achieving the health SDG 3: Good health and well-being. FBD are an important contributor to health burdens in LMIC: the burden is comparable to malaria, HIV/AIDS and tuberculosis. FBD are associated with correspondingly large costs and psychosocial distress, which can also negatively impact good health and well-being. FBD are more common and frequent in LMICs than HICs and may be trending upwards in LMICs in response to increase in demand for more risky foods along with poorly governed agri-food system transformation.

Food safety has a significant influence on other SDGs, especially:

- SDG 6: Clean water and sanitation. Many infectious FBD can be transmitted via water and people and animals infected with these diseases can contaminate water making it less safe (e.g. cysticercosis, cryptosporidiosis). Lack of clean water for washing food and food equipment and for food handler hygiene increases the risk of food being unsafe. Food production and processing may use a large amount of water reducing the availability of water for other uses such as sanitation and drinking. Water sources provide a habitat for many food and waterborne pathogens and vectors such as schistosomes and the aquatic hosts of human infective fluke. Food production and processing can contaminate and pollute water sources leading to lack of clean water and if this water is used in food processing it can contaminate food. Intensive production of animal source food (livestock and fish) is especially likely to contaminate water sources.
- SDG 1: No poverty. Ill health is a major factor in causing and maintaining poverty. FBD is one of the major causes of ill health in LMIC. FBD is associated with a range of costs that fall on poor people and contribute to their remaining in poverty. Beyond the direct costs of illness, disease may also act as a "poverty trap" that is, a self-reinforcing mechanism causing poor individuals or countries to remain poor (Grace et al., 2017).
- SDG 2: Zero hunger. FBD has multiple complex interactions with nutrition. These include: Causing illness, which worsens nutritional status; toxins may directly lead to malnutrition, for example, there is a strong association between ingestion of aflatoxins and stunting; Food production (livestock) may result in greater exposure to animal faecal bacteria which is associated with environmental enteric dysfunction. The most nutritious foods are also the most implicated in foodborne disease (animal source food and fresh vegetables).

1.7 Other considerations

There is little systematic information on the range of investment options for food safety or the return to investments. Other health issues of comparable burden (e.g. malaria control, water and sanitation) have much better economic information. In general, investments in health appear to be attractive.

This paper argues that health and economic impacts should be much influential in setting donor investments. but in fact, there is a strong mix of public and private goods and public and private standards that drive food safety policy, regulation and investment. The case of aflatoxins is illustrative, where the public health burden is both complicated to assess, and only part of the motivation for intervention (Box 4).

Mycotoxins produced by fungi are one of the most serious food safety problems affecting staple crops (especially maize and groundnuts). They can also be present in animal source foods, if animals are given moldy feeds. Aflatoxins are one of the most highly researched and funded food safety problems for historical and other reasons. As such, they can illustrate some more important aspects of food safety, including:

- For hazards created in farmers' fields or whose main reservoirs are livestock, controlling the hazard on farm is an effective and attractive option.
- Many hazards in food or water are best controlled by integrated or multiple barrier methods. For aflatoxins, these include: the use of biological control, resistant varieties, good agricultural practices, sorting grains before eating, hepatitis B vaccination, efforts to improve dietary diversity.
- It is difficult to develop market mechanisms whereby poor farmers' will undertake the cost of on-farm control of hazards.
- It is very difficult to develop models whereby poor consumers will pay more for safer food. Problems include lack of trust in food safety assurance and lack of ability to pay.
- Understanding the health impacts of food hazards can motivate other financing but these can be very complicated and difficult to assess in the case of toxins.
- Because food safety is an emotive area, advocates for safer food are often convinced by low levels of evidence: this is very evident for pesticides, genetically modified organisms, irradiation and toxins, where peoples' opinions of importance commonly go far beyond the evidence.
- Proving causality requires experimental studies. RCTs are currently the best way of obtaining this. The only RCT on aflatoxins and childhood stunting finds aflatoxins do not cause stunting (in press). (Although there were suggestions of linkages which arguably warrant further study.)

Even ambitious initiatives to reduce aflatoxins may have rather limited public health impacts. In the last 20 years the CGIAR has successfully reached nearly 40,000 farmers with a highly effective biocontrol product, Aflasafe. Ambitious targets are in place. By 2022, it is planned that 1 million hectares and 461,000 farmers will have adopted Good Agricultural Practices and biocontrol to mitigate aflatoxin contamination. This will result in 1 million tonnes low aflatoxin maize and groundnut for consumption out of 50 million tonnes being consumed. This will avert 60 deaths a year. Undoubtedly, investments in control of other FBD would have far greater public health impacts.

However, the problem of aflatoxins has been prominent in export and regional trade, aflatoxins have resulted in very visible and shocking outbreaks in which dozens of people died, they are of great concern to consumers, they have significant effects on livestock (many species of which are much more susceptible than humans) and their control is a pre-occupation of the emerging formal markets and humanitarian food buyers (e.g. World Food Program). All these factors have a role in determining investments.

Box 2 Health impacts of aflatoxins

Investment advice:

- **Food safety is underinvested in relative to its health burden. It has a health burden comparable to HIV/AIDS, malaria or tuberculosis but likely receives less a twentieth of the donor investment.**
- **Most previous investments related to food safety have not been well aligned to tackling health burdens caused by FBD. They focus more on chemical hazards and export, whereas biological hazards and domestic markets are more important from a health perspective.**
- **Studies suggest that global public health goods are under-invested in relative to national public goods, and this is likely true for FBD where there are considerable cross-border risks.**
- **Food safety is relevant to many agriculture and health initiatives but unless food safety and health outcomes are proactively addressed, intentionally planned for, and monitored and evaluated they are unlikely to be attained.**

- Food safety projects have often taken solutions from HICs and attempted to implement them in LMICs (e.g. rigorous standards and HACCP). These have often proven too costly or complicated especially for small and medium sized operations. Donor investments targeted to improving food safety in mass domestic markets should aim for “good enough” rather than “best practice” and those that don’t are likely to be bad investments.
- Consensus on how to generate and use evidence on agriculture is lacking and likely underlies the disconnect between donor investments and health burdens.

Question 1b: What are the burdens of foodborne disease?

This section summarises information on food safety in domestic markets concluding that FBD imposes an enormous health and economic burden. At least one in ten people fall ill from FBD and FBD is responsible for around 50,000 deaths in the 3 countries and a burden of nearly 4 million Disability Adjusted Life Years and billions of dollars.

1.7 Health burden of FBD in the three countries and sub Saharan Africa

Our review found that the best estimates of the health burden of FBD in African countries were those provided by the recent World Health Organisation (WHO) Foodborne Disease Epidemiology Reference Group (FERG). (Annex 2 sets out methods of estimating the health burden of FBD).

For many years, information on health impacts of FBD was not available or limited to selected developed countries, for example, the United States of America, Canada and the Netherlands (Scallan et al. 2011; Thomas et al. 2013; Havelaar et al. 2015). To address this gap, an initiative was launched by the WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) in 2006. Based on almost a decade of work by various experts and expert panel groups, the report was launched in December 2015. FERG used a structured elicitation of scientific judgement which consisted of expert panels combined with various mathematical models. Overall, 72 experts were involved across 115 panels. The study provided estimates of global foodborne disease incidence, mortality and disease burden were calculated in terms of Disability Adjusted Life Years (DALYs).

The most widely used and accepted global metric of human sickness and death is the Disability Adjusted Life Year (DALY). One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

The DALY was developed for the World Health Organization in its Global Burden of Disease project in 1990. It is increasingly used by to assess and monitor their population's health and to set priorities within their health sector. The DALY has several advantages as a health metric:

- It combines mortality and morbidity
- It allows comparison of different diseases
- It facilitates prioritisation, monitoring and cost-effectiveness assessment

Box 3: Definition of Disability Adjusted Life Year (DALY)

Out of a longer list of potential foodborne hazards, the study included 31 foodborne hazards for which there was sufficient evidence to develop credible evidence on health burden. This list comprised 11 diarrhoeal disease agents (one virus, seven bacteria and three protozoa), seven invasive infectious disease agents (one virus, five bacteria and one protozoon), 10 helminths and three chemicals. Other chemicals were assessed only for regions and not globally.

Several important hazards were not included, for example, *Staphylococcus aureus*, *Bacillus cereus* and *Vibrio parahaemolyticus*. Chemical risk assessments are more complicated, and several will only be released in 2018. It is expected that the burden of arsenic and cadmium will be very substantial, perhaps as high as non typhoidal salmonella, but much of this burden falls on Asia and not SSA.

FERG estimates were generated by a multi-year study involving dozens of food safety experts. The methodology was robust but inevitably relied on literature and expert opinion. Although FERG data is considered to be the best estimate of FBD, it is acknowledged by the authors to be conservative. Countries with good reporting and ability to estimate FBD typically have higher estimates of FBD incidence, for example one in three people in Greece are estimated to fall ill each year from FBD, and it is not likely that FBD is less of a problem in SSA than in Greece.

The FERG does not report individual country data but rather reports by sub-regions¹. A sub-region consists of countries with similar health status. Ethiopia lies in the Africa E region along with Botswana; Burundi; Central African Republic; Congo; Côte d'Ivoire; Democratic Republic of the Congo; Eritrea; Kenya; Lesotho; Malawi; Mozambique; Namibia; Rwanda; South Africa; Swaziland; Uganda; United Republic of Tanzania; Zambia; Zimbabwe.

¹ data was collected at country level but was aggregated for the report and country-level data is not easily available

It makes up around one quarter of the population of this region but its diet and epidemiology has many distinctive and unique features that means data aggregated across the region may not be very relevant to Ethiopia. Nigeria and Burkina Faso are both in the Africa D region with countries such as Senegal, Guinea and Mali. Nigeria represents x% of the population of this region. Countries in this region also have unique features which means generalising across a region loses accuracy (for example, much more fish is consumed in coastal regions, and pork is mainly consumed by non-Muslim populations). At the same time, the FERG study is currently our most credible source for understanding FBD in Africa.

Most important hazards in region Africa E and D

The FERG report finds that diarrhoeal diseases are by far the most important contributor to the overall burden of foodborne disease in African region E and D, followed by helminths and invasive bacteria. Chemical hazards and toxins are relatively un-important, with the burden more or less equally shared between aflatoxins and cassava (Figure 7).

Most lay people and many decision makers incorrectly think that chemicals in food are responsible for a large proportion of negative health impacts. There are psychological reasons why people tend to be much more worried about chemical hazards than biological hazards. There is also a marked contrast between food safety experts and lay people: the former recognise the dominance of biological hazards while lay people, or even health experts in other domains, systematically over-estimate the impacts of chemical hazards and under-estimate the impacts of biological hazards.

It can be rightly argued that it is more difficult to ascertain the health impacts of chemicals as effects may be more insidious and take a much longer time to manifest. However, rationally, it does not make sense to prioritise hazards which do not have known and proven effects (but which people are worried about) over and above those hazards with known and proven effects. This is accentuated by the reality that biological hazards are much easier to manage and mitigate than chemical hazards. In a more evidence-based and rational system, the priority should be to get better information on those hazards with missing information, and judicious use of the precautionary principle when evidence is not available, but concerns are strong. If this principle were to be applied, investments should be greatly increased in biological hazards and the relative share of investments in toxins and chemicals should decrease.

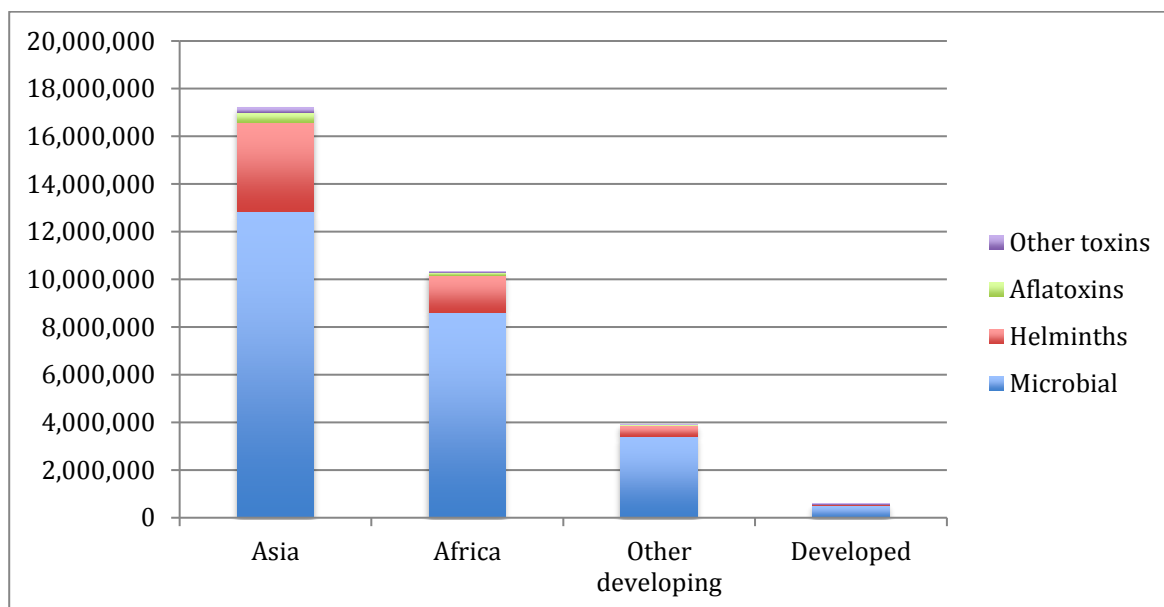


Figure 2: Burden of foodborne disease in DALYs

1.8 Economic burden of FBD in the three countries and in sub Saharan Africa

Foodborne diseases are associated with a wide range of economic costs. These can be divided into: a) the harm caused by the disease (e.g. lost productivity from illness); b) the cost of response (e.g. treatment, food recalls); and, c) cost of prevention (e.g. food safety governance, risk reducing practices) (Shaw & Grace, 2015). Alternatively,

costs may be allocated to different actors (consumer, health care, agro-food industry, government) (McLinden et al., 2014). Zoonotic diseases often exert additional burdens on the livestock sector and it is important that estimates of costs cover multiple sectors.

Loss of life may account for the biggest share of health valuation estimates (Narain and Sall, 2016). In economic terms the value of a statistical life (VSL) is the amount of money a person (or society) is willing to spend to save a life. (Annex 2 explains in detail the methods and data for these estimates).

| | Burkina Faso | Nigeria | Ethiopia | SSA |
|--|---------------------|----------------|-----------------|----------------|
| Population | 18,646,433 | 185,989,640 | 102,403,196 | 1,033,568,823 |
| Estimated deaths from FBD per year per 100,000 | 24 | 18 | 13 | 16 |
| Deaths per country/SSA | 4,532 | 33,055 | 12,875 | 136,950 |
| Value statistical life (USD) | 640,000 | 485,000 | 102,000 | 283,541 |
| Annual loss from deaths due to FBD USD | 2,900,670,542 | 16,031,479,636 | 1,313,227,132 | 38,831,076,900 |

Table 2: Foodborne disease cost in terms of lost human capital due to death from FBD

Illness can also be costed in terms of foregone output, assuming people who are ill are unable to work. The value of DALYs lost due to FBD can be calculated by multiplying the estimated DALYs loss due to FBD in the FERG data by the Gross Domestic Product (GDP), income, or purchasing power parity (PPP) adjusted income per capita for the same year, using human capital approach as in the paper on Economic Burden for Injuries. (In this relatively simplistic calculation we do not adjust for age or discounting.)

| | Burkina Faso | Nigeria | Ethiopia | SSA |
|--|---------------------|----------------|-----------------|----------------|
| DALY loss annual | 328,064 | 2,458,243 | 990,516 | 10,431,869 |
| GDP per capita, PPP (current international \$) | 1,771 | 5,861 | 1,734 | 3,724 |
| GDP per capita (current US\$) | 627 | 2,176 | 707 | 1,464 |
| GDP loss PPP | 581,001,660 | 14,407,762,242 | 1,717,554,505 | 38,847,952,667 |
| GDP loss current USD | 205,696,240 | 5,349,136,775 | 700,294,714 | 15,272,256,216 |

Table 3: Foodborne disease cost in terms of lost human capital due to disease burden

Cost of illness approach

The cost of illness (COI) approach seeks to account for the direct and indirect costs of death and illness. Direct financial costs include transport costs to get treatment, medical expenses paid by the patient, wages lost, and costs of public health provision. Indirect costs include productivity losses from missed business due to sick employees, the monetized value of forgone household chores and others. There is some inconsistency in whether costs are considered direct or indirect in the literature. There are not studies on the cost of FBD from Ethiopia or Burkina Faso, and only one, relatively weak, study from Nigeria.

ILRI conducted a study on COI of FBD in Nigeria (ILRI, 2015). This was based on extrapolations about the proportion of diarrhoea attributable to food and survey information on diarrhoeal incidence, treatment seeking behaviour, out of pocket costs and the number of days work lost. This does not include costs of running the health systems.

| | Annual cases | Treatment costs USD | Treatment & lost labour costs USD |
|--|---------------------|--------------------------------------|--|
| Diarrhoea episodes (95% confidence intervals) | 346,842,276 | 3,129,078,383 (0.87-6.45 billion) | 3,648,491,200 (1.24-7.10 billion) |
| Food borne diarrhoea (95% confidence intervals) | 173,421,138 | 1,685,192,686 (0.44-3.62 billion) | 1,964,637,151 (0.62-4.06 billion) |

Table 4: Annual cases of diarrhoea, direct out of pocket medical costs and combining out of pocket and lost labour in Nigeria

In Ethiopia, diarrhoeal diseases represent 93% of the total cases of FBD, 73% of the deaths and 70% of the FBD DALY burden, according to the FERG study. Limited information is available on the cost of diarrhoeal disease from Ethiopia. One relatively strong study focusing only on infants from 0 to 59 months, found that out of pocket direct medical expenses for outpatient treatment of diarrhoea were \$5, most of this due to medication (Memire et al., 2017). Severe diarrhoea accounted for 9.1% of the diarrhoea cases and the mean inpatient costs for this were \$79 (most due to medicines, supplies and bed-charge). The mean associated direct non-medical costs (mainly transport costs) were \$2 for outpatient care and \$20 for inpatient care. These are largely consistent with limited literature from Africa. A crude extrapolation that these costs apply also to adult diarrhoea and to the entire country suggests the annual out of pocket costs are \$145 million.

Out of pocket expenses are easier to measure than costs of running health services, but for the poorest countries there appears to be an approximate relation between out of pocket expenses, government health spending and development assistance: out of pocket spending represents 40% of the total (figure 2). Assuming this holds true for FBD and assuming we can extrapolate to SSA (big assumptions!), the costs of illness in terms of expenditure may be around half a billion USD for Ethiopia and Nigeria and more than 10 billion USD for SSA. These are very large assumptions, reflecting the massive uncertainty around costs of FBD, but the results are not incompatible with much stronger assessments of the cost of FBD from mainly HIC.

| | Ethiopia | Nigeria | SSA |
|-------------------------|-----------------|----------------|----------------|
| Cases foodborne disease | 11,026,181 | 20,547,168 | 91,031,198 |
| Cases out-patient | 10,044,851 | 14,321,376 | 73,098,052 |
| Cases inpatient | 1,003,382 | 6,225,792 | 17,933,146 |
| Cost inpatient \$ | 7 | 3 | 5 |
| Cost outpatient \$ | 99 | 14 | 56 |
| Out of pocket cost \$ | 169,648,826 | 219,176,646 | 4,183,156,642 |
| Total cost \$ | 424,122,064 | 547,941,614 | 10,457,891,604 |

Table 5: Foodborne disease cost in terms of cost of illness to patients, government and donors

Note these costs are in addition to those calculated by the VSL and GDP methods.

Illness as a shock

Illness does not only incur costs that are additional expenses in the household budget: it can also cause families to drop into poverty, and “poverty traps” may mean they never escape (Grace et al., 2017). Across dozens of poor countries, people report that poor health and associated expenses are among the top two or three causes of falling into poverty. In the Ethiopia study cited above, 6% of the households with a case of severe diarrhoea were pushed below the extreme poverty threshold of purchasing power parity (PPP) US\$1.25 per day

The cost of foodborne disease

Our estimates of the cost of FBD rely on large assumptions, reflecting the massive uncertainty around costs of FBD, but the results are not incompatible with much stronger assessments of the cost of FBD from mainly HIC. In the USA, cost estimates of 15 FBD were developed by the United States Department of Agriculture. These 15 pathogens cause over 95 percent of the 9.4 million cases of foodborne illness in the United States for which a pathogen cause can be identified. ERS estimates that these 15 pathogens impose \$15.5 billion per year in medical costs, wages lost from time away from work, and societal willingness to prevent premature deaths. Other studies give higher estimates. (US\$78 billion in the USA, US\$2 billion in the UK, US\$1.3 billion in Australia, US\$234 million in the Netherlands, US\$171 million in Sweden) (Scharff, 2012; Abelson et al., 2006; Mangen et al., 2014; Toljander et al., 2012).

Although there is much less evidence on the cost of FBD in LMICs, a recent study in India, based cost estimates on the human capital approach (foregone output due to premature mortality) applied to FERG data, gave results broadly compatible with our estimates for the Three Countries and SSA. The India study implied the 2010 economic costs are in range of USD 12 billion to 55 billion USD (WUR & ILRI, 2017).

Summary of burdens of FBD in the three countries and sub Saharan Africa

- **FBD causes at least 33 million illnesses, is responsible for nearly 17,000 deaths and imposes a burden of nearly 4 million DALYs in the Three Countries.**

- Economic burdens are also high:
 - VSL: summarises only costs associated with lives lost, and not cost associated with sickness or treatment, it implies costs of FBD of around \$40 billion for SSA
 - GDP: summarises only costs associated with inability to contribute to the economy because of sickness or death and not costs due to treatment, it implies of costs around \$15-40 billion for SSA.
 - GDP and VSL measure aspects of human capital and overlap.
 - COI: summarises only costs due to treatment (out of pocket and health care system) and not loss of productivity or willingness to pay to avoid death. As such, these costs are additional to those measured by the human capital approaches (GDP and VSL). They imply costs of around \$10 billion for SSA.
- Take home: FBD likely costs a minimum of \$20 billion a year in SSA in terms of human sickness and death and more plausibly around \$40 billion.
- In addition, FBD imposes economic costs related to impacts in the agri-food sector.

Question 2: Where to invest? Export or domestic, commercial or smallholder sector, in the household or along the value chain?

2.1 Export or domestic

The previous section sets out the burden of FBD resulting from food eaten in domestic markets. However, most food safety investments have targeted export value chains and the formal agri-food system. *This section summarises information on export, import and domestic food markets. More details are given in annex 3. It concludes that while there are certainly food safety issues in exported and imported food, these are probably much less than the aforementioned burdens associated with FBD from domestic markets.*

Exports from the three countries

Currently, with the exception of Ethiopia, risky food exports are sometimes strategic but overall not very important in the three countries considered. This contrasts with some other LMIC (such as Vietnam or Kenya) where food exports are key to national economies

- The Government of Ethiopia is strongly encouraging exports in order to improve balance of trade and obtain currency for development investments. Ethiopia exported \$1.7 billion (B) and imported \$19B of goods in 2016. Food is an important part of Ethiopian exports, especially coffee (41% of exports, followed by dried legumes (15% of exports)). The major food exports in 2016 were: coffee, (tea, spices) USD 0.75B, dried legumes 0.25B; vegetables 0.1B and meat 0.035B
- The Nigerian economy is heavily dependent on exports, but these are mainly oil and natural gas (>95% of exports). In 2015, Nigeria exported \$48B worth of goods and imported \$40B. The major food exports in 2016 were: cocoa USD 0.89B, oilseeds 0.28B, fish 0.11B and fruits/nuts 0.06B
- Burkina Faso is a land-locked country and is the largest exporter of cotton in sub-Saharan Africa: food export is not a major policy objective. Burkina Faso exported \$3.5B and imported \$3.2B in 2016. Exports were dominated by gold and cotton (73% and 13% of the total value respectively). Major food exports were: oily seeds USD 0.12b and nuts USD 0.08B. (All export data from TradeMap).

Because the foods that dominate exports are relatively low risk (with the exception of meat from Ethiopia), food safety is not a major impediment and the levels of rejections, even from demanding markets, is low. This demonstrates ability of the agriculture export sector to comply with standards. A published analysis of food safety notifications between 2006 and 2010 found that none of the three countries were in the top 15 countries for food alerts (the top five were China, Turkey, the United States of America, India and Iran, in that order (Anon, 2012).

For this report, we analysed data from the European Union on export rejections between January 2007 to October 2017 (Figure 4 and 5). Over this period, Nigerian food accounted for 373 alerts, Ethiopian for 53 reports and Burkina Faso for only 7. In Ethiopia and Nigeria, the most commonly detected hazards were aflatoxins and in Burkina Faso, *Salmonella*. Only in Nigeria was attempted illegal exports a significant problem.

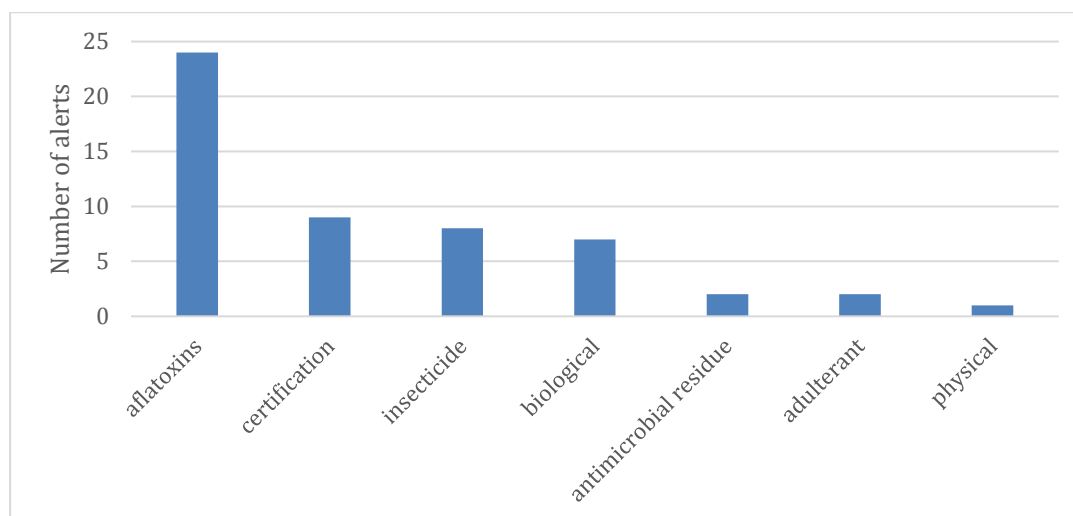


Figure 2: Hazards in food safety notifications for exports from Ethiopia to the European Union

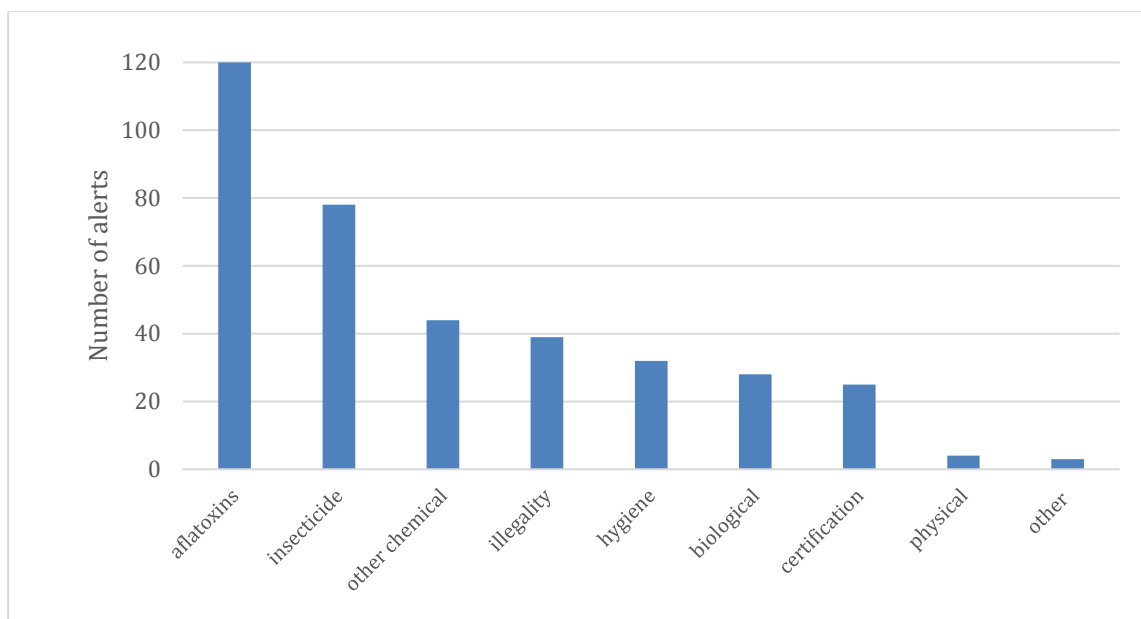


Figure 3: Hazards in food safety notifications for exports from Nigeria to the European Union

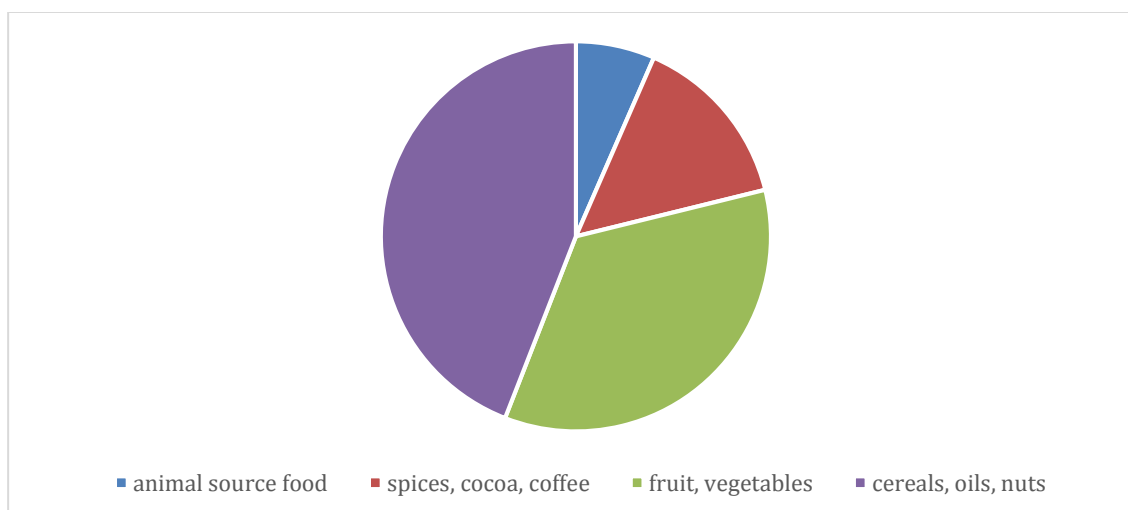


Figure 4: Foods in notifications for exports from Ethiopia, Nigeria and Burkina Faso to the European Union

Moreover, food safety is not the key constraint to exports from the three countries. The operational cost of compliance in Africa is estimated at 2-11% of the cost of exports (Shafaeddin). However, cost of compliance with food safety is rarely a bottleneck in gaining access to export markets. For example, ILRI research shows that African countries' export trade in live and processed animals is mainly constrained by costs of production and transactions between producer and foreign consumer rather than costs of SPS compliance.

ILRI's in-depth whole-chain studies identified cost items and market actor behaviours that contribute to poor export performance. High feed costs in Ethiopia, high transport costs in East Africa, and high marketing costs and lack of information in West Africa, were more problematic than standards (Baker et al., 2011).

Improving food safety in export products is intended to assure food safety in importing countries. There may be spill-over benefits as a result of investments in food safety for export improving capacity in-country that leads to improvement in domestic food safety: there is very little evidence that this actually happens and no quantitative evidence on the extent of the benefits, but a study is underway by Michigan State University which should generate evidence on this. (Preliminary findings suggest that spill over benefits from investments in SPS are very difficult to determine and may not be large.) It is also possible that exports can worsen food safety, as unsafe products

rejected from export value chains before export, likely end up being consumed in domestic markets. There is solid evidence that this occurs but little evidence on the extent of this problem.

Imports to the three countries

All three countries are net food importing but imports consist mainly of low FBD risk cereals, oils and sugars. In sub-Saharan Africa overall, food made up 15% of all officially recorded imports in 2011 (by value); however, imported food still constituted only a small proportion of total food consumed: around 1-3% between 2002 and 2011 (IIED, 2015). However, for some foods much of the total amount consumed is imported: especially Asian rice consumed by the urban poor, and dairy and poultry consumed especially by urban rich or middle class. Imported rice constitutes around half the total consumed in Nigeria (6 million tonnes). Total broiler meat imports into SSA from all sources rose from 6,000 tons to 1.22 million tons in 2014, accounting for 44 per cent of total domestic consumption (USDA-ERS, 2014 and Nigeria is a major destination, despite a ban on importation of frozen chicken.

- In Nigeria, food makes up 32% of official imports. Around half the rice is imported and much of the poultry meat and powdered milk. Wheat, frozen fish and sugar are the top three official imports by value (OEC)
- In Burkina Faso, food makes up 17% of official imports: rice, wheat and sugar are the top three.
- In Ethiopia, 15%: palm oil, raw sugar and rice (World Bank, OEC).

The major formal sector or legal food imports to the countries considered are food oils, rice and sugar and sweeteners. Major importers include Indonesia (mainly palm oil), India (mainly rice and sugar) and USA (mainly food aid). The commodities imported are mainly low risk, they tend to come from countries with better food standards than the African importing countries and inspection of imported food is one of the better conducted food safety activities. Hence, formally imported food is not a high issue of concern from the perspective of food safety.

Informal cross-border trade

Around half of all intra-African cross-border trade is classified as informal (FAO, 2017) and informal cross-border food trade is significant in all three countries. It is conducted mainly by individual traders; in west Africa, many of these are women, but men dominate in east Africa.

- Ethiopia: Major outflows are livestock from Ethiopia to Somalia, beans from Ethiopia to Kenya, Sudan and Somalia, maize from Ethiopia to Kenya and Somalia. Major inflows include rice from Somalia to Ethiopia and sheep and goats from Kenya to Ethiopia. Although information is difficult to obtain, informal exports from Ethiopia may value \$0.5-1B or more.
- Nigeria: Major inflows of imported foods take place from Togo and Benin; major inflows of livestock from Burkina Faso, Mali, Niger and Chad; and major outflows of cash crops and processed food to neighbouring countries. For example, anecdotal evidence suggests that official data on the country's trade with Benin represent only about one 1% of the actual volume, and that at least 70–80 per cent of overall trade between Nigeria and its neighbours is unrecorded.
- Burkina Faso: like other landlocked west African countries, Burkina Faso imports cereals, tubers, fruits and vegetables from coastal countries (Côte d'Ivoire, Senegal, Ghana and Benin) and in turn, livestock flows from Burkina Faso to coastal countries. One study estimated that \$212 million worth of livestock are exported from Burkina Faso (\$54.4 million are officially reported) (Josserand, 2013).

There is little evidence on the food safety implications of this trade, but given the absence of any sanitary checks, there is certainly the possibility of food safety issues. Banned foods such as milk powder containing melamine have been found at relatively high levels in east Africa (6% of milk powder sampled in Dar-es-Salaam (Schoder, 2010)).

Informal trade is extremely important for food and nutrition security and livelihoods. On the other hand, it reduces government revenue, escapes food safety inspection, and may contribute to overall poor governance. There is much debate on the extent to which informal trade should be suppressed, encouraged or formalised. There is some evidence that attempts to formalise this trade have low success and have negative consequences (Little, 2015).

Summary of the issues around investment in export or domestic sectors

In summary, the last chapter showed that FBD is highly prevalent in domestic markets and imposes considerable costs. It appears less problematic in formal export/import markets. While there are few documented spill over benefits for domestic food safety resulting from investments in export markets, there is the potential for these to be enhanced. Little is known about FBD and informal export/import markets, but recent government attempts to formalize them may have been ineffective and anti-poor.

2.2 Traditional, smallholder versus modern, industrial agri-food sector

Conventional wisdom is that, food safety can be best attained through modern, market-oriented, high-input, large scale and industrial systems and that these systems will rapidly and inevitably replace traditional, small-scale and low-input systems. We find little evidence for either belief.

Smallholder and traditional farming dominates

In all three countries, most food is produced by smallholders and sold through the traditional sector. In Ethiopia and Burkina Faso around 80% of the population are engaged in agriculture: in Nigeria around 70%. Small-scale farmers produce more than 90% of food crops. In Ethiopia, smallholders also produce more than 90% and coffee, the main export. The reductions in rural poverty and increase in food production over the last few decades have largely through improvements in smallholder production and productivity. Recent years have seen more government investment in smallholder agriculture, including training extension workers, improving roads and micro-irrigation in all three countries. However, use of inputs, adoption of technology and productivity still remains low.

Government encourages commercial and export farms

Especially in Nigeria and Ethiopia government has had a long-standing interest in expanding “modern and commercial” farms.

- In Ethiopia government has offered huge parcels of land at extremely low lease rates, along with tax holidays (Anseeuw et al 2012). Commercial farms and ranches can contribute to improved food security, through the generation of foreign exchange; improved incomes as a result of on- and off-farm employment created by investment projects; and food production that is marketed within Ethiopia. It is difficult to assess the impact of these investments, because of lack of data and early stages of some investments. However, preliminary information suggests they have had high failure rates and often negative impacts on local people (Fisseha 2011; Portner et al., 2014; Hindeya, 2017).
- Nigeria also has a history of government support for ambitious, large-scale and industrial farming. However, most of these failed to meet their potential including: cocoa, groundnuts (peanuts), rubber, and palm oil production.
- Burkina Faso has seen less emphasis on commercial and industrial farming.

Contract farming or out-grower schemes have potentially more benefits for local communities, but experiences are mixed (Hall et al., 2017). There is little evidence on food safety levels of food produced from modern or traditional farming in the three countries, although work from elsewhere shows smallholders can produce safe food, and that large scale is not always safe (Grace, 2015).

Government also encourages agro-processing

In a similar vein, recent government policy emphasizes commercial agro-processing. For example, in Ethiopia, The Growth and Transformation Plan 2 (2015/16-2019/20) prioritizes agro-food processing, leather and textile. Integrated agro-industrial parks are under construction.

However, nearly all agro-food processing remains in the traditional sector. There is little evidence on food safety levels of food produced from modern or traditional farming although work from elsewhere shows traditional processing can be safe, and modern processing is not necessarily safe (Grace, 2015).

Food retail dominated by the traditional sector

A study by the International Food Policy Research Institute (IFPRI) in 2013 characterized food retail in Addis Ababa, a city of 3 million people. Modern retail was negligible and there was no sign of the much-heralded “supermarketisation revolution” (Woldu et al., 2013). Most of the risky foods (meat, fruit and vegetables) are sold by traditional shops, specialty shops or micro-sellers. A study on dairy retail in Addis found that 55% was purchased from the open market, 36% from specialty shops and 8% from modern retail (Bekele et al., 2015). Likewise, in Burkina Faso and Nigeria, most fresh food continues to be sold in the informal sector. There is little evidence on relative food safety from different outlets, although modern retail is both more expensive and offers goods of better visual quality. Work from elsewhere shows that food from modern retailers is not always safe, nor is food from the traditional sector necessarily risky (Grace, 2015). In our SLR we found *Listeria monocytogenes* was in general low in locally produced cottage cheese, but high in processed dairy products from supermarkets (Seyoum2015).

Agri-food system transformation

In all three countries, although most markedly in Nigeria, food systems are in transformation. Changes include:

- increase in urban and peri-urban farming
- “telephone farmers” who operate in the traditional sector and at medium scale but have higher use of inputs and information and may be filling in the “missing middle” of African agri-food systems
- changing dietary patterns with increasing consumption of animal source food and produce
- expansion of modern retail, although from a very low base
- increasing consumer concern over food safety
- increasing food imports

The implications of these changes for food safety are not well understood and may be counter-intuitive.

2.3 Food safety in the household or along the value chain?

There is a disconnect between the public health development community and the food safety community. The former sees the problem of food safety as mainly a household issue, where interventions should focus on training and technology for household food handlers. The only review we found of food safety interventions focused on household level food hygiene. Nine studies were identified, and overall showed improved practice, decreased pathogens in food and hands, and reductions in self-reported diarrhoea. However, most were of short duration, only three had a control group, many were rather costly involving repeated visits and provision of cleaning material, and most relied on self-reported improvements (Woldt et al., 2015).

Lessons may be learned from point-of-use household-based water treatments where interventions were also aimed at changing behaviour and practice in households. Intervention studies showed good effects but when participants were blinded as to whether they were in an intervention or control group, significant effects were not found suggesting reported improvements were due to courtesy bias (Cairncross et al., 2014). Moreover, many evaluations were of low quality and short duration and there is evidence self-reported adoption is over-estimated and that adoption fades with time (Darvesh et al., 2017).

The food safety community sees food safety as a “farm to fork” issue and puts greater emphasis on ensuring food that gets into households is safe. They cite experience from HIC that suggests that while most home cooks know about safe home food handling procedures, compliance is generally low and has not been significantly improved by campaigns (Shapiro et al. 2011). It is easier to change behaviour of value chain agents than consumers, as they are fewer in number and more amenable to incentives than household members. However, in LMIC contexts there is also a lack of good evidence that interventions in value chains can lead to sustained improvements in food safety and that these translate to improved health outcomes in consumers. Moreover, it is more difficult to address food safety in value chains in LMICs as value chains involve far more people, are mainly informal, and less amenable to incentives such as regulatory oversight, reputational risk, and legal liability for selling unsafe food.

Summary of household or along the value chain

Given the lack of evidence for household-level interventions and the challenges with attaining food safety, it is probably best to focus on farm-to-fork, including households. There is an argument for multiple barriers (or redundancy) in the system so that if one barrier to contamination fails there are other opportunities to block contamination or decontaminate.

2.4 Previous food safety investments

Ethiopia, Nigeria and Burkina Faso have been major recipients of donor aid and are also well represented in terms of food safety projects. The forthcoming report led by GFSP will provide detailed information on this important topic.

Investment advice:

Most previous investments related to food safety have been linked to SPS projects supporting access to formal international markets. For maximum health and livelihood benefits, investments should prioritize food in domestic markets and not export markets.

Although the Ethiopian and Nigerian governments see much potential in commercialization of food production and processing, the evidence on feasibility, benefits and costs to date is patchy and contradictory. Given their dominance, investments in smallholder agriculture and traditional processing and retail may have greater impact.

Food systems are rapidly transforming, especially in Nigeria and Ethiopia, and there is little information on how this transformation influences, and is influenced, by food safety. Further research on food system transformation could better guide major policy decisions, especially: regional differences in supermarketisation; the filling in of the missing middle; consumer responses to food safety

A huge informal trade sector is mainly driven by policies that create incentives to trade informally. The food safety implications are little understood. An easily implemented, but politically challenging investment is regularizing informal trade. This would reduce risks.

Question 3: Which hazards to invest in managing?

3.1 Why prioritise hazards

Prioritising food safety hazards for assessment and management can lead to better use of scarce resources. Ideally, the hazards prioritised would be a combination of those that have greatest negative impacts and those that are most amenable to management. Unfortunately, much prioritisation is still based on the presence of hazards in food, and not on their impacts on human health (Box 3) or on their amenability to management. From a development perspective, while the economic and other impacts of foodborne disease are important, there is good reason to use health burden as a key criterion for prioritisation.

This review compares a well-conducted stakeholder prioritisation, which has much in common with other rigorous attempts to develop priorities through structured stakeholder consultation (Grace et al., 2012). However, it appears to produce very biased results. An actionable finding is that while the FERG evidence-based prioritisation clearly conformed to the general rule of health prioritisation, that a small number of hazards are responsible for the greater proportion of the disease (also known as the Pareto principle or the law of the vital few and the trivial many), the stakeholder consultation did not.

Hazards are things that have potential to cause harm. In the context of food safety, a hazard can be classified as a substance (biological: virus, bacteria and parasites; chemical: growth promoters, antibiotics, pesticide residues; or physical) present in food that has the ability or the potential to cause an adverse health effect in consumers.

Risk is the chance that a person might be harmed if exposed to a given hazard. Risks in food safety are usually referred to as having short-term or long-term effects on human health.

Box 4: Hazards and risks defined

3.2 First global assessment of health impacts of foodborne hazards

The FERG does not report individual country data but rather reports by sub-regions. A sub-region consists of countries with similar health status. Ethiopia lies in the Africa E region along with countries such as Botswana; Central African Republic; Kenya; Lesotho; South Africa; Swaziland; Uganda; United Republic of Tanzania; Zambia; Zimbabwe. Nigeria and Burkina Faso are both in the Africa D region with countries such as Senegal, Guinea and Mali.

Most important hazards in sub Saharan Africa

The FERG report finds that diarrhoeal diseases are by far the most important contributor to the overall burden of foodborne disease in African region E and D, followed by helminths and invasive bacteria. Chemical hazards and toxins are relatively un-important, with the burden more or less equally shared between aflatoxins and cassava (Figure 7).

Most lay people and many decision makers incorrectly think that chemicals in food are responsible for a large proportion of negative health impacts. There are psychological reasons why people tend to be much more worried about chemical hazards than biological hazards. There is also a marked contrast between food safety experts and lay people: the former recognises the dominance of biological hazards while lay people, or even health experts in other domains, systematically over-estimate the impacts of chemical hazards and under-estimate the impacts of biological hazards.

It is rightly argued that it is more difficult to ascertain the health impacts of chemicals as effects may be more insidious and take a much longer time to manifest. However, rationally, it does not make sense to prioritise hazards which do not have known and proven effects (but which people are irrationally worried about) above those hazards with known and proven effects. Moreover, biological hazards are much easier to manage and mitigate than chemical hazards. In a more evidence-based and rational system, the priority should be to get better information on those hazards with missing information, and judiciously use the precautionary principle where worry is high and evidence weak. If this principle were to be applied, investments should be greatly increased in biological hazards and investments in toxins and chemicals should focus more on finding out how much harm they cause.

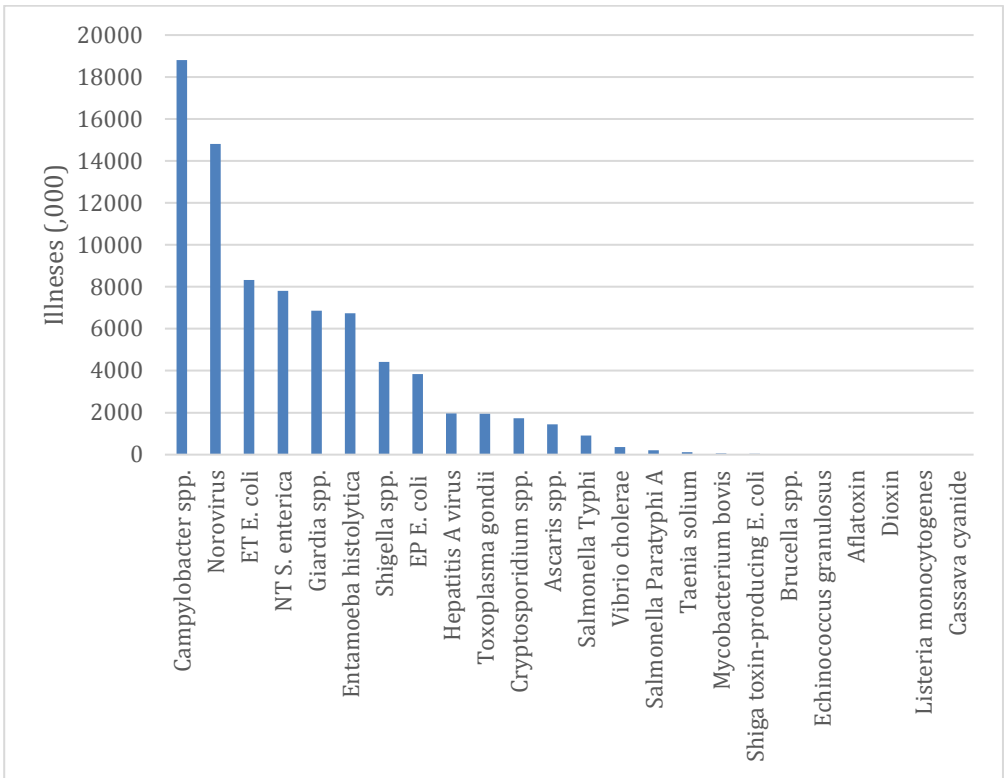


Figure 5: Food borne disease illnesses in sub Saharan Africa

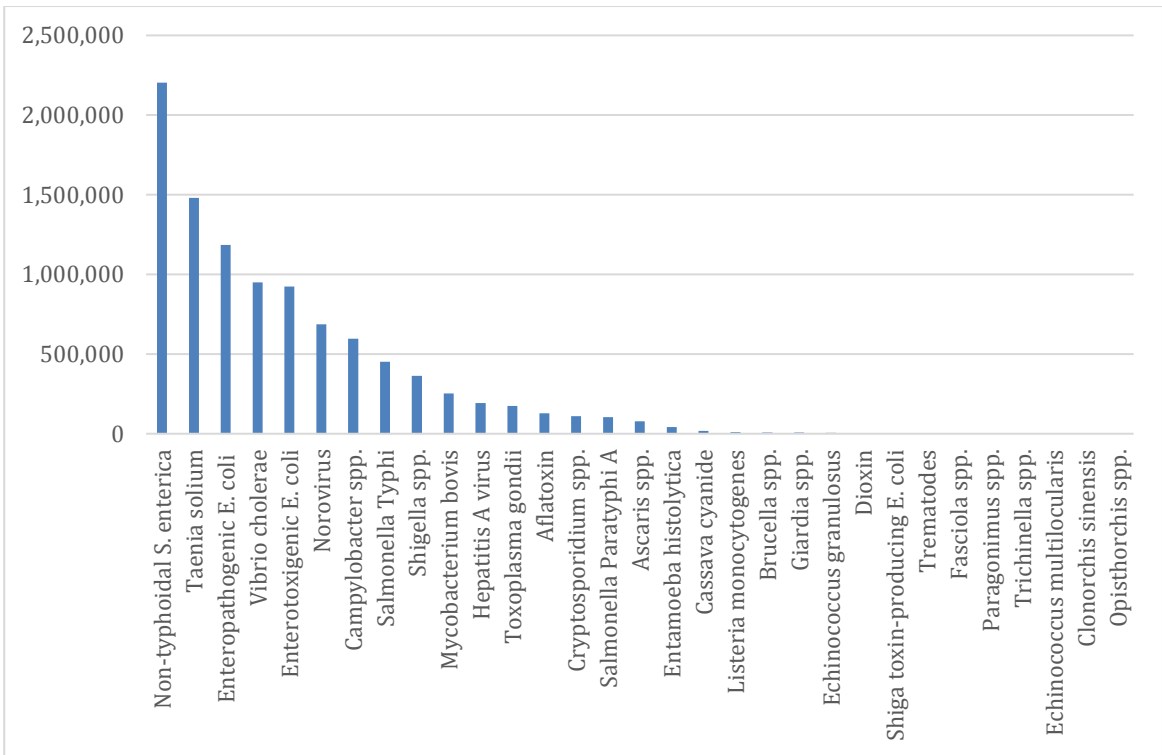


Figure 6: Foodborne disease illnesses in sub Saharan Africa

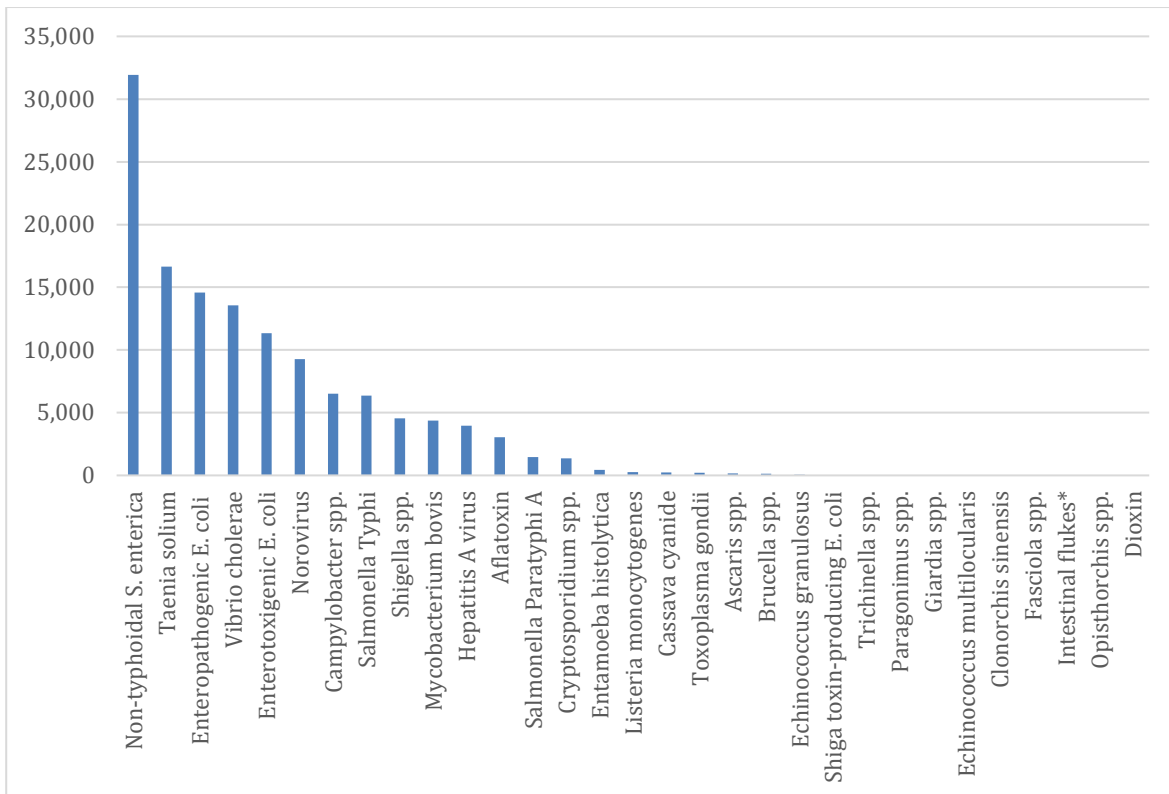


Figure 7: Foodborne disease deaths in sub Saharan Africa

Pareto Principle: The vital few and the trivial many

A key insight to the management of disease, including foodborne disease, is that the vast majority of the health burden is caused by a small number of hazards, that is, the Pareto Principle or Law of the Vital Few appears to apply. This states that, for many events, the greater part of the effects come from the smaller part of the causes. For example, the Global Burden of Disease study shows 6 infectious diseases (20% of the total classified) are responsible for 75% of the total disability-adjusted life years (DALY's) lost (WHO, 2008); similarly, 90% of health research is devoted to 10% of the world's health problems (the 10/90 gap).

There are over 600 potential biological causes of foodborne disease and thousands of chemicals, yet we restrict our focus to those where we have credible evidence of burden, there are only a handful of hazards responsible for a majority of ill effects. For Ethiopia, just nine hazards are responsible for 90% of the deaths from FBD and just seven hazards are responsible for 90% of the FBD health burden.

Challenges with using FERG data to prioritise hazards

There are challenges with using the FERG to understand priority hazards. First, several important hazards, known to occur in the countries discussed were not included because of the difficulty of obtaining global data (e.g. *Staphylococcus aureus* or *Bacillus cereus*). One assessment estimated that 20 cases of staphylococcal intoxication per 1,000 people in Ethiopia, which would rank in the top 16 hazards in Ethiopia (Makita et al). Secondly, FERG data was gathered largely from available evidence and expert opinion, but although many literature reviews were commissioned, few were done at country level so the FERG estimates of FBD in a given country are not closely based on evidence on FBD collected in that country. Because of these issues, we also undertook a systematic literature review on FBD in the countries of concern. (Some issues identified by the FERG authors include: not all causes of FBD are included; not all consequences are considered; estimates rely on models and algorithms; uncertainty intervals are wide (Havelaar)).

Why evidence-based prioritisation is more useful than consensus-based prioritisation: example of systematic prioritisation of zoonotic diseases in Ethiopia

A recent study used a semi-quantitative tool developed at the U.S. Center for Disease Control and Prevention (CDC) to prioritize zoonotic diseases in Ethiopia. Five criteria were used, and the highest weighted was contribution to perceived human health burden (Pieraccii et al., 2016). (However, the authors did not appear to

be aware of or use global disease burden data). Among the 43 priority zoonoses ranked, there were 11 which are spread mainly through food. Comparing burden-based prioritization with stakeholder prioritization (which involved stakeholder perception of burden), there are interesting differences (Figure 8). Burden estimates show a strongly skewed distribution, with a few hazards responsible for most burden (this is an accurate reflection of disease burdens). Stakeholders see many hazards as being of high burden (this is not biologically accurate). More dread diseases, classical zoonoses and diseases of historical importance are seen as more important by stakeholders.

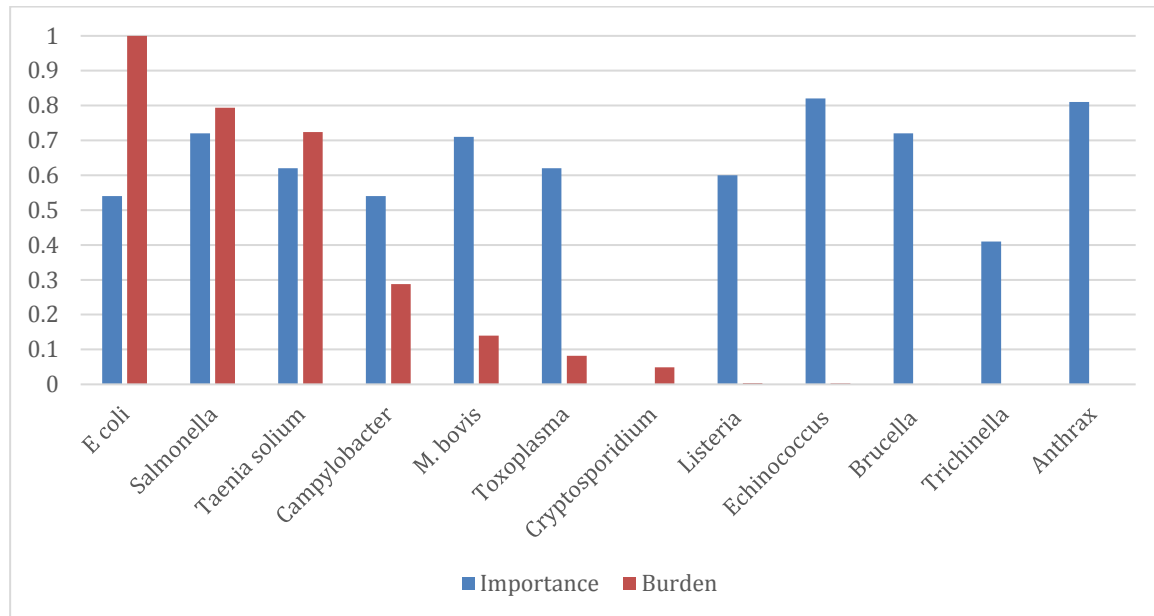


Figure 8: Normalised estimates of the importance of food-borne hazards based on Ethiopian stakeholders' estimation of importance in Ethiopia and FERG estimates of burden in Africa region E

3.3. What are the vital few and the trivial many in the three countries

Hazard-based interventions are focused on managing specific hazards and are carried out in conjunction with general hygienic practices. The majority of the top hazards in the countries of interest are amenable to hazard-based strategies. However, these have to be developed for each country and each context

Non typhoidal salmonella (NTS) was identified as top priority in terms of burden in Burkina and Ethiopia. The most common sources are poultry, eggs, pork and beef. NTS is relatively amenable to hazard-based management. For beef, processing is the key step for de-contamination.

Successful methods include:

- Farm: Biosecurity
- Farm: Consider vaccination
- Farm: Feed or water acidification
- Slaughterhouse: Organic acid and other chemical washes applied to hides post-exsanguination with proven efficacy were recommended for consideration as hazard-based interventions to control Salmonella.
- Slaughterhouse: Hot water carcass washes
- Slaughterhouse: Removal of deep lymph nodes and trimming
- Retailer: training and certification
- Consumer: use of Five Keys

Pig tapeworm, or *Taenia solium*, ranks second in terms of health burden in both Nigeria and Burkina Faso. Pig tapeworm is highly amenable to hazard-based management. The World Health Organisation has a validated strategy for cysticercosis prevention, control and possible elimination. Interventions with an approach spanning veterinary, human health and environmental sectors are required.

Eight interventions for the control of *T. solium* can be used in different combinations designed on the basis of the context in the countries, and the plan for each country requires country-specific planning and reliable epidemiological data on geographical distribution of *T. solium* taeniasis/cysticercosis in people and pigs

- mass drug administration for taeniasis;
- identification and treatment of taeniasis cases;
- health education, including hygiene and food safety;
- improved sanitation;
- improved pig husbandry;
- anthelmintic treatment of pigs (Oxfendazole at doses of 30 mg/kg – commercially produced and registered for the treatment of cysticercosis in pigs);
- vaccination of pigs (TSOL18 vaccine – commercially available); and
- improved meat inspection and processing of meat products.

Similar hazard-based strategies can be developed for other top-ranking hazards such as cholera and toxigenic *E. coli*.

3b Systematic literature review to prioritise hazards

Systematic Literature Reviews (SLR) are not straightforward, especially when the question is related to an issue in a developing country. They are highly time intensive and costly. A recent review found that the average time to complete the project and publish the review was 67 weeks, the mean yield rate was 3% and the mean number of authors five (Borah et al., 2017). Other studies have shown that a SLR may cost \$50,000 to \$100,000. ILRI has considerable experience in conducting SLRs on developing country literature (Alonso et al., 2016). Common problems are:

- Lack of literature and most studies are poorly conducted
- Lack of harmonisation or standardisation making meta-analysis difficult
- Study topics do not follow any clear logic
- Much literature is not captured in easily available databases
- Some countries have abundant grey literatures (Ethiopia, Kenya, Nigeria); in other countries, this is much more limited (Burkina Faso).

For this investment report, we undertook three systematic reviews (one for each country) involving six researchers experienced in food safety in developing countries. Here we summarize some of the most relevant findings.

3.4 Systematic literature review of hazards in Ethiopia

The systematic literature review yielded 75 full papers from which data was extracted.

It can be seen that most studies focus on hazards, that is presence or prevalence of potentially harmful organisms or chemicals in food, with less evidence on incidence or prevalence in humans as well as health and economic impact.

Comparing the hazards investigated with the hazards likely responsible for most burden, we see that bacteria dominated both. However, viruses were under-represented and chemicals over-represented. Finally, in terms of bacterial hazards studied, it is notable that non-typhoidal salmonella, likely one of the most important bacteria in terms of public health gets good coverage. However, the SLR also covers important FBD causing pathogens that were not included in the FERG study such as *Staphylococcus aureus* and *Bacillus cereus*.

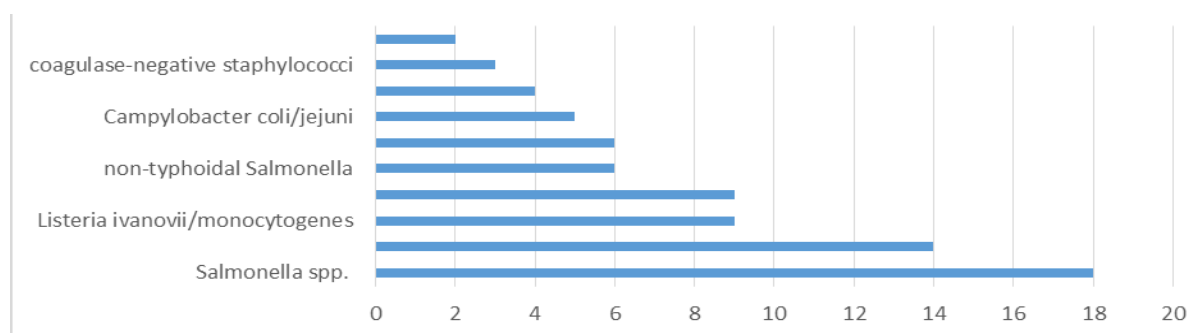


Figure 9: Systematic literature review: what bacteria were investigated

Foodborne related health impacts

Only one study was found with estimates of FBD related health impacts. A mathematical modelling approach was used to calculate the risk associated with Staphylococcus enterotoxin (SE). The risk assessment estimated that 20 cases of SE intoxication per 1,000 people were associated with consumption of raw milk in Ethiopia.

Dairy value chain

- **Staph:** Results show that milk collected at the farm (directly from the animal, or from pool milk) is very likely to contain *S. aureus*; studies report milk-farm prevalence ranging from 27% to 44%. Two studies reported much lower prevalence of 4-8%. Factors such as geographical location or farming systems are likely to determine the likelihood of animals shedding *S. aureus*. Informal milk shows a prevalence of 20-23%. Moreover, one study reported 37.5% of milk in informal markets carrying the *S. aureus* enterotoxin (the toxigenic product of *S. aureus*).
- **Listeria:** 4-13% of raw milk samples at retailer carrying *L. monocytogenes*. While pasteurization will kill this bacterium, one study reported 20% of pasteurized milk samples carrying this pathogen, likely derived from cross-contamination during processing. *L. monocytogenes* was in general low in locally produced cottage cheese (0-1% positive samples). On the contrary, 15 samples of processed cheese and 20 samples of yoghurt (representing different processing companies) from supermarkets showed 4 of them (27%) and 1 (5%) respectively positive to *L. monocytogenes* (Seyoum2015). Also, two publications reported 15-20% of ice cream samples contaminated with *L. monocytogenes* (Molla2006, Garadew2015).
- **Bacillus cereus:** one study found 63 out of 100 milk samples from an open market contaminated (Ashenafi 1990).
- **Salmonella spp.:** is less often present in milk. However, studies report farm prevalence of 3-20% in milk. While several studies did not find *Salmonella* spp in dairy products or pasteurized milk, 6% of raw milk samples from retailers in one study were found to be contaminated.
- **Mycobacterium bovis.** In one study, 13% of farms with TB reactors have milk contaminated with *M. bovis*. Between 3-14% of TB infected animals were reported to shed *M. bovis* in their milk.

Beef value chain

Consumption of raw meat is common in Ethiopia, and for this reason the presence of foodborne pathogens is of particular relevance to this value chain. Other studies report prevalence in meat in butchereries (raw meat consumption) to be between 9-11%.

- **Salmonella:** one study reported *Salmonella* in raw meat samples in 36% of sampled butchereries. In that study, 24% of butchers had *Salmonella* spp in their hands, which indicates a truly high risk of cross-contamination, making the butchereries an important melting point for dissemination of *Salmonella*. Another reported prevalence of *Salmonella* in raw meat in restaurants were relatively high ranging from 12-30% of contaminated raw meat samples
- **L. monocytogenes** was also reported in meat and minced meat at retailer shops, with prevalence ranging from 5 to 27%. , while one study reported contamination with
- **E. coli O157** in those matrices was found to be much lower (0-1%).
- **Shigella** spp was found in 13% of hand swabs in butchereries, and 0-11% of raw eat samples. No studies looked at presence of *S. aureus* in meat, but 27% of carcass and environmental samples at slaughterhouse were found to be contaminated.
- **Mycobacterium bovis** is transmitted through meat. Post mortem visual inspection of carcasses supposedly reduces the risk for humans by removing infected carcasses from the value chain. The sensitivity and specificity of the method is however low, as confirmed in a study in Ethiopia were out of the total of 63 carcass positive to detailed PM examination, 14% were found positive for TB in laboratory analysis; more interestingly, 6-13% of carcass negative in routine PM examination were found to be positive in the laboratory.

Other food value chains:

- Camel milk. Consumption of common milk is common in rural areas in Ethiopia, particularly among pastoralist. Only one study investigated milkborne pathogens in milk, although results were not provided by pathogen type.
- Eggs: one study reported 5% of eggs collected from retailers carried *S. enteritidis*; another study showed that up to 18% of samples of raw egg were positive for *Salmonella* spp. More surprisingly, 4.3% of egg sampled at retailer had *L. monocytogenes*.

- Fruits (avocado, banana and mango): studies on fruits only investigated the presence of parasites (e.g. Ascaris, Toxocara, Crypto, Giardia, Entamoeba), and none looked at the bacterial or viral load. Prevalence ranged between 38-49% (carrying at least one parasite) in fruits according to the included studies.
- Vegetables: higher parasite prevalence was reported for a range of raw vegetables (incl. green paper, carrot, tomato, cabbage, lettuce). Estimates for samples positive for at least one parasite ranged between 49-71%. Few studies looked at bacterial hazards in vegetables. These included Salmonella spp and Shigella spp (10-20% prevalence)
- Crops: this is the only value chain for which chemical hazards were studied in the selected papers (which exception of one study investigating antimicrobial residues in milk). Mycotoxins (incl. aflatoxins, ochratoxin, deoxynivalenol, nivalenol, fumonisins, zearalenone) were the primarily chemical hazard studied. The distribution of the various mycotoxins varies according to the food product. Ochratoxin were the most frequently found mycotoxin in the different staples, including teff, wheat, sorghum and barley (22-27% of samples positive). Aflatoxin B1 was most commonly found in Teff (23% of positive samples), while deoxynivalenol was commonly found in barley and sorghum (35 and 90% of positive samples respectively). While the health hazards associated with aflatoxin B1 are well established, this is not the case for the other mycotoxins, so it is not possible to translate these findings into estimates of likely health risk. Samples of groundnut seeds and locally produced groundnut cake (Halawa) were also found frequently contaminated with aflatoxin B1 (27 and 40% positive samples respectively) and to lesser extent with B2 (15 and 6% of positive samples respectively). One study reported 75% of maize samples collected from households (for human consumption) containing Dichlorodiphenyltrichloroethane (DDT) levels above the maximum-residue level (MRL).

Prevalence of foodborne hazards in the environment

Very few studies investigated presence of hazards in the environment of food handling premises. One interesting study investigated carriage of foodborne hazards by food handlers in cafeterias in Ethiopia. 40 out of 200 individuals sampled (20%) carried *S. aureus* in their hands and 11% carried *G. lamblia* and 6% *Entamoeba histolitica* in their faeces. The study confirms the role of food handlers in the spread of foodborne disease, and emphasizes the importance of hygiene in the value chain to reduce human exposure to foodborne pathogens. Other studies among food handlers in restaurants reported 1-4% of individuals carrying *Taenia* spp, 5-10% carrying *Giardia lamblia* and 8% carrying *A. lumbricoides*.

The abattoir is another value chain step where cross-contamination plays an important role on dissemination of foodborne hazards. One study reported 6% of abattoir staff carrying non-typhoidal *Salmonella* in their faeces. Food handlers in butcheries were reported to carrying *Salmonella* (24%) and *Shigella* spp (13%). *Salmonella* was also found in the faeces of healthy butchery staff (1-4%)

Prevalence/incidence of foodborne hazards in humans

Parasites are the most prevalent foodborne hazard reported in people. In healthy adults 25-35% carried intestinal parasites. Similarly, 37% of healthy street dwellers carried *Ascaris lumbricoides*. In children, studies reported prevalences of 7-29% for *A. lumbricoides* (prevalences were shown to be significantly higher in public school), and 38% for Hookworm.

A study explored the risk of congenital transmission of *Toxoplasma gondii* and showed that 85% of pregnant women monitored in a hospital in Ethiopia had seroconverted by the third trimester of pregnancy.

In children with diarrhea, norovirus was the most frequently isolated pathogen (25%), and much less commonly isolated *Salmonella* spp (7.5%). *Salmonella* spp, *Campylobacter jejuni* and *Shigella* spp were also commonly isolated from adults with diarrhea.

3.5 Systematic literature review in Burkina Faso

There was much less available literature from Burkina Faso, although we included both French and English papers. Overall 130 papers met the initial search criteria, but 107 were eliminated on screening of the abstract and of the 23 which went through only ten were of quality to permit data extraction.

Of these, 9 were conducted in the capital Ouagadougou and one in Bobo-Dioulasso (the second largest city in the country, with a considerable research presence). Most papers presented studies of pathogens prevalence in food, as opposed to incidence/prevalence in humans, and risky animal source foods were most studied. The most-studied hazards were the bacterial pathogens known to be important in Africa.

Prevalence/incidence in humans

Only one paper investigated incidence in humans: a hospital survey among children (1-15yr) presenting with acute poisoning. Overall, 22% of cases of acute poisoning in children derived from food/drink poisoning. Most of children with food/drink poisoning (includes alcohol) were in age range 1-4yr. The highest mortality among young children was not due to food poisoning, but to ingestion of drugs; 8% of cases of food/drink poisoning were due to dairy products, followed by fish (5.6%).

Another paper reports prevalence of FB hazards in humans: a study among patients with diarrhoea (3 stools in a day); screened for a range of pathogens:

- rotavirus most prevalent (21% of cases)
- followed by *Entamoeba histolytica* (7.6% of cases)
- followed by *Giardia intestinalis* (5% of cases)
- Then *Salmonella* spp. (4.2% of cases) and Shigella (3.4% of cases)
- *E. coli* and *Yersinia* around 1% each.

The paper confirms the important role of rotavirus in diarrhoea, followed by intestinal parasites and, to lesser extent, to other (bacterial) foodborne pathogens.

Prevalence of foodborne hazards in food

8 papers covered prevalence of FB hazards in different food products (mostly animal source foods, but also water and vegetables). Most of the studies were conducted in foods sampled at retailer.

Beef value chain (3 studies):

- Diarrheagenic *E. coli* was found in 44% and 52% of raw meat and intestines respectively (retailer).
- No *Salmonella* found in raw in market or in meat-based sauces in restaurants, but 7% prevalence in raw meat in restaurants (in a different study).
- 3.3% of meat-based sauces in restaurant did not meet *Staphylococcus* spp standards.
- High levels of *Salmonella* (13%) and diarrheagenic *E. coli* (53%) in intestines.

Poultry meat/carcasses (4 studies):

- Diarrheagenic *E. coli*: reported prevalence ranged between 29-45%. Another study presented EPEC and EAEC as the most prevalent ones.
- *Salmonella* spp: *Salmonella enterica* was found in 57% of poultry meat samples and *S. Derby* in 28%.

Other value chains:

- pork (1 study): 30% of pork carcasses were positive for *Toxoplasma gondii*
- shoat meat (2 studies): Diarrheagenic *E. coli* (38%), *Salmonella* spp (7%)
- vegetables (1 study): *Salmonella enterica* (2%)
- fish (1 study) – *Salmonella enterica* (24%)
- drinking water (1 study) – *Salmonella enterica* not found in tap water, one sample (out of 51) positive in well water

3.6 Systematic literature review in Nigeria

A total of 860 titles and abstracts were screened. Of which, 107 were finally selected and data extracted. 3 additional papers were further identified in the selected papers and included in the review. Only 15% of the studies ranked as being of good quality and about 35% judged as having poor quality. Similarly to what was found in Ethiopia and Burkina, most studies focused on assessing foodborne hazard prevalence in foods (92), and just one study looking at health and economic impact, 15 studies looking at prevalence in humans and 6 looking at prevalence in the environment (figure 11).

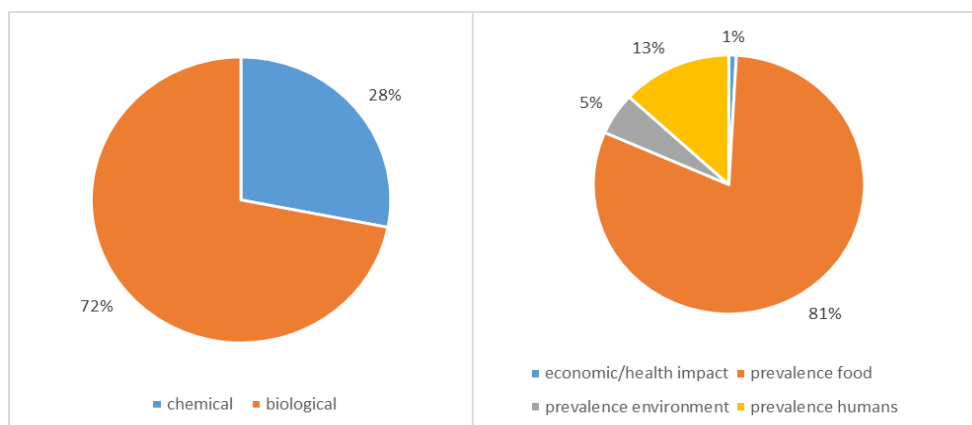


Figure 10: Systematic literature review for Nigeria: type of hazards investigated and type of studies

Considering the low quality of many studies, due mostly to lack of details on the study design and methodology, the results presented here should be interpreted cautiously. Overall, the studies report high presence of various important foodborne pathogens in foods at retailer, with most studies conducted in informal markets. While results are to be interpreted cautiously, they indicate real food safety challenges faced by food markets in the country.

Health and economic impacts

One recently published study (2016) uses mathematical modelling to estimate the expected health and economic impact derived from naturally occurring radionuclides in powder and liquid milk consumed in Nigeria. Levels of such radionuclides were within internationally acceptable levels. However, the total health detriment derived from consumption of these products - in infants, children and adults, was estimated to be 30 cases per 1million milk consuming infants (<1yr), 20 cases among milk consuming children (1-7yr) and 4 cases among milk consuming adults (>18yr). That translated into an economic impact of \$17,000 million from effects in children, \$12,000 million in adults and \$10,000 million in infants. Milk consumption among infants and children in Nigeria is very low (14-15Kg/year) and well below nutrition international recommendations. To reduce the health and economic burden, the authors recommend reducing infant and child milk intake to 8-13Kg/year, which doesn't seem to be justified given the low health impact estimated in the study.

One more study published in 2017 presented a mycotoxin-associated health risk assessment derived from consumption of groundnut, but the paper does not provide health risk figures.

Prevalence in food

Among the various food products, fruits and vegetables were the category more extensively investigated. Studies were in general of poor quality, and the vast majority reported very high presence of foodborne bacteria in raw fruits and vegetables in markets. Some of the most prominent findings are reported here.

Bacillus spp was reported in several studies, with prevalence of 15-60% in samples from vegetables in informal markets. One study detected B. cereus in 100% of samples from ogiri (a locally produced fermented product). Also, B. cereus enterotoxin was detected in between 30-50% of samples of raw vegetables in markets.

Other important foodborne pathogens, such as Salmonella spp, Proteus spp and S. aureus (6-52% of positive samples) were reported in various fruits (e.g. watermelon, pineapple, pawpaw). Also L. monocytogens was frequently isolated in different vegetables.

Beef value chain

The review shows that beef meat carries E. coli O157, S. aureus, as well as Toxoplasma and Taenia saginata (likely among many other pathogens). Studies report E. coli O157 isolated from beef meat. E.coli O157 was also isolated from intestines (14-22%) of cattle at slaughter, as well as other edible organs such as liver, kidney and heart (7-1%). S. aureus has been found in high prevalence (7-19% of positive samples in different studies) in various meat based products (including raw beef). A study conducted over 3 years in one slaughterhouse in Nigeria recorded T. saginata outcomes from postmortem examination. T. saginata live cysts were found in various parts of the animal; 16% of cattle presenting for slaughter over 3 years were recorded having cysts. Highest presence was observe in the tongue and heart and masseter muscles (4-8%), all of which are normally consumed in Nigeria. T. gondii is another important hazard in the beef value chain. One study reported 14% of meat samples at the abattoir positive for T. gondii (ELISA diagnostic test).

Dairy value chain

Dairy consumption in Nigeria is very limited, and this is reflected by the small number of articles that explored the presence of foodborne pathogens in these products. More remarkably, one study reported *E. coli* O157:H7 in various products: it was found in fresh milk (2%), fresh cheese (6%), fried cheese (2%) and fermented cheese (10%) from informal market. *E. coli* is associated with very serious health conditions, especially in children and immunocompromised individuals. The presence of this pathogen in the dairy value chain should be regarded as being of particular relevance.

Other food products:

- Pork: 30% of meat sausage samples and 7% of fried meat samples collected at restaurants (i.e. ready to eat) were found to carry *S. aureus*.
- A study on smoked fish sampled from hawkers in informal markets found all samples (100%) carrying at least one of a range of bacteria tested (*Bacillus* spp *S. aureus* and *E. coli*). Fungi were also isolated from a good proportion of the samples (exact results not available)
- A few studies looked at bacterial presence in traditional drinks. Among the most remarkable findings, *L. monocytogenes* was isolated from almost 90% of a locally produced cereal based drink; similarly *B. cereus* and *S. aureus*, were isolated from zobo (locally produced drink). These, in addition to *E. coli*, *Lactobacillus* and *Streptococcus* spp. were isolated from a soya-based local drink.
- The presence of *Aspergillus flavus* and *Fusarium* spp was assessed in wheat grains ready for processing. All 14 samples collected and tested were positive for *Aspergillus flavus*, and for at least one of *Fusarium* species. While data was not available, it is possible mycotoxin levels were high in such product. *Fusarium* and *Aspergillus* were also isolated in maize samples, but with much lower prevalence.

Prevalence of foodborne hazards in the environment

Only few studies were included in this category. Analysis of water-sachets for presence of *Salmonella* and *E. coli* reported 87% of samples positive for at least one of these pathogens. Another small study isolated *S. aureus* from 23% of samples of water used for washing and rinsing the food by informal retailers.

A survey conducted in fish markets to analyze the pathogen load in surfaces where fish are displayed found prevalence of between 6-38% for a range of pathogens. *S. aureus* was the pathogen most commonly found in the samples, followed by *Pseudomonas* spp., *Bacillus* spp, *Salmonella* spp, *Aspergillus* and *Rhizopus*.

Prevalence of foodborne hazards in humans

Only one study (published in 2014) looked at mycotoxin exposure in humans (AFM1, DON, fumonisin, ochratoxin and Zen) by testing presence of mycotoxins in urine samples from 120 volunteers. Evidence of exposure to Ochratoxin was found in 28% of individuals (including children, adolescents and adults) AFM1 was found in 14% of individuals and fumonisin in 13%. Other mycotoxins were found in much lower number of samples (the same study looked also at mycotoxin presence in various foods products, although those results were not released at the time of preparing this report).

One study looked at parasites in children 6-15yr. *Entamoeba histolytica* was the most frequent parasite, affecting 42% of children. Around 35% carried hookworm, tapeworm and whip worm, and 28% carried round worms. Some studies looked at foodborne pathogen presence in faeces of individuals with diarrhea. A study reported *S. aureus* in 6 out of a 100 individuals presenting with diarrhea to two hospitals. One interesting study compared the presence of *B. cereus* in the faeces of patients with diarrhea presenting to hospital with healthy counterfactual, founding that 19% of diarrhea patients, as opposed to 8% of health individuals, had *B. cereus* in their faeces. A study among 96 children (3months to 12 years of age) presenting with diarrhea found *Proteus* spp and *E. coli* as the most frequently isolated bacteria, followed by *Pseudom* and *Klebsiella*. However, the information in the paper does not allow to link this results with potential causes of diarrhea.

Literature review conclusions

The results from the SLRs confirm, once more that, in Nigeria, Ethiopia and Burkina Faso, as for most LMICs, we lack accurate information primarily on the impact (health and economic) of food-borne disease. However, we know that diarrhoea, the most common manifestation of food-borne disease is a major cause of sickness and death. Studies agree that the most important causes of diarrhoea are toxigenic *E. coli*, *Salmonella* spp., rotavirus and *Shigella* spp., and some of the studies in the SLRs present results that are aligned with this. Bacterial causes of diarrhoea (most of which are zoonotic) appear to be of relatively high importance and diseases associated with toxigenic *E. coli* and

non-typhoid salmonellosis are high and increasing confirming the identification of these as key hazards by stakeholders.

Studies on hazards in food show high levels of contamination, with meat being particularly problematic. Abattoirs are extremely unhygienic and appear to be a critical point for contamination. Non-diarrhoea associated zoonoses which can be transmitted by food, or are occupational hazards, are also important. In particular, there is strong evidence that tuberculosis, brucellosis, leptospirosis, cystic echinococcosis, anthrax, Q fever and Rift Valley fever are endemic zoonoses which impose huge burdens on human health and the livestock economy in developing countries. Most of these zoonoses are largely under investigated in the target countries.

The literature already examined broadly supports the findings of the FERG with biological hazards of most importance and animal source foods and vegetables the most risky commodities. There is broad agreement between the hazards found in foods and the incidence or prevalence in people. Unsurprisingly, hazards which are difficult or expensive to identify are less studied.

Literature review can reveal local issues. For example, Ethiopia is unusual in that meat is commonly eaten raw: this likely leads to a greatly elevated risk from hazards associated with raw meat (e.g. echinococcosis and salmonellosis). In Nigeria, large quantities of animal skins/hides are eaten as human food: the health effects of this are not well understood because animal skins are not commonly eaten as food. However, skin is often highly contaminated during the slaughtering process. Groundnuts are widely consumed in Burkina Faso and are often highly contaminated with aflatoxins.

Of concern, is the lack of a systematic approach to risk prioritisation. This means many foods and hazards seem to have been studied on the intuition that they were important, probably based on data from developed countries or because there was a study group working on a given food or hazard. But because the FERG studies rely on expert opinion especially where data is lacking, and because they draw on regional experts, there is very likely to be a bias in that experts make estimates according to their experience, but their experience is not based on any systematic approach to prioritising and hence may be systematically biased in a way that is not obvious.

Investment advice:

Most previous investments into managing food safety hazards have not been based on the contribution of the hazard to health burden. A key insight of this study is that the law of the vital few and trivial many applies to burden associated with food hazards. Just 10 hazards are responsible for more than 90% of the burden in the regions in which the 3 countries considered fall. Tackling these will be much more useful than devoting investments to other hazards.

Countries and communities have unique food cultures and risk factors and hazard prioritization needs to be done at country level for national planning and community level for community planning.

Stakeholders tend to be quite poor at prioritization when compared to explicitly risk and burden based approaches. They tend to think everything is important, a challenge to prioritization.

When trying to understand health impacts, it is better to invest in one credible study (e.g. a RCT) than dozens of studies which can only show association and generate hypotheses (e.g. cross sectional and cohort studies).

Question 4: Which commodities and value chains to invest in?

Which foods make people sick?

Understanding the foods responsible for FBD is not straightforward. Epidemiological investigations can reveal statistical associations between foods consumed and illness, but these require good data on consumption, which is often lacking. Molecular analysis allows the relation between bacteria found in food and those found in sick people to be analysed.

There is no food attribution data specific to the three countries considered in this report, but some other countries have conducted attribution studies of varying quality to see which foods are responsible and the results are shown in Figure x. These are from countries where diets, food environments and food preparation and consumption are very different from India, so caution must be exercised in extrapolating the results (Produce here means raw vegetables and fruit: in general, vegetables are more risky than fruits especially those grown in fields, fertilised with animal or human waste, and eaten raw or minimally cooked (Hussain and Gooneratne, 2017)).

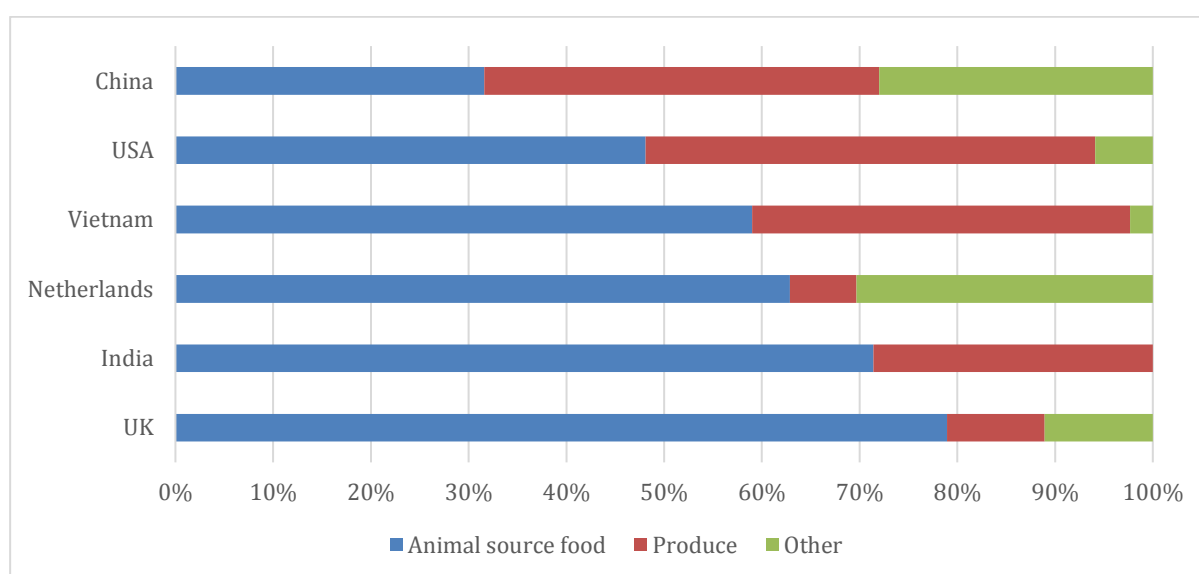


Figure 11: Studies attributing FBD to different foods Source: Authors' elaboration and Grace, 2015

Evidence from the FERG

The FERG study, mentioned several times in this report, provides insights into the food responsible for FBD health burdens. Again, this information is by region so extrapolating it for the three countries which are the focus of this report has risks.

Attribution data were largely based on expert opinion which can be problematic when the experts have little access to empirical information as is the case of FBD attribution in many countries. The FERG expert elicitation study was commissioned to provide food source attribution estimates for 11 hazards of the 31 foodborne hazards included in the WHO global burden of foodborne disease estimates, and these were specifically chosen to not include some hazards for which the route is simple and well-known (e.g. *Vibrio vulnificus* infections linked to seafood), or hazards where knowledge about the specific food exposures was assessed to be of little relevance for targeted disease prevention. This will introduce systematic bias.

Although there was substantial uncertainty around central tendency estimates, the FERG estimates provide the best currently available basis on which to link FBDs and specific foods including Africa. Moreover, the findings were largely compatible with other, literature-based studies (Grace, 2015). Overall, animal source foods are the most important sources of FBD followed by produce (fresh fruit and vegetables). Animal source foods and produce are mainly sold in the informal, traditional markets.

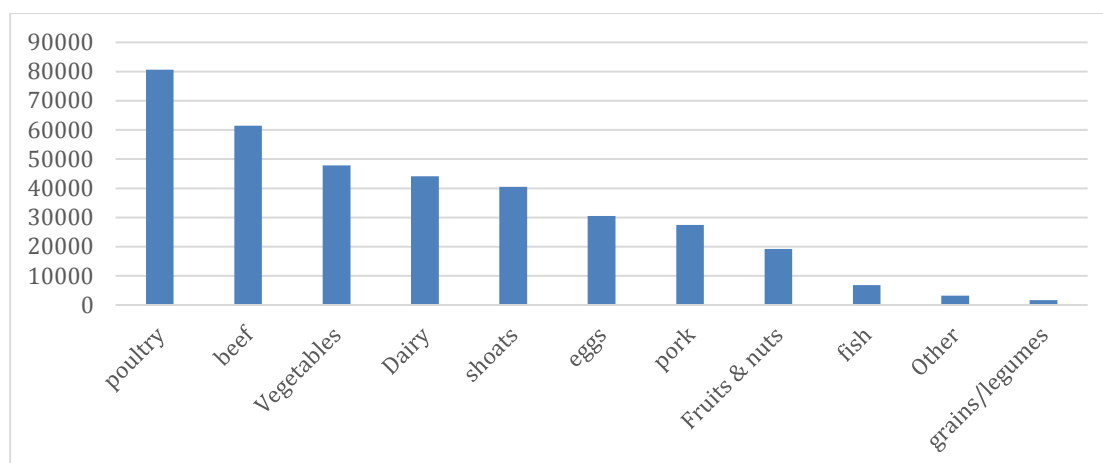


Figure 12: Foodborne disease burden (DALYs) attributable to different food groups in Africa Region E

Fruit may be less implicated than vegetables because it is less prone to contamination from the soil.

A recent systematic review looked at pathogens isolated from foods in seven African countries, including Nigeria (Paudyal et al., 2017). *E. coli*, *Salmonella*, *S. aureus* and *L. monocytogenes* were the major pathogens in foods and worryingly bacterial contamination of ready-to-eat foods was as high as the raw foods. Prevalence was highest in Uganda followed by Nigeria (then Sudan, Benin, Kenya, Ghana and Botswana in declining order).

| | Meat | Milk | Fish | Vegs & fruits | Ready to eat |
|--------------------------|------|------|------|---------------|--------------|
| Escherichia coli % | 49 | 40 | 38 | 60 | 36 |
| Staphylococcus aureus % | 49 | 35 | 31 | 30 | 21 |
| Enterobacteriaceaea % | 31 | 25 | 38 | 40 | 39 |
| Salmonella spp. % | 47 | 10 | 38 | 30 | 18 |
| Bacillus spp. % | 18 | 10 | 8 | 20 | 18 |
| Listeria monocytogenes % | 13 | 15 | 8 | 40 | 4 |
| Average % | 34 | 23 | 27 | 37 | 23 |

Ready to eat includes the composite menu items from street vendors, restaurants and local eateries, as well as cereals, pickles, sauces, dips and beverages like gruels and soups.

Table 6: Pathogens identified in different types of food in seven African countries

These need to be considered in light of consumption of risky foods. Comparing per capita intake to average for Sub Saharan Africa suggests maize, meat and eggs are important in Burkina Faso, milk in Ethiopia and vegetables and fish in Nigeria.

| | Milk | Maize | Vegetables | Fish | Meat | Eggs |
|--------------|--------------|--------------|--------------|-------------|-------------|------------|
| SSA | 97.9 | 99.5 | 71.3 | 27.2 | 55.0 | 4.6 |
| Burkina Faso | 74.6 | 187.7 | 39.8 | 10.2 | 34.7 | 7.1 |
| Ethiopia | 109.6 | 115.3 | 42.4 | 0.7 | 19.7 | 1.0 |
| Nigeria | 14.0 | 89.6 | 125.9 | 43.1 | 25.2 | 9.5 |

Table 7: Consumption of risky foods (grams per capita per day) FAOStat

Complementary and weaning foods

Human milk is the best form of nutrition for babies, but despite efforts to promote breast-feeding, infant formula is commonly given in developing countries. Most formula is based on bovine milk and may be contaminated by bacteria. *Salmonella* spp. and *Cronobacter* spp. have been identified as pathogens of most concern (WHO, 2007). Moreover, studies in developing countries have found home-prepared infant formula feedings frequently contaminated with

multiple pathogens: *Salmonella* and *Escherichia coli*, particularly enteropathogenic *E. coli*, have been commonly isolated (Sheth & Dwivedi, 2006; Anigo et al., 2007; Kung'u et al., 2009; Ma et al.,).

It is often assumed that contaminated water is the major risk source for infants. However, many studies related to infant diarrhoea have demonstrated that the level of contamination is higher in weaning foods than in drinking water (Barrell and Rowland, 1980; Imong et al., 1989; Henry et al., 1990; Motarjemi et al., 1993; Lanata, 2003; Kung'u et al., 2009). Sheth et al. (2000). In a study in an urban slum in Baroda, India, found that infant diarrhea incidence remained high due to contaminated foods whilst the drinking water was found to have no coliforms. As excellent progress is made in attaining water targets, but food safety remains in the doldrums, it is likely that unsafe food will be come relatively more often implicated in infant diarrhea and stunting.

A study used Demographic and Health Survey data from nine African countries with high childhood diarrhoea mortality including Burkina Faso, Nigeria and Ethiopia. It found introduction of complementary foods was significantly associated with diarrhoea (Odds ratio 1.3) (Ogbo et al., 2017). A longitudinal study in six countries, including two in Africa (but not the three countries of this study) found that higher entero-pathogens were associated with stunting even in the absence of diarrhoea (especially *Campylobacter* and toxigenic *E. coli*) (MAL-ED, 2017).

Several studies by ILRI (published and un-published) have found aflatoxins in milk at well above the Codex standards. One cross-sectional study found a positive relation between aflatoxin M1 in infant's diets and stunting but no relation between aflatoxin B1 and stunting

A systematic review found eight studies on the key problems and critical actions for complementary food production in LMICs. The most common problems were: storage of cooked food at ambient temperature for an extended period, (identified in seven studies); use of raw food products that had a high level of pathogens (six studies); contamination with pathogens from hands (six studies); inadequate reheating of food in terms of temperature and/or time (five studies); contamination with pathogens from utensils (four studies); and inadequate initial cooking of food (three studies) (Woldt et al. 2015).

Street foods

Street foods are a source of culturally accepted, inexpensive, convenient and often appealing foods for both urban and rural people worldwide. Women often play a major role in preparing and selling. Around 2.5 billion people eat street food every day The type of street food varies between countries and may cover full meals or snacks in some form. Cut fruits and vegetables are also commonly sold in many countries.

A wide range of intestinal pathogens have been isolated from street food vendors, and include pathogens such as *Salmonella typhi*, non typhoidal salmonellae, *Entamoeba histolytica*, *Ascaris lumbricoides*, *Enterobius vermicularis*, *Trichuris trichiura*. Several studies have also been conducted on pathogens in street food. In general, these are risky commodities with high levels of contamination. The Intervention Systematic Literature Review reported on later found several studies on street food with generally high levels of pathogens at baseline. A review of microbial quality of street food in Ghana identified 11 studies: *E. coli*, *Staph*, *Bacillus* and *Salmonella* were among the most frequently isolated pathogens with stews and soups being the riskiest foods (Yeleliere et al. 2017). Several studies from Ethiopia found high levels of contamination of street food with *E. coli*, *Salmonella* and *Staph* most frequently isolated (Kibret & Tadesse, 2013; Derbew et al. 2013; Bizuye et al. 2014, Bereda et al., 2016; Eromo et al. 2016

Investment advice:

Most previous investments into managing food safety hazards have not been based on the contribution of the food commodity to health burden. The FERG study provided key insights into this. It suggests animal source foods are responsible for around 80% of the foodborne burden in Africa and produce is also important. Other studies suggest animal source food and fruit and vegetables have similar high levels of contamination.

Foods targeted to infants (milk) and complementary foods may be especially significant, given that FBD and malnutrition are closely linked and that insults in the first 1,000 days may have life-long consequences.

Ready to eat food is increasingly popular in Africa, and of concern is some evidence that RTE food is as microbiologically contaminated as raw food. Usually, heating is effective at reducing contamination and the failure is likely related to re-contamination.

Question 5: Which interventions to invest in?

This chapter draws on five different strands to provide investment advice. The first is a Systematic Literature Review of food safety interventions; the second is a tool developed to rank, compare and identify investment priorities (Food Safety System Performance Tool), the third is confidential information from the OIE, the fourth a review of ILRI and IFPRI food safety studies, and the fourth is a framework for assessing food safety interventions.

5.1 Systematic literature review of food safety interventions in LMIC

A SLR was conducted to find out which interventions has been researched in Africa. Methods are outlined in annex 7. We screened 3,470 titles, obtained 498 abstracts, identified 84 papers and retained 67.

Interventions:

We developed a typology to set out the different type of interventions used along the value chain and at population level to improve food safety (Annex 4). Following is our estimate of their relative importance in LMICs.

| <i>Along the value chain</i> | Technologies | Training & information | New processes | Organisational arrangements | Regulation | Infrastructure |
|--|---------------------|-----------------------------------|----------------------|------------------------------------|-------------------|-----------------------|
| Farmer | +++ | +++ | + | +++ | + | ++++ |
| Processor & transporter | +++ | +++ | +++ | ++ | ++ | +++ |
| Retailer | + | ++ | + | ++ | ++ | +++ |
| Consumer | + | +++ | + | + | + | +++ |
| Government | | +++ | ++ | ++ | +++ | |
| <i>Population level:</i> | | | | | | |
| <ul style="list-style-type: none"> • Incorporating food safety into other health programs such as mother and child care or HIV treatment • Medical interventions such as vaccination for cholera or norovirus or binders for aflatoxins • Dietary diversity to reduce exposure and vulnerability to toxins • Water treatment | | | | | | |

Table 8: Typology of food safety interventions

In papers retained by the SLR:

- 9 interventions were aimed at producers and two thirds of these focused-on export.
- 14 were aimed at value chain actors, all at formal operators: 8 were aimed at slaughterhouses, 3 at dairy processors, 3 at produce processors
- 15 were aimed at retailers: 8 at restaurants or institutional caterers, 2 at street foods, 2 at modern retail establishments, 3 at traditional markets
- 11 were aimed at consumers: 6 were Willingness to Pay Studies, 3 were food preparation interventions and 2 were information interventions.
- 3 were aimed at the public sector
- 10 were aimed at the general population rather than the food value chain:

Technologies dominated the interventions: 34 involved this varying from antibacterial clothes, to biocontrol for aflatoxins, to vinegar sprays for decontaminating carcasses. The next most common intervention was around training and information with 29 interventions evaluated: these varied from one day trainings of street food vendors to two-year trainings of government medial and veterinary officers. Interventions around new processes, including HACCP, FSMS, GAP, food labelling and willingness to pay for quality assured products comprised 24 interventions. There were 7 interventions on regulations and only one on infrastructure.

Ten interventions aimed to reduce FBD but were not directed at the food value chain. These were: five interventions integrating food safety with other health programs; two medical interventions (a vaccination and a toxin binder); one initiative aimed at improving hygiene in schoolchildren; one at a cleaning technology for mothers in households; and, one assessing the impact of dietary diversity on reducing exposure and vulnerability to toxins (aflatoxins and cyanide).

Some interventions focused on specific types of hazards: 38 focused on microbial hazards, eight on mycotoxins, three on pesticides and two on chemical hazards (cyanide and cadmium). Of these, only three focused on multiple categories of hazard.

It can be seen that some of the most invested in interventions are among the least evaluated (provision of infrastructure; strengthening of national control systems) and that the export sector, formal processing, and institutional catering are over-investigated relative to their influence on health burden. The hazards studied are more aligned to the FBD than donor investments are, although the lack of any interventions specific to nematodes is a gap.

Design

Only 6 of the studies used a randomised control design which is the gold standard in finding out whether a community level intervention has impact. Seven studies had experimental designs which are suitable for finding out if a technology works or not (e.g. whether irradiation reduces bioactive amines in sausages). Two studies comparing diagnostic methods used diagnostic test validation, the gold standard for this.

Two were ex ante studies which are appropriate for exploring hypotheticals. Four studies were investigating the results of interventions using appropriate qualitative methods. One study was a review. These non-experimental studies can offer insights not obtainable by RCTs. For example, one paper in describing how much of the fish from Lake Victoria did not actually comply with the standards which everyone claimed prevailed, introduced the novel and useful concept of

There were seven Willingness to Pay (WTP) studies. Four used conjoint valuation which is very prone to over-estimate WTP. One used an auction with an endowed money. One assessed revealed behaviour, when participants had to use their own money to purchase “improved” vegetables, which is the most accurate way of assessing WTP.

Twenty-five studies used “before and after” designs and nine used “with and without” designs which are prone to bias and would have been more convincing as RCTs. Many were also of small size and with questionable selection of participants

Overall 26 studies used gold standard methods and 41 used less than optimal methods, showing room to improve.

Outcomes

Two papers described interventions but did not report any outcomes. Most papers had only one type of outcomes, but 17 reported on two types and four on three types. The most commonly measured outcome was changes in knowledge, attitude and/or practice. This is a poor indicator of impact.

| Outcome | Number | Percentage |
|-------------------------------------|--------|------------|
| Knowledge, attitude, practice (KAP) | 25 | 28 |
| Hazard level or presence | 24 | 27 |
| Indicator of hazard | 17 | 19 |
| Willingness to pay (WTP) | 7 | 8 |
| Health outcome | 6 | 7 |
| Compliance | 4 | 4 |
| Quality attribute | 4 | 4 |
| Infrastructure | 1 | 1 |
| Livelihoods | 1 | 1 |

Table 9: Outcomes measured in food safety interventions

Outcomes and Impacts

Thirty four studies claimed success (significant change in beneficial outcomes), three partial success, and only three admitted failure: suspiciously high levels of success. Of well-designed studies, 12% interventions failed completely or partially and of poorly designed studies 14% failed partially or completely

Most experiments evaluating the effectiveness of technologies were successful (see Annex 6 for a summary of all interventions). Successes included:

- Irradiation successfully reduced bio-amines in sausages.
- Sealing the anus and throat of cattle during slaughter successfully reduced carcase contamination.
- Spraying carcasses with vinegar reduced contamination.

- The biocontrol agent, *Trichoderma harzianum*, reduced *Aspergillus flavus* infection of groundnut in the field and increased yields.

Many training interventions were successful:

- Simple hygiene messages were given to mothers and microbial quality of complementary food improved as evaluated by a RCT.
- School canteens were given hygiene training. After the intervention, staff hygiene knowledge and practice scores, food temperature, aerobic colony count (ACC) and *Staphylococcus aureus* load in ready to eat (RTE) meal improved significantly compared to baseline.
- Farmers were trained to remove visibly contaminated maize kernels and to wash the remainder. Compared to baseline, mycotoxins in urine significantly decreased.

Interventions around introducing new processes could lead to improvements:

- The introduction of HACCP to an ice-cream making plant resulted in a reduction in microbial contamination of the product.
- Certified green bean farms in Kenya had much better safety performance than non-certified pepper farms in Uganda.
- Detailed abattoir inspection led to a higher detection of tuberculosis infected carcasses than routine inspection.

All willingness to pay experiments indicated consumers were willing to pay for safer food.

A note of caution

While the results of the SLR appear promising, we must flag up some concerns. We have identified seven critical success factors for food safety interventions and these are poorly addressed in the literature.

Efficacy

Promising interventions may not be effective. It is common for interventions that succeed in small, badly conducted research to fail when properly evaluated. Randomised control trials are the best means of evaluation.

- Early anecdotal evidence suggested microbial hand towels reduced contamination in households in western Kenya. A large RCT found no effect on health outcomes (Slayton et al).

Interventions use different study designs to show impact. Unfortunately, the majority of designs used are very prone to bias and cannot be used to claim impact. The RCTs, considered the gold standard, did not use blinding, and while there were some objective measures (microbial contamination), there was also reliance on self-reporting. The example of point-of-use interventions to improve water quality is cautionary. Several RCTs showed large benefits, but all the RCTs where the end-user was blinded as regards the intervention showed no effects (Cairncross et al.)

Interventions measure changes in outcomes. Unfortunately, there is an inverse relationship between how easy outcomes are to measure and how meaningful they are.

- Changes in knowledge and self-reported practices are not sufficient to demonstrate benefit. Many of the training interventions rely on KAP
- Changes in indicators (such as microbial load or pH) are suggestive of real world change but not enough to show benefits.
- Reduction in hazards, along with other information, is a good indicator that health benefits have been obtained.
- It is desirable to measure changes in health outcomes, but these should not rely on self-reporting. The literature on household water treatment

It is essential to measure efficacy, because food safety interventions have the potential to make things worse.

- A study in abattoirs in Nigeria found carcasses more contaminated after washing, because water was not clean (Bello et al.)
- Pot-chlorinators failed to achieve WHO recommended chlorine levels in well water during a cholera outbreak and conveyed a false sense of security to local residents, some of whom stopped chlorinating their household water.

- We show that chlorine inadvertently added to soils with e.g. urine or biogas digestate strongly increased crop Cd concentrations. This resulted in wheat grain Cd levels that could result in exceeding recommended WHO limits for dietary intake.

Efficacy may be partial but not sufficient

- Foam cleaning was more effective than traditional disinfectants in South Africa convenience food shops. However, neither foam cleaning nor conventional disinfectants eliminated *Listeria* (Lambrechts et al). South Africa is currently in the throes of the world's worst listeriosis outbreak.

Enabling Environment

Most of the studies only looked at impacts in the very near term. Without an enabling environment, interventions are unlikely to be sustained.

We consider enabling environment to have two elements: a) buy-in from leadership and a culture shift in users; b) absence of constraining culture, rules and regulations. Only 19 of the interventions considered the effects, negative and positive, of this.

Several studies flagged up the importance of buy-in and demand:

- Establishment and implementation of a quality system requires a paradigm shift in mindset amongst employees at all levels within the organisation. Quality culture within an organisation refers to the norms and beliefs of employees that lead to changes in the manner in which work is carried out in the organisation
- Management commitment to the management system played a vital role in improving the quality of inspection services within the government veterinary services
- The first challenge for NAFDAC was to establish the need for an aflatoxin facility. Nigeria derives over 90% of its foreign earnings from the sale of crude oil. Thus, agriculture is at best a secondary area of trade. Yet policy makers were convinced that to meet the regulatory requirements of importing countries and to participate in the international trade in food, the quality of agricultural commodities must be monitored. Once convinced of this point, the government committed to support NAFDAC (Walyiar et al)
- Bean exporters in Kenya have better compliance including hazards than pepper exporters from Uganda. Kenya has better legal framework, more power with suppliers, quality assurance departments, intensive support from importers (Nanyunja et al)

Other papers flagged up the problems of a disabling regulatory environment:

- Therefore, the three serious constraints on progress for protecting food consumers in Botswana are poor consumer awareness about food safety issues; and no currently available formal recognition of the achievement of food safety standards within the government system, and inadequate regulatory mechanisms and out-of-date legislation.
- Street vendors are often subject to harassment from authorities and forced to pay bribes.

Economically feasible or frugal

Interventions that are very costly have very little chance of going to scale. Only 11 interventions considered economics and four of these found that cost was likely a barrier to sustainability. We marked all the interventions as to whether we considered them affordable (a one day training for street vendors) or expensive (introducing HACCP to a firm). We considered 35 to be costly and 32 to be affordable.

- A one-day workshop for street food vendors based on the "Five Keys" in Ghana was effective in improving KAP
- Ghana street vendors: Training sponsorship was solicited from companies in the food industries such as Unilever, Nestle and Ghafco, which was an opportunity for such companies to launch their products (Tortoe et al)
- The Nigeria Field Epidemiology and Laboratory Training Program (FELTP) was established in October 2008 and has trained 207 residents as of 2014. However, financial sustainability is in doubt

There are some examples of food safety solutions which are almost costless.

- Abolish requirement of a medical certificate for food handlers: Many SSA countries require a medical certificate for food handlers but there is no health justification for this. According to South African health authorities, there is no scientific indication for the *routine* medical examination of food handlers in the

prevention of spread of food-borne pathogens, whether on recruitment or otherwise. The practice is not recommended (NDSC, 2004, Preventing Foodborne Disease: A Focus on the Infected Food Handler).

Yet requiring health certificates had become both a burden and excuse for illicit payments in many countries.

- In Kenya, a health certificate must be purchased and no examination is carried out. It merely adds to the cost of doing business of poor vendors.
- In GHANA, vendors visited contracted medical service provider in a mass health screening exercise virtually under coercion by the metropolitan assembly. The queues were long, the process was slow, fees were arbitrary and some were not covered by receipts

- Decrease meat inspection where it has few health benefits relative to cost: Meat inspection is unable to detect the most important causes of FBD, ties up scarce veterinary resources in non-beneficial activities, and covers only a small minority of animals killed.

The main purpose of meat inspection is to detect and prevent public health hazards such as food-borne pathogens chemical contaminants in meat. Yet existing inspection practises often date back decades and might not always adequately protect public health. techniques are not suitable for detecting FBD diseases such as campylobacteriosis, salmonellosis and virulent strains of *E.coli*, or contamination by chemical substances such as steroids or veterinary drug residues.

There is limited evidence that meat inspection is effective at even detecting visible lesions. In a cysticercosis endemic region of Kenya, ILRI observers noted no rejections in over 100 days of meat inspection, In Ethiopia, routine abattoir inspection failed to detect 72% of TB infected carcasses.

- Permit use of lactoperoxidase and food grade hydrogen peroxide in food

“A hawker who was caught transporting milk laced with a hydrogen peroxidase to Nairobi will spend two years in jail. He also told Justice Hatari Waweru the punishment was too harsh, and there was no evidence the milk was for human consumption”

Numerous studies find It hydrogen peroxide is a good preservative for raw milk and allows milk to stay fresh and healthy for up to 24 hour during transportation from production areas to consumption under the challenging ambient conditions in much of SSA. There is even more evidence on the safety, cost effectiveness and acceptability of lacto-peroxidase, a substance naturally present in milk.

Yet policies in SSA penalize use of these safe and effective risk mitigating methods.

Incentives

Knowledge is not enough. There is much evidence that while training can result in short term benefits, longer term change requires incentives, especially there is a considerable gap between knowledge and health or hygienic behaviors (Fishbein and Ajzen, 2010; Mullan et al., 2013) and knowledge alone does not lead to use of safer practices (Willock, Pun, Khanona, & Aung, 2004).

In the papers reviewed, only six considered the issues of incentives, and some of those found that incentives were not present.

- Private eating establishments in Libya have better hygiene. “Staff in these institutions is aware of the high penalty of losing their jobs by being instantly dismissed if they do not follow such practices, whereas with government most workers are fairly assured that they have their jobs secured regardless of whatever situation” (Abogrean et al)
- An initiative in Ghana to train street vendors found few consumers are concern about the safety of street foods. All the partners vigorous pursue consumer awareness of street foods at schools, colleges, universities, churches, and social clubs (Torte et al)
- The type of food safety culture existing within a business can explain why food handlers choose not to implement known food safety practices (Clayton and Griffith, 2008) and why training, although important, may not change practices.
- One study examined why take-up of GAP/IPM was much lower in Turkish than in Moroccan tomato exporters. Moroccan farmers were large, vertically integrated, exported to demanding countries, with strong control, and had a large export premium and high penalty for pesticides. Turkish farms were small, exported to less demanding countries with weak control and got a smaller premium for export. Both farmer factors and incentives appeared to drive uptake of GAP/IPM (Codron et al).

As mentioned, all the WTP studies found that consumers were WTP for safer products. However, more detailed studies by IFPRI reveal that setting up market-based incentives in poor countries is much more complicated than may appear (Box x).

Equity and unintended consequences

Finally, there is the very real possibility that food safety interventions may have unintended and unwanted consequences. Only one study looked at livelihood benefits from participation in an intervention relevant to food safety, and only one explicitly considered benefits in terms of food accessibility. This study compared street food and fast food outlets in Nairobi and found that while the first had lower hygienic quality, the food sold was cheaper and the patrons poorer (Olumakaiye & Bakare). This implies that actions to penalize street foods may reduce food access.

Many of the interventions focused on upgrading value chains, but it is well known that this risk excluding women and the poor (Kristjanson et al).

Investment implications: As revealed by a SLR the track record for food safety interventions is rather encouraging. The major evaluated interventions of technologies, training and information, new processes and willingness to pay for food safety given generally good results. However, major investments in infrastructure, national control systems and organizational innovation have not been well evaluated. Moreover, evaluated interventions fail to take into account an enabling environment, economic feasibility, incentives or unintended consequences.

5.2 Food safety system performance

The **food safety system** is those activities whose primary purpose is to ensure food is safe to eat. As such, the food safety system includes actors whose main mandate is assuring food safety (e.g. food safety authorities) and actors who are concerned with food safety as one aspect of food (e.g. local government authorities, institutional providers of food, and workers at all stages of the 'farm to fork' food production-to-consumption pathway) (Grace, 2018).

Food safety system performance system benchmarking can help decision-makers understand relative performance and motivate improvements. In addition, assessing and benchmarking food safety system performance can help in identifying capacity-building and investment needs, and in setting and monitoring targets.

Global comparative food safety ranking studies are rare and usually restricted to certain aspects (e.g. labelling, export rejections) or have an inadequate evidence-base. Obtaining information on food safety systems is challenging. Data from systematic literature reviews and the information from Global Burden of Disease Assessments are currently our best estimates of the level of foodborne disease (FBD.) However, a well performing system faced with many challenges may be associated with higher levels of FBD than a poor-performing system with less challenges.

Recent years have seen several initiatives on health and agriculture performance, but these are difficult to interpret and combine. They include: International Health Regulations (IHR) spearheaded by the World Health Organisation (WHO); Enabling the Business of Agriculture led by the World Bank; Performance of Veterinary Services led by the World Animal Health Organisation (OIE); and, the Global Health Security Agenda supported by USAID and with a similar agenda to the IHR.

While many of these initiatives cover aspects of food safety system performance (FSSP), the only dedicated tool is that described in the report *2014 World Ranking: Food Safety Performance* of the Conference Board of Canada (Le Vallée and Charlebois, 2014). However, this has only been applied to ranking food safety system performances in 17 Organisation for Economic Cooperation and Development (OECD) countries. This tool takes an explicitly risk-based and systematic approach to identify and evaluate common elements among food safety systems across three areas: risk assessment, risk management and risk communication (Appendix 1). Unfortunately, many of the indicators are not directly applicable to low and middle income countries (LMIC).

The FSSP tool was developed to allow rapid, objective assessment of food safety system performance in LMIC. It explicitly follows a risk-based framework addressing risk assessment, risk management and risk communication. Understanding food safety capabilities draws on the sustainable livelihoods literature.

The index is composed of a list of indicators carefully analysed to express the characteristics of the national food safety system based on reliable and readily accessible data available on secondary sources. Developing the index

involved trade-offs between information that was most useful and information that was available. The schemata of the index is described below.

Food Safety Capabilities

- 1.** Natural capital or lacks thereof
 - 1.1. Climate: Annual precipitation and average temperature
 - 1.2. Population density and urbanisation
- 2.** Human capital
 - 2.1. Fewer vulnerable people “YOI%-young, old, HIV positive”
 - 2.2. More years of schooling
- 3.** Social capital
 - 3.1. Gender equity
 - 3.2. Avoidance of risky foods
- 4.** Physical capital
 - 4.1. Access to improved sources of water
 - 4.2. Access to electricity
 - 4.3. Access to latrines
- 5.** Economic capital
 - 5.1. Gross Domestic Product per capita

Food Safety Risk Assessment

- Academic Research in food safety
- Pesticide use

Food Safety Risk Management

- National food safety response capacity
- Food-borne illness rates
- Trade violations
- OIE National Focal points
- OIE personnel resources

Food Safety Risk Communication

- Risk communication performance self-reported
- Internet penetration

The tool is described at length in a separate report. Here we focus on the implications for the three countries. All three rank in the bottom half of the performance league (table 11). Nigeria and Burkina Faso are in the bottom half of the capabilities index (indicating they face more severe challenges than other countries) but Ethiopia is barely in the top half. As a result, Burkina Faso and to a lesser extent Nigeria are doing rather well in the face of challenges but Ethiopia rather poorly.

In terms of capabilities:

- Burkina Faso is challenged by ecological factors, lack of schooling, low access to electricity, low access to latrines, less GDP and a relatively high consumption of risky foods. It does well with access to water, relatively small proportion of vulnerable people, and good gender equity.
- Ethiopia is challenged by lack of schooling, low access to electricity, low access to water. It does well in terms of ecological factors, a small proportion of vulnerable groups, high GDP and good gender equity.
- Nigeria is challenged by ecological factors, access to water, a high proportion of vulnerable groups. It does well in schooling, electricity, GDP and gender equity.

In terms of performance:

- Burkina Faso has deficits in trade violations, risk communication as reported under the IHR, veterinary personnel, and high burden of disease. It does well in publications, OIE focal points and transparency and moderately in food safety as reported to IHR and internet access.
- Ethiopia has deficits in publications and food safety as reported to the IHR. It does well in risk communication, OIE focal points and transparency. It does moderately in trade violations, veterinary personnel, and burden of disease.

- Nigeria has deficits in trade violations and transparency and burden of disease (IMHE). It does well in food safety as reported to IHR, veterinary personnel and internet access and moderately in publications, risk communication

| | Performance score | Performance rank |
|----------------------------------|-------------------|------------------|
| Botswana | 8.9 | 1 |
| Mauritius | 9.6 | 2 |
| Ghana | 13.2 | 3 |
| Seychelles | 14.7 | 4 |
| Gabon | 15.9 | 5 |
| Namibia | 16.1 | 6 |
| Rwanda | 16.2 | 7 |
| South Africa | 16.2 | 8 |
| Cameroon | 17.3 | 9 |
| Cape Verde | 17.6 | 10 |
| Sao Tome and Principe | 18.3 | 11 |
| Zambia | 18.9 | 12 |
| Congo | 20.4 | 13 |
| Kenya | 20.6 | 14 |
| Malawi | 20.7 | 15 |
| Cote d'Ivoire | 21.3 | 16 |
| Djibouti | 21.8 | 17 |
| Tanzania | 21.8 | 18 |
| Togo | 21.8 | 19 |
| Comoros | 22.2 | 20 |
| Zimbabwe | 22.6 | 21 |
| Senegal | 22.8 | 22 |
| Swaziland | 23.2 | 23 |
| Lesotho | 23.3 | 24 |
| Uganda | 23.6 | 25 |
| Equatorial Guinea | 23.9 | 26 |
| Mozambique | 24.8 | 27 |
| Nigeria | 24.9 | 28 |
| Burundi | 26.1 | 29 |
| Burkina Faso | 26.2 | 30 |
| Ethiopia | 26.2 | 31 |
| The Gambia | 27.3 | 32 |
| Democratic Republic of the Congo | 27.8 | 33 |
| Benin | 27.9 | 34 |
| Guinea-Bissau | 28.4 | 35 |
| Mauritania | 29.2 | 36 |
| Guinea | 31.3 | 37 |
| Madagascar | 31.6 | 38 |
| Angola | 31.6 | 39 |
| Central African Republic | 31.8 | 40 |
| Mali | 31.9 | 41 |
| Niger | 34.4 | 42 |
| Liberia | 34.8 | 43 |
| Sierra Leone | 35.3 | 44 |
| Chad | 35.9 | 45 |
| Somalia | 36.2 | 46 |
| Eritrea | 36.9 | 47 |
| South Sudan | 42.1 | 48 |

Table 10: Food Safety System Performance Tool

Other factors of food safety system performance were elicited for the three countries and some comparators: this information is provided in annex 6.

5.3 IFPRI experiences in supporting food safety through incentives

Incentives to improve food safety: The case of aflatoxin in Kenya

Kenyan maize is frequently contaminated with aflatoxin, a hepatotoxic, carcinogenic metabolite produced by certain fungi. The level of dietary exposure to aflatoxin in Kenya is among the highest in the world, due to a combination of high maize consumption and agro-ecological conditions. There is high awareness and concern by consumers, private sector and policymakers. The maize market in Kenya includes grain sold on the informal market, branded (sifted) maize flour processed in large-scale, formal sector roller mills, and unbranded flour processed by small-scale, often unregistered, hammer mills. A positive relationship between price and -food safety gradient exists in the Kenyan branded maize flour market, likely because firms that rely on brand equity invest in higher quality, safer inputs (Hoffmann and Moser, 2017).

Regulators not regulating

However, there is a discordance between high rates of non-compliance documented by independent studies and the low frequency of maize flour recalls. No maize millers interviewed had a citation from the regulator for exceeding the allowable limit. 94 packets of maize meal from one of these millers were tested for aflatoxin by two of the authors for a previous study, and 27% were found to be contaminated beyond the allowable limit

No incentives for maize millers – apart from their conscience

One reason for high levels of noncompliance with the aflatoxin standard, even among some of the millers that test incoming maize for aflatoxin, is the difficulty of accurately sampling and testing for the toxin. APTECA was established in 2014 by Texas Agrilife Research to improve capacity for aflatoxin testing among maize millers, traders, and regulators in Africa, and has operated since 2015 with assistance and collaboration from COMESA and FAO. APTECA provides aflatoxin proficiency testing at no cost to participants, but charges for aflatoxin reference material, training, and sample analysis. Millers claim they get no profits or business advantage from testing and they do it because of their concern over public welfare. Millers acknowledge they stop testing during droughts when maize is very scarce (and more contaminated) because at these times they are struggling to get enough maize to keep their business going and cannot afford to turn away maize (Grace pers. Com).

No premium for safe maize for millers

Despite growing capacity for food safety testing, firms remain reluctant to label their food as 'aflatoxin-safe'. One reason is fear of attracting increased regulatory scrutiny. A randomized study of consumer response to the logo showed an initially large impact on sales, but this effect faded by the third week of active marketing (Hoffmann, Moser and Herrman, 2017). The transient consumer response to marketing based on food safety, compared to the brand-terminating impact of a recall suggests an asymmetric response to food safety information, possibly driven by an assumption that food is safe unless proven otherwise.

Farmers won't invest in costly food safety without an artificially high premium which still has to be subsidized

A mobile maize drying service shown to reduce aflatoxin by 76% was offered to farmers in the study at three randomly varied prices: the full anticipated commercial cost, operating cost recovery and free of charge. Eligibility for a premium payment for maize that tested aflatoxin-safe 3 months after harvest was also experimentally varied across farmers. This increased demand for the dryer among market producers by 16 % on average. The premium offered was artificially high and could not be matched by the private sector; yet the full anticipated cost of the mobile dryer per KG of maize dried is even higher than this premium level, suggesting market-incentives will not be sufficient for adoption of mobile maize drying.

Cheaper technologies are more attractive

While the market is unlikely to support the scale-up of mobile maize dryers without a significant subsidy for their capital cost, other technologies are available at similar cost and higher efficacy. Aflasafe KE01 was approved in 2015 and has been shown to reduce aflatoxin contamination by upwards of 80% (Bandyopadhyay et al., 2016). Calculated at the yield of the median market producer in the Hoffmann and Jones study, the cost of Aflasafe per KG of maize treated is 1.8 shillings.

(A caveat when considering the impact of Aflasafe is that while it has proven highly efficacious in closely monitored on-farm trials, effectiveness has not been well documented under unsupervised smallholder application in rainfed conditions. Both the timing of Aflasafe application and availability of moisture soon after application are critical for efficacy. The product, which comprises fungal strains that outcompete the strains that produce aflatoxin, must sporulate during a particular stage of maize growth for maximum impact. An ongoing study in eastern Kenya found low rates of sporulation in Aflasafe applied by smallholder farmers (IITA, 2018), suggesting the need for intensive training of farmers and caution in the extrapolation of results from efficacy trials.)

Subsistence farmers aren’t amenable to market incentives

much of the maize consumed in Kenya is produced by small scale farmers and never traded (CIMMYT, 2015); for these farmers, investment in aflatoxin control is purely an investment in household health. Previous literature shows that demand for preventive health goods among the poor is highly sensitive to price (Bates et al., 2012). Results from the dryer study mirror this: 76% of farmers brought maize to be dried when the mobile service was offered free of charge, compared to 31% when it was offered at full cost. Subsidization of simple yet effective aflatoxin control technologies is thus likely to be important for achieving widespread adoption among subsistence farmers, including those who sell a portion of their maize.

Creating premium markets for safe maize may be anti-poor

The current market structure thus does little to encourage aflatoxin control at its source on the farm. Instead, millers achieve safety for their brand by rejecting contaminated lots of grain. This grain invariably finds another buyer, typically serving a lower tier of the market. In this way, the safety premium for maize concentrates aflatoxin exposure among poorer consumers, who typically buy low-cost brands, or source their maize from the informal sector.

Conclusions

The evidence presented here demonstrates the potential for market-based approaches to improve food safety. However, it is also clear that the market will not achieve this goal alone. Harnessing market forces to reduce aflatoxin levels in the food supply requires both regulatory enforcement to motivate processors, and public investment in the development of market linkages so that incentives for safer food can be transmitted to producers. Table 15 summarizes the evidence on various strategies for aflatoxin control in the Kenyan maize market

| Strategy | Adoption | Strengths | Weaknesses |
|---------------------------------------|--|---|--|
| Test for aflatoxins and reject | Followed by most large and medium scale millers | Relatively cheap | Testing capacity weak, incentives to accept failures; unsafe maize goes to informal market |
| Label for tested safe maize | Attempted but discontinued by one miller | Potential market advantage with sufficient private or social marketing effort | Draws regulatory attention, difficult to maintain compliance, no lasting market impact on sales shown in studies |
| Premium for tested safe maize | Exists in higher-priced brands despite lack of explicit labeling | Could potentially be passed on to farmers | Achieved through testing; lower-priced brands are consumed by the poor |
| Premium for farmers | Experimental or donor-driven | Encourages adoption of aflatoxin control technologies | Costly to implement |
| Linking farmers to millers | None to date | Reduces aflatoxin at the source | Aflatoxin-prone areas are far from premium markets; inclusion of smaller farmers unlikely to be feasible due to cost |

Table 11: Summary of evidence on strategies for aflatoxin control in the Kenyan maize market

While providing premium prices to producers for safe maize has been shown to increase the use of on-farm aflatoxin control technologies, this strategy is mostly limited to experimental studies and donors sourcing of food aid subject to a local procurement mandate at present. In order for the market premium for safe maize observed at the retail level to act as an incentive for aflatoxin reduction in the food supply, it will be necessary to link farmers in affected regions directly to millers. This will require public intervention, which should focus on geographic areas where aflatoxin contamination is most severe. High costs of the most efficacious aflatoxin reduction technologies imply that a market linkage approach will have little impact on smaller-scale market producers. For these farmers, as well as those who

produce maize solely for household consumption, subsidies for simple yet effective aflatoxin control technologies are likely to be critical for reducing exposure to aflatoxin.

(extracted, summarized and adapted from a report by V Hoffman)

5.4 ILRI experiences in supporting food safety

Generally, in developing countries food businesses are composed of “mice and elephants” that is, many informal sector actors that are untrained and difficult to monitor and a few large, monopolistic companies that have incentives to escape or capture regulation. These structural challenges are often compounded by inadequate or un-enforceable regulations. Previous attempts to improve food safety have often focused on the large-scale formal sector or on strengthening national control systems (public sector). While some successes have been achieved, there has been little appreciable benefits for the poor consumers who obtain more than 90% of their fresh foods from informal or traditional markets,

Fortunately, alternative, market-based approaches to improving food safety in informal markets are emerging (Robinson & Yoshida, 2016). These light-touch interventions change practice through capacity building, rewards (incentives), and provision of an enabling policy environment; they are especially suited to contexts where demand for food safety is high. They often target informal market agents because actors who aggregate product from many producers (for example, traders, processors, slaughterhouses) play a key role in maintaining and improving the quality of food, and they also may be easier to reach since there are fewer of them compared to either producers or consumers (Grace et al. 2012; Kouamé Sina et al. 2012; Kumar & Staal 2010; Makita et al. 2010).

ILRI has supported more than 10,000 farmers and value chain actors in Uganda, Kenya, Ethiopia, and India potentially resulting in millions of consumers obtaining safer food. The key components of the approach include: a) focus on informal or traditional value chains; b) enabling environment; c) capacity-building and appropriate technology; d) incentives for behaviour change; e) low cost so it can go to scale. However, the outcomes/impacts have been variously documented, and in at least one case there were no benefits from the intervention. Some of the better documented are captured in the following table.

| Particulars | Kenya | Kenya | Ibadan, Lagos | Assam state, India |
|---------------------------------|--|--|---|--|
| Value chain | Informal milk sector | Export, improved & typical slaughterhouse | Butchers | Informal milk sector |
| When | 1997-2006 | 2010-2011 | 2009-2011 | 2009-2013 |
| Number of traders | 25,000-30,000 | Several hundred in the 3 slaughterhouses | Around 900 in the market | Around 300 traders and 600 producers in the main milkshed |
| Number of market actors trained | In 2010, 4,200 traders registered nationally. In pilot areas, 85% of traders had been trained | Around 100 trained | 80 directly by the project and around 420 by peer to peer training | 265 traders and 480 producers have been trained |
| Consumers reached | Around 0.5 to 5 million | Nearly 1 million | Around 360,000 | Around 1.5 million |
| Gender aspects | Not explicit – women around 1/3 traders | Not included: all workers were men | Yes: targets for women participation and gender dimensions researched | Not explicit, but nearly all traders and farmers are men |
| Intervention | Training in hygiene and business practices; provision of hygienic dairy cans with wide necks; a certificate was given to successful trainees and this reduced harassment by officials. | Training in hygiene; raising awareness on food safety | Peer-to-peer training on basic hygiene; provision of boots, hats, aprons, fly-proof netting and food-safe disinfectants; banners and promotional material; use of butchers’ associations’ to monitor performance and ensure compliance. | In depth training needs analysis; training of trainers; training covered hygiene and business skills; traders motivated by better relation with officials and positive publicity; farmers by visible reduction in mastitis |
| Documented impact | Improved KAP after training | No change in KAP after training – the management did not provide soap or other necessities and were rather | Reduction of unacceptable meat from 97.5% to 78.5% (p<0.001); | Improved KAP after training |

| | | | | |
|----------------------------------|---|---|---|--|
| | Improved milk safety after training - reduction in unacceptable coliforms from 71% to 42% High economic benefits from the initiative - \$33.5 million a year | indifferent to practices and there was no obvious incentive for behavior change | Significant improvements in KAP KAP after training Cost of training is \$9 per butcher and estimated gains through diarrhoea averted was \$780 per butcher | Significantly higher milk production after training (7.8 and 6.8 liters respectively) and tendency for reduced mastitis Sector level benefits in Kamrup at least \$5.6 million a year |
| Policy influence | High – legislation changed and new institutions | None | Low- only engagement with market authorities | High- new institutions but no change to legislation |
| Current status of the initiative | Training and certification is episodic and project-led but trained vendors have an important share of the market | None – one off training | The pilot was intended to investigate efficacy and acceptability and did not have a strategy for sustainability. | Training and monitoring is ongoing and supported by government |
| Reference | Omoro & Baker, 2011 Kaitibie et al., 2010 | Mwai, C.W. 2011. | Grace et al., 2012a Grace et al., 2012b | Lapar et al., 2014 Lindahl et al., 2014 Mellin 2015 |

Table 12: Summary of evidence on training and certification in informal markets

Although there is some evidence of success, the approach is highly context specific and careful adaption is needed to fit to any given food system. In particular, the incentives for behavior change which are key to long-term sustainability have been difficult to generalize. In Kenya, where the approach was first developed in the dairy sector, informal sector traders were prone to harassment by authorities and a main motivation for training was obtaining a certificate that protected them from this (Kaitibie et al., 2010). On the other hand, in Assam (India), traders were mainly motivated by the good press which resulted from being trained and the opportunity to dialogue with government dairy development partners, rather than being regarded as a nuisance by them (Johnson et al., 2015). Perhaps surprisingly, in none of the three evaluated trials have trained traders been able to charge a premium for selling higher quality products which was initially considered to be a promising incentive.

While promising, many elements of this approach are unproven. Two RCTs are currently underway funded by BMGF and the Livestock Sustainable Intensification Lab (USAID), respectively. It may be better at enabling business than improving food safety.

5.6 A framework for decision-making about food safety investments

Based on the literature, but also a long-standing engagement in food safety research, we identified seven critical success factors for FBD interventions.

The EFICaCE framework.

Intervention requirements:

- **Efficacy:** Proven efficacy in reducing foodborne hazards or improving food related health outcomes. Ideally proven by randomized control trials or experiments.
- **Enabling environment:** there must be buy-in to the intervention by decision makers and the regulatory environment and implementation environment must not be hostile
- **Frugality:** the interventions should be affordable and when intended for poor people should be simple, short and cost little
- **Incentives:** incentives in place to motivate behavior change. Ideally, positive incentives that are directly observable and immediate
- **Capacity:** interventions should include capacity building
- **Change or innovation:** introduction of new technologies, processes or institutions can improve uptake
- **Equity:** the intervention should be gender sensitive and should not have un-intended consequences that make things worse for poor people

The framework starts with efficacy. If interventions cannot be shown to work, they should not be supported. The next step is demand or buy-in. If this does not exist it should be created. Also, the environment should be favorable to the intervention. Frugality underpins scale and sustainability and incentives are necessary for behavior change.

This framework turns conventional interventions upside-down. Most interventions start with an innovation or a desire to train people. Only later or never do they take into account incentives, enabling environment, demand or efficacy. Because many food safety interventions have had adverse consequences, we consider equity considerations the seventh essential factor.

Financing food safety investments

Development assistance for health (DAH), is unlikely to rise substantially in the near future, increasing reliance on domestic and innovative financing sources to sustain health programs in LMICs. When new problems rapidly rise on the agenda, as is the case of food safety, there may be added needs to identify new sources of funding which are not already committed. In addition, food safety is strongly associated with the private sector, and may be well placed to leverage funds from here.

A recent review in the Lancet examined innovative financing instruments (IFIs)—financing schemes that generate and mobilize funds—to estimate the financing mobilized from 2002 to 2015 (Atun et al., 2017). They identified ten IFIs, which mobilized US\$8.9 billion (2.3% of overall DAH) in 2002–15. The funds generated by IFIs were channeled mostly through GAVI and the Global Fund, and used for programs for new and underused vaccines, HIV/AIDS, malaria, tuberculosis, and maternal and child health. Some of these may be useful models for raising resources for food safety

5.7 A Road Map towards safer food in LMICs

We propose the following ten-step investment Road Map for food safety in LMIC in general and the three countries in particular:

1. Shift the investment focus from public sector and exports to private sector and domestic markets.
2. Promote end-user driven approaches that rely on well-informed consumers to put pressure on both public and private sector to improve food safety. These in turn require:
 - a. Accurate information on hazards, risks and mitigation must be generated
 - b. Careful dissemination of information via social media and other routes
 - c. Targeting to different consumer and stakeholder groups and building capacity to advocate for food safety
 - d. Training and information provided to conventional and new media
 - e. Monitoring and information of outcomes and impacts.
3. Focus on food safety along the value chain and not just in the household. Build capacity in the formal and informal private sector to allow them to respond to consumer demand: marketing skills, food safety, third party assurance.
4. Create institutions and incentives that do not only rely on government oversight to keep the private sector honest, for example, third party testing and dissemination of information to consumers.
5. Develop special initiatives for the informal markets which generate most of the health burden as well as massive livelihood benefits. The most promising approaches are market-based, light-touch, technically-innovative, incentive-driven and gender sensitive such as the training and certification of market traders.
6. Evaluate food safety investments ex ante on 7 critical success factors: Efficacy, Enabling Environment, Frugality, Incentives, Capacity, Change (innovations) and Equity: the EFICACE model.
7. Change unhelpful policies that block helpful technologies from use (e.g. hydrogen peroxide) or that create unnecessary barriers for no health gains (e.g. medical certification).
8. Help the public-sector step back from its current focus on standards, inspection, trade control and exports to focus on empowerment, co-regulation and co-ordination. Consider a single authority approach.
9. Remove barriers to intra-regional trade
10. Develop innovative financing initiatives to raise resources for food safety activities

Investment advice:

- There is a consensus that food safety is best managed by a ‘farm to fork’ or ‘boat to throat’ approach that tackles food safety along the value chain. There should also be multiple barriers (or redundancy) in the system so that if one barrier to contamination fails there are other opportunities to block contamination or decontaminate. Food safety risks are best assessed, managed and communicated using Risk Analysis

principles and methods which have been well described by FAO, WHO, CAC and others and are the basis of international trade under the auspices of the WTO.

- There is inadequate evidence on intervention options. Many previous investments in food safety have either been ineffective, badly targeted or done more harm than good. This should be taken into account in planning future investments.
- A systematic literature review provides some encouragement. Investments in technologies, training, information, new processes have often been successful.
 - Promising interventions at farm level include: organising producers in co-operatives or self-help groups thus making food safety capacity building easier; community-based or group certification to meet food safety standards; out-grower or contract schemes that include farmer training and support; farmer field schools and training in good agricultural practices and integrated pest management; technologies to reduce risk on farm such as vaccines for pig tapeworms. These interventions can also improve smallholder incomes, introduce other practices for better business and environmental protection, and improve the safety of food produced and consumed by farmers.
 - Promising interventions along the value chain include: providing and upgrading infrastructure such as roads and electricity; technical innovations such as cooling devices and water disinfection; vertical integration so that firms can manage safety; traceability; good manufacturing processes and approaches such as Hazard Analysis and Critical Control Points (HACCP).
 - Promising interventions at retail include: modernising retail; development of high-end niche domestic value chains; training informal sector retailers and street sellers; training food handlers. These interventions can also have economic, equity and environmental benefits.
 - Promising interventions at consumer level include: education and information; leveraging consumer willingness to pay for food safety; mechanisms whereby consumers get accurate information on food safety.
 - Promising interventions at population level include: vaccination for FBD; linking provision of training and technologies for food safety with other health programs; encouraging dietary diversity
 - Promising interventions in food safety control systems include: co-regulation; public private partnerships for food surveillance; single food safety authority; third party laboratory assurance.

In addition to this general Road Map, applicable to the three countries, we give some targeted advice based on country-specific information from the FERG, consumption data from FAOStat, veterinary services data from OIE, and literature review.

| | Burkina Faso | Ethiopia | Nigeria |
|---|--|---|---|
| Major hazards in terms of FBD burden | Non-typhoidal Salmonella Pig tapeworm Toxigenic E coli | Cholera Toxigenic E coli Non-typhoidal Salmonella | Non-typhoidal Salmonella Pig tapeworm Norovirus |
| Problematic value chains/systems According to burden | Pork, poultry Complementary food | Water Complementary food | Pork, poultry, beef Street food |
| Important problems from systematic literature review | Tuberculosis in beef/milk Dairy products Listeria in processed food Food handlers | Beef, poultry | Vegetables and fruit Beef Traditional foods |
| Risky foods highly consumed | Meat, eggs, maize | Milk | Vegetables, fish |
| Priority activities | Ground truth burden studies and identify high risk value chains/food systems Apply hazard-based management in high risk chains/food systems | | |
| Country-specific risky foods | Groundnuts | Raw meat Traditional dairy | Street food Cattle hides |
| Country-specific issues | Lack of water and poor sanitation | Substantial export of livestock | Relatively high proportion vulnerable groups |

| | | | |
|-------------------------------------|--|---|---|
| | | | High concern over fraud |
| Food system control deficits | Veterinary personnel | Residue testing | Food safety inspection |
| Opportunities | Small country, many development initiatives makes piggy-backing attractive | High coverage of government services makes public sector initiatives attractive | High urbanization, internet penetration, education make consumer led initiatives attractive |
| Risks | Lack of pre-requisites for food safety | Possible instability | Corruption and low transparency |

Table 13: Specific investment advice for the Three Countries

Other considerations

FBD and nutrition: Stunting, or extreme shortness (very low height-for-age), is the result of a combination of long-term (chronic) poor dietary intake in terms of quality as well as quantity of food and repeated infectious disease episodes. Both wasting (extreme thinness, or low weight-for-age) and stunting are associated with increased mortality as well as poor health and longer-term development outcomes. FBD and hazards may contribute to both wasting and stunting through additional pathways, for example:

- Diarrhoea is associated with malnutrition but a causal link is hard to demonstrate; a 9-country study found that 25% of stunting could be attributed to experiencing more than four episodes of diarrhoea before the age of 24 months (Checkley et al. 2008). Studies find a strong peak in diarrhoea after the introduction of supplementary foods and find that weaning foods often have high levels of microbial contamination and adulteration (Kumi et al. 2014).
- Aflatoxins may directly contribute to stunting, and there are demonstrated associations between higher toxin levels and poorer growth in several contexts, although a causal relation, while plausible, is as yet unproven (Leroy 2013).
- Ingestion of animal faecal material through food or from the environment may contribute to environmental enteric dysfunction² (George et al. 2015)

FBD and gender: There has been little research on the intersection between gender and food safety, but FBD can have important implications for women's resilience and vulnerability.

- Firstly, food safety has direct implications for women's health. Pregnant and lactating women are especially vulnerable to FBD because of their modulated immune system. In addition, some FBD cause foetal abnormalities, abortion and stillbirths and some chemical hazards can be transmitted to the newborn through breast milk.
- Secondly, culture affects the relative consumption of risky foods by men and women. In Nigeria and Somalia, women consumed more low-value offal and men more high-value muscle meat (FSNAU 2010; Grace et al. 2012). Offal consumption has been found to be a risk factor for diarrhoea (Stafford et al. 2008; Grace et al. 2012). In Africa, men have more access to meat because they predominate in bars that serve meat and alcohol (Roesel and Grace 2014). Food eaten in these places has increased risk of FBD. A similar pattern is seen with fish-borne disease in China, Vietnam and Korea. Men have more frequent eating opportunities at restaurants than women and have a significantly higher rate of fish-borne fluke (Han et al. 2013).
- Thirdly, food safety has implications for women's livelihoods. Women have an important (even dominant) role in many traditional food value chains but as chains modernize, partly driven by food safety concerns, women may be excluded (Grace et al. 2015).
- Lastly, women are risk managers in the realms of food consumption, preparation, processing, selling and, to a lesser extent, production. However, they are often disadvantaged by less access to support and services such as education and extension. Because of these links, gender analysis is important in assessing and designing interventions to improve food environments by enhancing food safety.

FBD and food scares

FBD outbreaks often receive huge media attention and cause large declines in purchase of associated food (although this tends to return to pre-scare levels weeks or months later). For example, when pig diseases were initially reported by the media in Vietnam, the majority of consumers stopped eating pork, shifted to chicken, or went to outlets that were perceived to be safer (ILRI 2010). Food safety scares and the government responses to them (such as occurred during the avian influenza outbreak, the Rift Valley fever outbreak and melamine contamination incidents) have been shown to adversely affect the livelihoods of small farmers (2 billion in developing countries) and pastoralists (50–200 million) (ILRI 2007; Kavle et al. 2015). In Ethiopia, we have seen strong and negative reactions to findings from an ILRI study that 92% of milk in Addis exceeded Codex standards for aflatoxins. In fact, the health impacts of this were very unclear but the concern was very high and out of all proportion to the known risks to human health.

Food fraud

Counterfeit and adulterated foods and medicines are believed to be common, especially in Nigeria. There are well-documented cases of both food counterfeiting and adulteration in Nigeria and Ethiopia. High value foods are most susceptible. Milk is especially prone to adulteration, but a recent major review did not find cases from However, claims of counterfeiting/adulteration are also used as a marketing strategy by the formal private sector and as part

² An incompletely defined syndrome of inflammation, reduced absorption and barrier function of the small intestine.

of government attempts to increase revenue by increasing formality (Little, 2015). However, food fraud has the important effect of lowering trust in the food safety system.

A more pervasive problem may be lack of quality control. Some cross-Africa work on infant food found that there was considerable variation in the amount of ingredients. Similar results have been found for agricultural inputs. In some cases, the active ingredients or more expensive ingredients are at a higher level than indicated by the label suggesting the problem is one of poor quality control rather than deliberate fraud.

Investment advice:

Food safety is one of many societal objectives and there are trade-offs and synergies between attaining food safety, optimal nutrition status, opportunities for women, and income for the poor are especially powerful.

Food fraud has been very little investigated. Generating information would help in understanding the health risks posed. In addition, improving trust in the food system is likely to be key to making other food safety interventions succeed and addressing food fraud is an important part of this.

Conclusions

Recommendation 1: Generate credible country-specific evidence on FBD and its management

A priority for rational investment in improving food safety, is better evidence on the nature and magnitude of the problem and the options for managing it. Although we have used regional information and systematic literature review to attempt to provide information on these, our estimates are best guesses and require ground-truthing. Some of this could be generated by desk study but country-specific evidence is required. Some important areas are: burden of FBD at country level; cost of FBD; extent, benefits and risks of informal trade; food fraud.

The top pathogens in terms of burden in the three countries are relatively amenable to hazard-based management. Confirmation of their importance, and identification of high risk food systems and value chains, should be followed by country-specific hazard-based strategies.

Recommendation 2: Build capacity to demand, and use, evidence on FBD

A pre-requisite obtaining and using better information is a greater awareness and understanding of FBD among stakeholders, including donors. Specifically: the difference between risk and hazards; the desirability of using risk rather than hazard for prioritization; the advantages of prioritizing food safety issues; targeting resources to where they can be most useful; the likelihood of unintended consequences; the benefits of 'joining up' agriculture and health policy. This understanding can be built through capacity building and communication.

Recommendation 3: Add food safety onto other value chain development initiatives

The countries considered benefit from a broad range of agriculture and value chain development initiatives. Many of these include food safety in their objectives. However, our reviews suggest unless food safety is specifically addressed by competent personnel, it will not happen by default. There is much scope to explicitly build food safety into or onto existing development.

Recommendation 4: Do no harm

There is a tension between "paralysis by analysis" and "the law of un-intended consequences". The authors of this report are researchers and are probably biased towards recommendations to get more evidence. However, a decade of evaluating food safety interventions convinces us that conventional wisdom and common sense often result projects and programs that have adverse effects on other societal objectives and even the safety of food. Although research should not get in the way of action, without better evidence on food safety, there is a real risk of investing in interventions that are ineffective or harmful.

Recommendation 5: Best bet interventions

In the absence of a strong evidence-base, some of the most promising interventions are those that target the enormous traditional and smallholder sector, those that rely on light-touch and hence feasible interventions, and those that place a strong emphasis on incentives.

Recommendation 6: Risk-based targeting

Without effective, evidence-based risk assessment, policy may be driven instead by consumer perceptions, special interests and political pressure. This report provides preliminary evidence on priorities. These include: the traditional, domestic market; the informal export/import market; biological hazards; animal source foods; complementary foods and street foods. In addition, countries have specific food safety challenges. Prominent are illness associated with consumption of raw meat and home processed milk in Ethiopia; food fraud and adulteration in Nigeria; aflatoxins associated with groundnuts in Burkina Faso.

Annex 1: Food safety and the sustainable development goals

Food safety is integral to attaining the goal

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| SDG 3: Good health & well-being | Causal | <ul style="list-style-type: none"> FBD are an important contributor to health burdens in LMIC: the burden is comparable to malaria, HIV/AIDS and tuberculosis. FBD are associated with correspondingly large costs and psycho-social distress which can also negatively impact good health and well being. FBD are more common and frequent in LMICs than HICs and may be trending upwards in LMICs in response to increase in demand for more risky foods along with poorly governed agri-food system transformation. Production, processing and consumption of food is also associated with diseases, and the associated health, psychological and economic burdens. These include exposure of agri-food sector workers to occupational hazards (e.g. pesticides or pathogens) as well as diseases associated with agriculture (e.g. antimicrobial resistant pathogens resulting from use of antimicrobials in food animals and pandemics emerging from intensively kept, genetically similar livestock). |
| | Bi-directional | <ul style="list-style-type: none"> FBD is related to other diseases which threaten good health <ul style="list-style-type: none"> FBD is a risk factor for stunting and malnutrition and vice versa: stunted children are more vulnerable to FBD and FBD increases the chance of being malnourished People with compromised immunity, infants, the elderly and pregnant women are especially vulnerable to FBD FBD may result in lowered effectiveness of vaccines The foods with most potential to address under-nutrition (animal source foods and fresh vegetables) are also the most risky in terms of being sources of foodborne disease. |
| | Un-intended | <ul style="list-style-type: none"> Concerns about food safety may shift diets in directions that affect health: <ul style="list-style-type: none"> Concerns over FBD are often a factor in driving increased consumption of local, organic or certified food which may have social, health (reduction in non-communicable disease) and environmental benefits but which may also lead to reductions in total amount of food produced and so have negative nutrition impacts Concerns may also lead to increased consumption of processed and packaged food which may have negative nutrition impacts (increased non-communicable disease associated with overweight/obesity and increased malnutrition associated with decreased consumption of nutrient rich, fresh foods) |

Food safety has a significant influence on attaining goals

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| SDG 6: Clean water & sanitation | Causal | <ul style="list-style-type: none"> Many infectious FBD can be transmitted via water and people and animals infected with these diseases can contaminate water making it less safe (e.g. cysticercosis, cryptosporidiosis) |
| | Bidirectional | <ul style="list-style-type: none"> Lack of clean water for washing food and food equipment and for food handler hygiene increases the risk of food being unsafe Food production and processing may use a large amount of water reducing the availability of water for other uses such as sanitation and drinking Water sources provide a habitat for many food and waterborne pathogens and vectors such as schistosomes and the aquatic hosts of human infective fluke Food production can pollute water sources leading to lack of clean water and if this water is used in food processing it can contaminate food. Intensive production of animal source food (livestock and fish) is especially likely to contaminate water sources. Wastewater (grey water) is often high in nutrients and methods exist to allow safe recycling and use for agricultural production. Agriculture can also protect water quality if well managed, for example, agro-forestry along river banks can prevent erosion and reduce contamination or stocking sheep next to watercourses instead of cattle |

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| SDG 1: No Poverty | Causal | <ul style="list-style-type: none"> • Ill health is a major factor in causing and maintaining poverty. FBD is one of the major causes of ill health in LMIC. • FBD is associated with a range of costs that fall on poor people and contribute to their remaining in poverty: <ul style="list-style-type: none"> ○ Cost of illness including out of pocket expenses and lost days of work ○ Some FBD can result in catastrophic illness (e.g. paralysis, brain damage) which can result in permanent descent into poverty ○ Food which is visibly contaminated or unsafe is often sold at a lower price or cannot be sold at all resulting in financial loss to producers and value chain intermediaries ○ FBD, which are zoonotic often, result in losses in livestock or reduced value of livestock products. Other agents may cause both FBD and reduction in crop productivity (e.g. the moulds which produce aflatoxins) • Beyond the direct costs of illness, disease may also act as a “poverty trap” that is, a self-reinforcing mechanism through which poor individuals or countries remain poor (Grace et al., 2017). |
| | Bidirectional | <ul style="list-style-type: none"> • Poverty is a major risk factor for FBD nationally, at household and at individual level. <ul style="list-style-type: none"> ○ The WHO report suggests that 97% of the burden of FBD falls on developing countries ○ Many FBD are zoonotic and the burden of zoonotic diseases is also much higher in developing countries • At the same time, while most infectious diseases show a rapid decline with improving wealth, this is less marked in the case of FBD. |
| | Unintended | <ul style="list-style-type: none"> • Concerns over FBD lead to standards and enforcement in some markets (especially export and high value domestic), which can result in high costs of compliance or exclude the poor from participation reducing opportunities for income generation. • Concerns over FBD can lead to government or donors discouraging certain food sectors or actors (smallholders, street vendors), which can reduce their income through market exclusion or through the necessity of paying bribes |
| SDG 2: Zero Hunger (sustainable agriculture) | Causal | <ul style="list-style-type: none"> • By definition, food security entails food safety and hence food security cannot be attained if food is not safe • Unsafe food may be destroyed resulting in reduced food availability |
| | Bidirectional | <ul style="list-style-type: none"> • FBD has multiple complex interactions with nutrition. These include: <ul style="list-style-type: none"> ○ Causing illness, which worsens nutritional status; ○ Toxins may directly lead to malnutrition, for example, there is a strong association between ingestion of aflatoxins and stunting; ○ Food production (livestock) may result in greater exposure to animal faecal bacteria which is associated with environmental enteric dysfunction ○ FBD is especially problematic when infants are first introduced to foods • The most nutritious foods are also the most implicated in foodborne disease (animal source food and fresh vegetables) |
| | Unintended | <ul style="list-style-type: none"> • Attempts to improve food safety by making illegal or discouraging foods or food sectors perceived as risky (e.g. street food or raw milk) often increase the price and decrease the proximity of food to poor people which can have adverse nutritional consequences. • Concerns over food safety can also affect food security: <ul style="list-style-type: none"> ○ Consumer concerns of over foodborne disease can reduce food availability; ○ Concerns over foodborne disease can change consumption patterns resulting in reduced consumption of fresh foods; ○ Control of FBD can reduce availability; |

Food safety contributes to attaining goals

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| <p>SDG 9: Industry, innovation & infrastructure</p> | <ul style="list-style-type: none"> • In most LMICs, agri-food chains are undergoing rapid growth and transformation in response to growing demand of food and change in dietary habits. This change is most pronounced for animal source foods, fresh fruits and vegetables and processed foods, and higher concern over food safety is a feature of these changes. This demand-driven change drives innovation in food technology and marketing. • Infrastructure is an important factor in food safety. Improvements in transport can reduce FBD associated with keeping food for longer times at high temperatures (microbial pathogens). • Improved infrastructure tends to increase market orientation of farmers and use of agricultural inputs: this can increase risk from chemical hazards. When value chains lengthen and become more complex, there may be greater risk of FBD. • <i>There are risks that concerns over FBD could exclude smallscale actors from emerging opportunities in food production, processing and retail.</i> |
| <p>SDG 12: Responsible consumption</p> | <ul style="list-style-type: none"> • Reducing the high level of waste and losses and rebalancing the share of animal products in diets can contribute to sustainability and health. • There are complex interactions between dietary composition, dietary sustainability and risks of FBD. In general, increasing consumption of fresh, locally produced vegetables would reduce non-communicable disease and lower environmental costs but it would lead to increased waste and increased FBD unless mitigation is in place. Meanwhile, decreasing animal source food consumption would bring likely health benefits for developed countries but worsen nutritional status in many developing countries. Animal source food is associated with a higher environmental footprint. |
| <p>SDG 8: Decent work & economic growth</p> | <ul style="list-style-type: none"> • FBD entails high costs, which have negative impacts on economic growth. There is good evidence that investment in control of FBD can have economic benefits. For example, a review found that there was \$6 benefit for every \$1 invested in brucellosis control; the average benefits per dollar were higher in developing countries (McDermott et al., 2013) • Especially, in developed countries a significant proportion of costs are incurred by the agri-food industry, slowing economic growth • FBD also results in lost value from exports that are rejected and lost opportunities when countries cannot meet standards. • FBD are often transmitted by multiple routes and many are occupational risks for those working in the agriculture and food sector. • While imported food is often safer than domestically produced food in LMICs, there is a risk of “dumping” unsafe food on less discriminating markets. • <i>There are also cases where detection of hazards in exports alerted authorities and researchers to previously unknown hazards present in domestic markets. For example, high levels of toxic chemicals were discovered in smoked fish exported from Cote d’Ivoire to France leading to improvements in local production (Roesel & Grace, 2014</i> • <i>In Africa and Asia most food production and distribution occurs in the informal sector. This provides employment to billions of people. Agri-food sectors are responding to increased and changing demand by restructuring; this development could provide new opportunities to smallholders and smallscale market actors. However, food safety is an important mediator of the trajectory of restructuring and if smallholders and smallscale actors (many of the women) cannot meet food safety requirements they risk will be forced to exit markets.</i> |
| <p>SDG 5: Gender equality</p> | <ul style="list-style-type: none"> • Women have a major role in agricultural production. In many countries, they predominate in livestock and horticulture and often have a role in crop production. • <i>Most fresh foods in LMIC are processed, sold and cooked by women. As food production and distribution systems develop, women often fall out of these systems removing an important source of their income and also power.</i> • Food is a gendered commodity and there are many taboos around food consumption that on the whole tend to nutritionally disadvantage women • Men and women have different vulnerabilities to FBD and pregnant women are especially vulnerable |

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| SDG 10: Reduced Inequalities | <ul style="list-style-type: none"> FBD are most common and serious in vulnerable populations specifically the young, the old, the pregnant, the malnourished and the immunosuppressed. Hence FBD can contribute to worsening inequities. Some FBD result in social stigmata and hence social disapproval, for example, in many poor, pig-keeping communities cysticercosis is a major cause of epilepsy, and epilepsy is often stigmatised <i>Livestock, horticulture and crops are a source of income, create employment and small enterprise opportunities and provide market participation to poor rural households. Concerns over food safety may exclude these from increasingly demanding markets.</i> |
| SDG 14: Life below water | <ul style="list-style-type: none"> Fish is a major source of dietary protein but also highly vulnerable to contamination resulting in disease and food losses. Demand for fish is increasing rapidly in LMIC, which is putting increasing pressure on wild sources as well as stimulating rapid growth in aquaculture. Some livestock systems use large amounts of fishmeal as feed, and the sector's water pollution can lead to eutrophication and hypoxic water conditions. |
| SDG 15: Life on land | <ul style="list-style-type: none"> Livestock products are highly nutritious but have a disproportionately high contribution to FBD. Demand for livestock products is increasing rapidly in LMIC resulting in significant restructuring of livestock systems. Livestock use major swathes of land and can have both positive and negative effects on biodiversity depending on how they are managed. Bushmeat is an important source of animal source foods in some communities. Methods of capture and sale mean that risk of FBD is high as well as the risk of occupational health hazards to hunters. Over-use of bushmeat can also reduce biodiversity and ecosystem resilience. |
| SDG 11: Sustainable cities & communities | <ul style="list-style-type: none"> <i>Concerns over food safety put urban agriculture and wet markets at risk.</i> <ul style="list-style-type: none"> <i>Hundreds of millions of people in cities are engaged in urban agriculture which produces much of the fresh foods consumed within cities and contributes to food security, nutrition, jobs creation and liveability but which require management of health and sanitation threats.</i> <i>Vibrant traditional wet markets and street foods are an important contributor to culture, tourism, and livable cities.</i> |

Food safety is a minor consideration in attaining goals

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| SDG 16: Peace, justice & strong institutions | <ul style="list-style-type: none"> Much food is produced by smallholders and in many systems land tenure is a constraint. <i>Much food is sold in informal sector, which had been often ignored by development initiatives and is vulnerable to official "crack-downs" and other actions.</i> |
| SDG 4: Quality education | <ul style="list-style-type: none"> Animal-source foods are key to cognitive development in children, <i>and there is some evidence that concerns over foodborne disease decrease their use in school meals and other programs.</i> |
| SDG 7: Affordable & clean energy | <ul style="list-style-type: none"> Food preparation and cooking is an essential part of reducing risk of FBD but also a major user of fuel. |
| SDG 13: Climate action | <ul style="list-style-type: none"> Many foodborne diseases are climate sensitive and will change (often increasing) in response to climate change Agriculture (especially livestock production) contributes significantly to GHG emissions, but there is also have large mitigation potential Meeting needs for safe and nutritious food will entail adaptation to climate change |

Annex 2: How to measure the burden of Food Borne Disease

There are five main sources of evidence for FBD health burden this:

1. **Official reports:** These tend to significantly under-estimate the burden of FBD; in many countries, there is no requirement to report FBD. Even if there is a requirement, the reporting system may not be adequate, resulting in massive under-reporting. For example, in Gansu in China, there were an estimated 30 million cases of acute gastrointestinal disease but only 400 cases reported to the official system (Sang et al. 2014), and in Malaysia, estimates suggest less than 0.1% of cases are officially reported (Gurpreet et al. 2011).
2. **Community surveys of self-reported illness and cause:** Only a few surveys have been carried out in developing countries. The studies that exist find acute gastrointestinal disease is common (around one in two people a year or 50% of people report being affected, with much higher rates in some vulnerable populations) and around one-third of cases (12–55%) have been attributed to food (Bureau of Epidemiology 2004; Ho et al. 2010; Chen et al. 2013; Sang et al. 2014). However, self-reporting can be a reasonably good way to estimate occurrence of illness, but people are not good at attributing the source or identifying if food is responsible.
3. **Surveys of FBD using symptoms or diagnostic tests:** Some FBD can be diagnosed through characteristic symptoms in conjunction with diagnostic tests. These include many diseases caused by macro-parasites such as fish fluke or epilepsy caused by pig tapeworm. Reviews of hospital and community surveys often suggest relatively high levels of FBD (Torgerson et al. 2006; Bruno et al. 2013).
4. **Risk assessments:** This is a method for predicting the level of FBD based on the level of hazards in food consumed, the quantity consumed and the susceptibility of the population. There are a limited number of microbial and chemical risk assessments from developing countries and many are not quantitative but most indicate a high level of FBD, for example, around 13% of people suffer from pork-borne salmonellosis each year in Vietnam (Dang-Xuan et al. 2016) and around 1% of children are exposed to zoonotic *Cryptosporidium* in Nairobi (Grace et al. 2012).
5. **Health burden assessments:** Some FBD have been included in Global Burden of Disease Assessments produced by WHO and the Institute for Health Metrics and Evaluation. These indicate high burdens for the included diseases. The recent WHO report on the global burden of FBD is the most definitive burden study. It found that 31 FBD agents (biological and chemical hazards) accounted for around 420,000 deaths in developing countries, imposing a burden of around 33 million DALYs each year. Moreover, this estimate is likely to be conservative.

We explore three ways of measuring the economic burden of FBE

Human capital approach – value of a statistical life

Loss of life may account for the biggest share of health valuation estimates (Narain and Sall, 2016). In economic terms the value of a statistical life (VSL) is the amount of money a person (or society) is willing to spend to save a life. The only way to measure the VSL is through indirect methods (e.g., surveys or observed human behaviour in risky environments). Various methods have been used, such as discounting forgone income, using wage differences between occupations with different risks, and observing how much people pay for safety features. Studies generally provide average values for the overall population although there is some evidence that values may be different for adults and children.

There are few studies on the VSL from Africa, but literature suggests VSL should be adjusted by per capita income at country level. A recent paper calculated VSL for countries with insufficient data by using a base VSL from the United States calculated using labour market estimates from Census of Fatal Occupational Injuries data, adjusted for differences in income: the VSL for Burkina Faso, Ethiopia and Nigeria of \$640,000, \$102,000 and \$485,000 respectively (Viscusi & Masterman, 2017). Using VSL methodology, the costs of FBD in terms of deaths are around \$3 billion for Burkina Faso, 1.3 billion for Ethiopia and \$16 billion for Nigeria. The costs for SSA are nearly \$40 billion and Nigeria is a substantial contributor to this.

These results are broadly compatible with the literature (Yaduma et al., 2012; Leon & Miguel, 2013), although some studies make a case for considerably lower VSLs. (For example, one study provided an un-adjusted extrapolated VSL for Ethiopia of \$107,200 and adjusted using an elasticity of 1.5 (\$14,000)).

Human capital approach – Gross Domestic Product

Illness can also be estimated as foregone output, assuming people who are ill are unable to work. The value of DALYs lost due to FBD can be calculated by multiplying the estimated DALYs loss due to FBD in the FERG data by the Gross

Domestic Product (GDP), income, or purchasing power parity (PPP) adjusted income per capita for the same year, using human capital approach as in the paper on Economic Burden for Injuries. In this relatively simplistic calculation we do not adjust for age or discounting.

(There are two ways to measure GDP (total income of a country) of different countries and compare them. One way, called GDP at exchange rate, is when the currencies of all countries are converted into USD (United States Dollar). The second way is GDP (PPP) or GDP at Purchasing Power Parity (PPP): this is measured by finding the values (in USD) of a basket of consumer goods that are present in each country (such as maize, pencils, etc.). If that basket costs \$100 in the US and \$50 in Nigeria, then the purchasing power parity exchange rate is 1:0.5, this reflects that the cost of buying basics in LMICs may be less so people in LMICs are “richer” in terms of buying things than their GDP might reflect.)

People can be unable to contribute to the economy because they are sick or because they are dead. As such there is some overlap between the GDP method and the VSL method which uses a different approach to place economic values on lost life. The FERG suggests that around 90% of the years of healthy years of life lost from FBD are due to death rather than disability. This suggests the two estimates should be triangulated rather than added.

Cost of illness approach

The cost of illness (COI) approach seeks to account for the direct and indirect costs of death and illness. Direct financial costs include transport costs to get treatment, medical expenses paid by the patient, wages lost, and costs of public health provision. Indirect costs include productivity losses from missed business due to sick employees, the monetized value forgone household chores and others. There is some inconsistency in whether costs are considered direct or indirect in the literature. There are not studies on the cost of FBD from Ethiopia or Burkina Faso.

Annex 3 Trade and Domestic markets

Importance of formal/official export food market

Globally, there has been an increase in world agricultural trade; this is likely to continue. Trade in animal-source foods, produce and processed foods is growing at a faster rate than for other food, mainly as the result of rapid growth in consumption of these foods, especially in developing countries. This in turn is driven by increasing global incomes and changing dietary preferences (Popkin et al. 2012). It is often argued that agricultural countries can “trade their way out of poverty” by encouraging agricultural exports yet African imports of food are trending up. Increasing population, urbanisation and dietary shifts create demands for food yet relatively slower agricultural productivity growth and under-developed value chains inhibit ability to supply.

Opinions vary as to the potential of African agriculture to effectively meet demand, but most consider food exports from Africa may not be a large part of economies in the 21st century: the population is set to exceed 4 billion by 2010 which will create challenges to supply food for domestic markets. At the same time, regional official trade in food is constrained by several structural barriers, and some believe there is considerable potential to remove these. Intra-African markets accounted only for 34% of the total agricultural exports from African countries between 2007 and 2011 (Badiane et al., 2014)

Safety of exported food is verified by importing countries, but only a proportion of food is checked. Some countries have higher standards and more rigorous checking than others (countries in the European Union are typically more rigorous than Japan and the United States of America, which in turn are more rigorous than the Middle East and Asian countries). In the European Union, detailed information is available from reports to the Rapid Alert System for Food and Feed (RASFF).

Currently, with the exception of Ethiopia, food exports are sometimes strategic but overall not very important in the countries considered. This contrasts with other LMIC such as Vietnam or Kenya where food exports are key to national economies

- The Government of Ethiopia is strongly encouraging exports in order to improve balance of trade and obtain currency for development investments. Ethiopia exported \$1.7B and imported \$19B of goods in 2016. Food is an important part of Ethiopian exports, especially coffee (41% of exports, followed by dried legumes (15% of exports)). The major food exports in 2016 were: coffee, (tea, spices) USD 0.75B, dried legumes 0.25B; vegetables 0.1B and meat 0.035B
- The Nigerian economy is heavily dependent on exports, but these are mainly oil and natural gas (>95% of exports). In 2015, Nigeria exported \$48B worth of goods in 2016 and imported \$40B. The major food exports in 2016 were: cocoa USD 0.89B, oilseeds 0.28B, fish 0.11B and fruits/nuts 0.06B
- Burkina Faso is a land-locked country and is the largest exporter of cotton in sub-Saharan Africa: food export is not a major policy objective. Burkina Faso exported \$3.5B and imported \$3.2B in 2016. Exports were dominated by gold and cotton (73% and 13% of the total value respectively). Major food exports were: oily seeds USD 0.12b and nuts USD 0.08B. (All export data from TradeMap)

Importance of domestic food market

In Africa and Asia, domestic food markets are much more important in terms of livelihoods, nutrition, and health than export or import markets.

- In 2016, Nigeria had an estimated population of 186 million: 93 million in rural and 93 million in urban areas: 16 million were under-nourished and 33% of children stunted (FAOSTAT). The value of agriculture was \$85B (World Bank).
- In 2017, Ethiopia had an estimated population of 104 million: 83 million in rural areas and 21million in urban areas: 29 million were under-nourished and 40% of children stunted. In 2016, the value of agriculture in Ethiopia was \$25B (World Bank).
- In 2017, Burkina Faso had an estimated population of 19 million: 13 million in rural and 6 million in urban areas: 3.7 million were under-nourished and 35% of children stunted (FAOSTAT). The value of agriculture was \$3.5B (World Bank).

Importance of official import food market

All three countries are net food importers but imports consist mainly of low FBD risk cereals, oils and sugars. In sub-Saharan Africa overall, food made up 15% of all officially recorded imports in 2011 (by value); however, imported food

still constituted only a small proportion of total food consumed: around 1-3% between 2002 and 2011 (IIED, 2015). For Nigeria, food makes up 32% of official imports and for Burkina Faso and Ethiopia 17% and 15% respectively (World Bank).

However, for some foods much of the total amount consumed is imported: especially Asian rice consumed by the urban poor, and dairy and poultry consumed especially by urban rich or middle class. Imported rice constitutes around half the total consumed in Nigeria (6 million tonnes). Total broiler meat imports into SSA from all sources rose from 6,000 tons to 1981 to 1.22 million tons in 2014, accounting for 44 per cent of total domestic consumption (USDA-ERS, 2014 and Nigeria is a major destination, despite a ban on importation of frozen chicken. Powdered milk makes up 75% of milk consumed in Nigeria (around 1.2 million tonnes is imported) and is also important in Burkina Faso but is relatively minor in Ethiopia.

Importance of informal food export and import markets

Around half of all intra-African cross-border trade is classified as informal (FAO, 2017) and informal cross-border food trade is significant in all three countries. It is conducted mainly by individual traders; in west Africa, many of these are women, but men dominate in east Africa.

- Ethiopia: Major outflows are livestock from Ethiopia to Somalia, beans from Ethiopia to Kenya, Sudan and Somalia, maize from Ethiopia to Kenya and Somalia. Major inflows include rice from Somalia to Ethiopia and sheep and goats from Kenya to Ethiopia. Although information is difficult to obtain, informal exports from Ethiopia may value \$0.5-1B or more.
- Nigeria: Major inflows of imported foods take place from Togo and Benin; major inflows of livestock from Burkina Faso, Mali, Niger and Chad; and major outflows of cash crops and processed food to neighbouring countries. For example, anecdotal evidence suggests that official data on the country's trade with Benin represent only about one 1% of the actual volume, and that at least 70–80 per cent of overall trade between Nigeria and its neighbours is unrecorded.
- Burkina Faso: like other landlocked west African countries, Burkina Faso imports cereals, tubers, fruits and vegetables from coastal countries (Côte d'Ivoire, Senegal, Ghana and Benin) and in turn, livestock flows from Burkina Faso to coastal countries. One study estimated that \$212 million worth of livestock are exported from Burkina Faso (\$54.4 million are officially reported) (Josserand, 2013).

In West Africa “re-exports” are a significant form of informal trade. Re-exports are goods imported legally through formal channels into countries with low trade barriers (typically the coastal entrepôts of Benin and Togo) and then shipped unofficially in large volumes to neighbouring countries with higher barriers, with minimal or no processing aside from transport services. For example, in Nigeria, rice, poultry and cooking oil are heavily protected which has the effect of encouraging informal trade. On the other hand, Benin and Togo keep tariffs low to encourage income generation through import and re-export activities. Unsurprisingly, most of Benin's poultry imports (>95%) are destined for Nigeria and nearly all of this trade is illegal.

Informal trade is extremely important for food and nutrition security and livelihoods. On the other hand, it reduces government revenue, escapes food safety inspection, and may contribute to overall poor governance. There is much debate on the extent to which informal trade should be suppressed, encouraged or formalised. There is some evidence that attempts to formalise this trade have low success and have negative consequences (Little, 2015).

Food safety has implications for trade and trade has implications for domestic food safety. The implications of trade liberalization on food safety are both negative and positive. On the negative side, increased food trade may introduce new safety hazards, revive previously controlled risks and spread contaminated food widely (Hawkes et al. 2015). On the positive side, food that is legally imported from high-income countries is usually of high safety levels and may indeed be safer than food sold on the domestic markets.

Investments in food safety to improve trade often consist of helping countries comply with the Sanitary and Phytosanitary (SPS) Standards. These are the rules, methods and governance mechanisms that World Trade Organisation members are obliged to follow when they set SPS measures governing food and feed safety, animal health and plant health.

For most African countries, national production volatility is considerably higher than regional level volatility. Consequently, expanding cross-border trade would reduce price instability. There is considerable scope for exploiting the less than perfect correlation of volatility patterns across countries. Despite the recent upward trends,

the level of intra-African and intra-regional trade is still very low compared with other regions. Intra-African markets accounted only for, on average, 34% of the total agricultural exports from African countries between 2007 and 2011 (Badiane et al., 2014). Among the three regional economic communities (RECs), SADC had the highest share of intra-regional trade (42%), and ECOWAS the lowest (6%). The COMESA share of intra-regional trade was 20% (Badiane et al., 2014).

The improvements include three possible scenarios:

1. Across the board reduction in trading costs by 10%.
2. Elimination of informal barriers to cross-border trade.
3. Increase in crop yields, also by 10%.

These show cumulative increases in intraregional trade in local staples of up to 3 to 4 million tons above current trends between 2008 and 2025 (Badiane et al., 2014).

The European Union provides a good example of how barriers to trade can be removed, allowing free movement of goods across borders.

Annex 4 Typology for Food Safety Interventions

The following typology sets out where interventions can take place. A key distinction is between interventions that are focused on food safety and broader interventions that include food safety as one aspect. In this typology we focus on the former. Another distinction is in which sector the intervention occurs: we classify according to a) export, b) domestic modern or large scale, and c) small-scale, pastoralist or traditional. The third distinction is the level of the value chain at which the intervention takes place (Figure x)

Producer (including hunting and fishing)

- **Technologies:** Many interventions have focused on technologies aimed to improve food safety. These include: biocontrol for aflatoxin mitigation; improved milk cans for hygienic milk handling; fermenting to reduce microbes in food; plastic containers for fruit. Many have been shown to be effective, but adoption is generally more problematic.
- **Training & information:** Many interventions aim to change farmer practices, generally through training and information provision. These may be linked with improved technologies.
 - **Farmer field schools:** farmers in schemes benefited but there was little diffusion or sustainability beyond the project. While yields and profits appear to have increased, there is little evidence of health benefits, partly because these were often not monitored or evaluated (Waddington and White 2014).
 - **GAP:** Good Agricultural Practices are codes developed by private companies, government agencies or international governmental organisations. Smallholders can successfully meet export GAP standards if there are efforts made to include them (Unnevehr and Ronchi 2014). However, domestic GAP seems less successful both in terms of adoption and evidence of improved safety (Schreinemachers et al. 2012). Common challenges are that rules are complex and fees high and there is often little incentive for participation.
 - **Aflatoxin mitigation:** GAP have also been applied to aflatoxin reduction (hybrid seeds, irrigation, fertilisers, insecticide, post harvesting handling). This is technically effective but adoption is low.
 - **Hygienic dairies:** In the livestock sector, several initiatives have developed around hygienic milking and milk handling.
- **New processes:** These can be seen as different ways of doing farming. Again, food safety is usually not the only objective but it may be important.
 - **IPM:** Around 12 million farmers in over 90 countries across Asia, Africa and Latin America have been trained in integrated pest management (IPM) which has a major objective of reducing use of pesticides, intended to benefit farmer and consumer health. There is little evidence, although much concern, that pesticides in food is a major public health issue. Where incentives are in place and sufficient training uptake can be good.
 - **Organic farming:** organic farms are often perceived as producing safer food although there is little evidence this is true. Organic produce is growing in popularity in LMIC but there is little evidence on the extent to which organic processes are actually followed.
 - **Community-based certification:** A range of quality assurance schemes have been developed, often involving a brand. These do not require government monitoring and are typically simpler and cheaper than GAP. There are local successes but insufficient evidence on scalability or effectiveness in improving food safety.
- **Organisational:** These are usually broader initiatives with food safety as one aspect. They include grouping farmers in co-operatives, groups, vertical integration, and contract farming. There is some evidence that these can improve adoption of risk mitigating practices and technologies.
- **Regulatory:** Regulations have been effectively deployed for export markets, although there is evidence that they are often imperfectly followed. Some of the larger domestic supermarkets are able to impose private standards on suppliers. Much of the produce in LMICs is not effectively regulated.
- **Infrastructure:** Although there is little investment in on-farm infrastructure, general investments in roads, electricity, water and sanitation can have important benefits for food safety. An exception is biogas which has benefited from major investments in several countries.

Transport and processing

- **Technologies:** Many interventions focus on technologies and uptake by the formal and export sectors are quite high. There is much less uptake in the informal domestic sector.

- **Training and information:** There have been very large initiatives around post harvest loss aimed at small and medium producers and many could be expected to improve food safety. However, there is little evidence that they actually have. Donors have also invested considerably
- **Infrastructure:** This has been a common approach at firm level with major objectives being upgraded slaughterhouses, chilling plants for milk and upgraded wet markets. There has been little evaluation of the long-term effects of this upgrading, but the few studies done typically show poor success; this is attributed to the complexity of managing and the added expense and inconvenience, making them unpopular with users.
- **New processes:** These have been a major focus of investment in the export and formal processing sector.
 - **Hazard Analysis and Critical Control Points (HACCP), Food Safety Management Systems (FSMS), International Standards Organisation (ISO) standards and Good Manufacturing Practice (GMP):** Although most developing countries have adopted HACCP approaches to food safety, which are considered best practice, they have only been able to implement these for exported food and (to a limited extent) in some larger, formal sector agro-industries. This is not surprising given the failure of most small and medium companies in HIC such as the United Kingdom to implement these approaches (Taylor 2008).
 - **Traceability and certification:** This is a requirement for export and works to some extent. In domestic markets, uptake is very limited: complicated by the large numbers of farmers, low trust of consumers, premiums associated with branded food and low availability. The case of Vietnam is typical: after more than 10 years of major efforts and investments by state authorities and market actors, the 'safe vegetable' production and distribution system has not yet been able to take a significant share of the vegetable market and gain widespread consumer trust (Nguyen-Viet et al. 2017).
- **Organisational:** These typically involve linkages with farmers. See previous section.
- **Regulatory:** Export and formal domestic sectors have been the focus for most regulatory interventions.

Retail

- **Technologies:** Some interventions focus on technologies and uptake by the retail sector but this area has been generally neglected.
- **Training and intervention:** training informal sector retailers can improve food safety. It is important that there is an incentive to attend training and motivate behaviour change after the training and it has proven difficult to establish long-term monitoring. Short-term studies show food safety improves but there is limited evidence on longer-term effects. The only meta-analysis of interventions to train food handlers found trained handlers had around 30% improvement in knowledge over controls (n = 9 studies) and 70% improvement in practices, but this was based on self-reported practices, which are prone to exaggeration; moreover, only three studies were from developing countries (Soon et al. 2012).
- **Organisational:** At retail level, this applies to new ways of interacting with other actors which are partly motivated or justified by food safety. These include vertical integration in those cases where it extends to farm level.
- **Practices and processes:** At retail level, this refers to new ways of doing business which are partly motivated or justified by food safety.
 - **Modern retail:** There is a trend for modern retail to increase and, especially in Southeast Asia, it has been favoured by governments as a way of improving food safety. Evaluations have been mixed: where there is demand, outlets have been successful, but their share of the market remains low and there is limited evidence to suggest food is safer. They are challenged: by high costs; consumer preference for fresh, un-chilled food; and, resistance from retailers (Wertheim-Heck et al. 2015). In some contexts, products from formal retail are safer than those from the informal sector, but perhaps surprisingly, this is not always the case (Roesel and Grace 2014).
 - **Specialist retail:** Many developing countries have retailers which sell food at a premium with strong emphasis on safety; these may sell food as 'organic' and emphasize traceability. While these appear to be growing, they reach only a small segment of the better-off consumers. There is evidence that food safety practices are often better in these market segments but there is little evidence on food safety or health outcomes, although there is probably a tendency for higher-end, more expensive products to be safer (Hoffmann and Moser 2017).
- **Regulatory:** Formal domestic sectors have been a focus for regulation and the informal sector is subject to sporadic and generally unhelpful regulation.

Consumer

- ***Technologies:*** In some HICs there have been major efforts to distribute meat thermometers. The main technologies promoted in LMICs are water treatment and hygiene. Where consumers are advised to use treated water for food preparation this can be food safety intervention.
- ***Training and information:*** Several programs have provided information on food risks and their prevention to consumers through mass media (newspaper, radio, posters, loudspeakers). These were very common during the avian influenza outbreaks. Recently there is interest in the use of information technology to send messages. Some initiatives have used more innovative methods such as infotainment, including messages on food safety in a television soap. Other initiatives have informed the community through social structures such as church congregations, neighbourhood meetings, youth groups. Training goes beyond information provision by offering structured, short to long term training on food safety. Domestic science is part of several curricula and often covers food safety. There have been some initiatives to train household food producers on sorting and removing contaminated maize, which have been quite successful, or to train mothers on food hygiene.
- ***New processes:*** Many in developing countries found that consumers report they are willing to pay a premium for safer food (Jabbar et al. 2010). The few studies on actual behaviour suggest low willingness to pay a premium for safety in the long-term. Moreover, there are ethical issues in selling food as 'safe' including the risk of channelling least safe food to the poorest (Grace 2015). Labelling has been promoted as a way to provide information about such health related issues as allergens and sell by date.

Governance/policy

- ***Technologies:*** there have been some efforts to give access to new technologies such as computers to regulators. There has been much interest in the use of technologies for traceability.
- ***Training and information:*** Building national control systems (such as through legislation and standard setting, staff training, and laboratory capacity building) has been the single largest category of donor investment in food safety in sub-Saharan Africa. A major focus has been training personnel in risk assessment, standard writing, surveillance or other aspects of public food system control.
- ***Practices and processes:*** There has also been focus on new ways of working for the public sector. This includes: attempts to support co-regulation; use of ISO standards and HACCP; quality assurance in public laboratories.
- ***Regulatory:*** This has been a major area for donor investment with dozens of projects set up to support policy review, regulations and standard setting. Although some of this is necessary to reach high value export markets, there is evidence this can have negative impacts on intra-regional and domestic markets. Assessments of food safety in LMICs point out the huge gap between enforcement and regulation. However, few initiatives have addressed this.
- ***Organisational:*** In most LMICs, food safety authority is fragmented. Some initiatives have managed to create a single food safety authority (e.g. India, China). A single unified structure or an integrated system is likely to be more effective but is not sufficient to improve food safety. In many LMICs, co-ordinating committees or national task forces have been set up to bring together different authorities, sometimes with other stakeholders. Participation in Codex has also been supported.

Population

Another set of interventions are not aimed at food value chains but at the general population or sub-groups thereof.

- ***Linking with other programs:*** There have been several initiatives in which food hygiene packages (e.g. soap, water disinfectant) have been distributed in other programs (e.g. antenatal clinics, HIV clinics). This can reduce the cost of delivering hygiene impacts and also support the host program in attaining goals. These have been successful, at least in improving KAP
- ***Medical preventative:*** Vaccination for cholera and norovirus; NovaSil for aflatoxin; hepatitis B vaccination for liver cancer linked to aflatoxins; deworming.
- ***Dietary Diversity:*** Increased dietary diversity can reduce consumption of toxins and increase intake of nutrients that could counteract the toxicity of such chemicals. In Qidong, China, a population that previously consumed a monotonous maize-based diet and increased dietary diversity since the 1980s has experienced a dramatic reduction in liver cancer mortalities.

Annex 5: Summary of food safety interventions

| Intervention | Outcome 1 | Hazard | Success | Design | VC | Type |
|---|------------------|----------------------|---------|-----------------------|----------------------|--------------------------------|
| Antimicrobial towel in HH vs air drying | Hazard | Microbial | F | RCT | Population | Technology |
| Private catering hygiene practices vs public | KAP | | Y | With and without | Retail catering | Training |
| Improved fermentation of milk vs existing | Hazard | Microbial | Y | Review | Producer trad | Technology |
| HACCP in slhouse vs traditional | Hazard | Microbial | Y | Before & after | VC SH | HACCP & Technology |
| Street vendors trained with 5 keys vs untrained | KAP | Microbial | Y | Before & after | Retail SV | Training |
| Farms certified for export vs non certified | Compliance | microbial, pesticide | Y | with and without | Producer export | GAP export certification |
| Carcases washed vs unwashed | Hazard | Microbial | F | Before & after | VC SH | Technology |
| Hygiene package for exported fish | Compliance | microbial | s/F | Before & after | Producer export | Technology & institutions |
| Packages for garri compared to traditional open storage | Hazard | Microbial | Y | Experiment | Retail market | Technology |
| Effect biocontrol on groundnut aflatoxin | Hazard | Mycotoxin | Y | Experiment | Producer trad | Technology |
| Comparing slaughter with stunning to without | Quality | Microbial | Y | Experiment | VC SH | Technology |
| Comparing carcasses from trained abattoir workers and untrained | KAP | Microbial | Y | With and without | VC SH | Training |
| Review of 5 studies on WTP for safe street food | WTP | | Y | Conjoint | Consumer -RTE | Assurance |
| WTP for quality and safety | WTP | | Y | Conjoint | Consumer trad | Assurance |
| Upgraded stall vs traditional stall | WTP actual money | | Y | Field auction | Consumer trad | High end |
| WTP for quality and safety | WTP | | Y | conjoint | Consumer modern | WTP |
| Effect of FSMS | Compliance | pesticide, microbial | | adoption (after) | VC-produce export | Processes |
| Comparing detailed abattoir inspection and routine | Hazard | Microbial | Y | Diagnostic validation | VC SH | Technology |
| Comparing typhoid vaccination with no vaccination | Health outcome | Microbial | Y | Desk study | Population | Vaccine |
| Effect of sealing anus and throat of slaughtered cattle with not sealing | Indicator | Microbial | Y | Experiment | VC SH | Technology |
| Effect of GHP training on food handlers in schools | KAP | microbial | Y | Before & after | Retail catering | Training food handler |
| Effect of irradiation on bioactive amine production in stored trad sausage vs no irradiation | Hazard | Microbial | Y | Experiment | Retail modern | Technology |
| Comparing EU standards on livelihoods of fish exporters versus no standards | Livelihoods | | Y | with and without | Producer fish export | Technology & institutions |
| Comparing conventional cleaning with disinfectant and rinse and modern foam cleaning in convenience food stores | Hazard | Microbial | Y | With and without | Retail modern | Technology |
| Effect of training, incentives and simple tech on butchers | Indicator | microbial | Y | Before & after | Retail market | Training & simple technologies |
| Effect of training on food handlers | KAP | | Y | Before & after | Retail catering | Training food handler |
| Comparing detailed abattoir inspection and routine | Hazard | Microbial | Y | Diagnostic validation | VC SH | Technology |
| comparing insecticide treated net protected butchers with non protected | Indicator | microbial | Y | RCT | Retail market | Technology |
| Effect ultra hermetic storage on aflatoxin growth in grains vs none | Hazard | Mycotoxin | Y | Experiment | Producer SS & LS | Technology |
| Comparing trained and untrained food handlers | KAP | | Y | with and without | Retail catering | food handler training |
| Comparing trained (sorting and washing) and untrained farmers for aflatoxin in urine | Hazard | Mycotoxin | Y | Before & after | Consumer trad | Training |
| Effect training and technology on hygiene and diar of school children | KAP | Microbial | f | cRCT | Population | technology & training |

| | | | | | | |
|---|------------------------|-----------------------|-----|-----------------------|-------------------------|-------------------------------------|
| Effect training on food handlers | KAP | | Y | Before & after | Retail catering | food handler training |
| Effect a) integrating hygiene with vax; b) hygiene training and material | KAP | Microbi al | Y | CRCT | Population - integrated | Information & technology & linking |
| Effect a) integrating hygiene with antenatal; b) hygiene training and material | KAP | Microbi al | Y | Before & after | Population - integrated | Information & technology & linking |
| Effect a) integrating hygiene with antenatal; b) hygiene training and material | KAP | Microbi al | s/f | adoption (after) | Population - integrated | Information & technology & linking |
| Effect of introducing HACCP at a formal cheese making plant | Quality | Microbi al | Y | Before & after | VC -dairy processor | HACCP |
| Effect of introducing HACCP at a formal ice cream making plant | Quality | microbia l | Y | Before & after | VC -dairy processor | HACCP |
| Effect of a hygiene package of simple technology | KAP | Microbi al | S/F | With and without | Population - integrated | Technology |
| Institutionalising mycotoxin testing | Labs to test aflatoxin | Mycoto xin | Y | Before & after | Government | national control |
| ISO accreditation of VPH in abattoirs | Practices | Microbi al | Y | adoption (after) | government | national control |
| Comparing large, iso, and haccp dairies with others | Indicator | microbia l | Y | with and without | VC -dairy processor | HACCP |
| Training farmers in GAP for aflatoxin | Hazard | Mycoto xin | Y | Before & after | producer | Technology |
| Messages for mothers on hygiene and providing technologies | KAP | microbia l | Y | RCT | Consumer | technology & training |
| Effect of improving dietary diversity on exposure CN Africa and aflatoxin China | Health outcome | mycotox in, chemica l | Y | Desk study | Population | dietary |
| Effect of training food handlers in hospital | KAP | Microbi al | Y | Before & after | Retail catering | food handler training |
| Ex ante evaluation of govt responses to street vending | WTP | | Y | Ex ante | | regulation |
| Review of traceability in Nambibia | Compliance | | Y | Adoption (after) | Producer export | traceability |
| Effect of Novasil on aflatoxins in kids serum | Hazard | Mycoto xin | Y | RCT | Population | medical |
| Effect of training farmers in maize handling to reduce fumonisins | Health outcome | mycotox in | Y | Before & after | Consumer | Training, processes |
| Effect of grinding food in agro-industry compared to not grinding | Indicator | Microbi al | F | Before & after | VC miller | Technology |
| WTP for safer food | WTP | | Y | Conjoint | Consumer | wtp |
| Effect of urine/biogas on soil compared to trad manure | Hazard | Chemica l | N/A | Experiment | PRoducer | Technology |
| Review of interventions to reduce CN in cassava | Hazard | chemica l | Y | review | consumer | Technology |
| Effect of vinegar on carcasses to reduce e coli | Indicator | microbia l | Y | Before & after | VC SH | Technology |
| <i>Effect of monitoring & technology to reduce listeria on avocados in formal</i> | <i>Hazard</i> | <i>microbi al</i> | Y | Before & after | <i>VC fruit</i> | <i>Technology & instiutions</i> |
| Effect of mission to improve FSMS in meat firms | Practices | Microbi al | s/F | Before & after | producer | HACCP |
| Description of modules to train stree vendors | not assessed | microbia l | | Before & after | | Training food handler |
| Comparing export to improved local to local abattoiirs for game | Practices | | F | with and without | Producer -game export | regulation |
| ipm/gap in morocco and turkey | Practices | pesticide | Y | Case study | Producer export | practices |
| trained and non trained food handlers | KAP | | Y | with and without | Retail catering | |
| Five keys applies | Disseminatio n | | Y | with and without | consumers, retailers | |
| FELTP training | Practices | | Y | Before & after | government | national control |
| Comparing street food and fast food providers near a university and before and after training | Practices | | y | before & after | Retail catering | Training food handler |
| Comparing school food handlers before and after training | KAP | | Y | Before & after | Retail catering | |
| Effect a) integrating hygiene with antenatal; b) hygiene training and material on friends of recipients | kap | Microbi al | Y | Before & after | Population- in tegrated | Information & technology & linking |
| WTP for quality and safety | WTP endowed money | Microbi al | Y | Experimenta l auction | consumer | |

Annex 6: Systematic literature review methods

SLR food safety interventions

Methods:

- A syntax was developed and tested for to see if the expected kind of publications could be found. Then using the syntax, CabDirect and PubMed was searched, and hits downloaded to Excel.

Inclusion criteria:

- Time line: 2000- 2017 (June); Studies in English; Includes an intervention aimed at improving food safety Includes evaluation on hazards or health impacts (the outcome studied should be either effect on health or on hazard occurrence); Study conducted in Africa

Exclusion criteria:

- Not related to food-borne hazards; Studies conducted only in laboratories; Studies only focusing on prevalence or risk factor analysis

Process:

- The initial search identified 3470 titles
- These were screened by two independent reviewers and 498 abstracts identified as relevant
- These were independently screened by two reviewers. In case of disagreement a third reviewer screened, and the majority decision held.
- As a result, 84 papers were identified. Full papers were obtained for all.
- On reading the full paper, another 17 were eliminated:
 - Five papers were interventions only aimed at improving water quality and these have been systematically reviewed by other authors
 - Five papers were descriptive with no intervention mentioned
 - For 2 papers the intervention was already described in another paper in the database (reflecting “piecemeal publication’ which is considered bad practice)
 - Two studies were reviews not descriptions of an intervention
 - One paper was a duplicate of another in the database
 - One paper described an intervention in India
 - One paper was a standard and not a paper
- This left 67 papers in the database. Although is relatively high for an SLR, we did not use strict criteria to exclude studies of weak design.