

EatSafe: Evidence and Action Towards Safe, Nutritious Food

Food Safety Education, Training, and Technology Interventions in Africa and Asia: A Review of Studies Relevant to Traditional Markets in Low Resource Settings

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This EatSafe report presents evidence that will help engage and empower consumers and market actors to better obtain safe nutritious food. It will be used to design and test consumer-centered food safety interventions in informal markets through the EatSafe program.

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ACRONYMS

Below is a list of all acronyms and abbreviations used in the report.

AFM1	Aflatoxin type M1
AFR	Africa Region
APTECA	Aflatoxin Proficiency Testing and Control in Africa
ASF	Animal Source Foods
BIS	Bureau of Indian Standards
BDS	Business Development Service
CCM	Community Counseling Meetings
CFU	Colony Forming Unit
DALYs	Disability Adjusted Life Years
EIA	Enzyme-linked Immunosorbent Assay
ELISA	Enzyme-Linked Immunosorbent assay
EMR	Eastern Mediterranean Region
FAO	Food and Agriculture Organization
FBD	Foodborne Disease(s)
FV	Fruits and Vegetables
FZT	Foodborne Zoonotic Trematodes
FHFS	Food Hygiene and Food Safety
FSEP	Food Safety Education Program
FSSR	Food Safety and Standards Regulations
FB1	Fumonisin group B1

H5N1	Highly Pathogenic Avian Influenza
HACCP	Hazard Analysis Critical Control Point
HDFSO	High Density Food Service Outlets
HDPE	High Density Polyethylene
HPLC	High Performance Liquid Chromatography
IEC	Information, Education, Communication
ILRI	International Livestock Research Institute
KAP	Knowledge, Attitude, Practices
LOD	Limit of Detection
LDFSO	Low Density Food Service Outlets
LMIC	Low- and Middle-income Countries
MLST	Multilocus Sequence Typing
PCR	Polymerase Chain Reaction
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Controlled Trial
SCO	Spot Check Observation
SEAR	South-East Asian Region
SLR	Systematic Literature Review
TPC	Thermoset Plastic Containers
TOT	Training of Trainers
TSOL18	Taenia Solium Vaccine
TTC	Thermotolerant coliform
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene
WHO	World Health Organization

EXECUTIVE SUMMARY

Unsafe food can have many health, nutrition, and livelihood implications, as documented by both the World Health Organization and the World Bank. Consumers experience economic impacts from foodborne diseases, including costs related to medical treatment and losses in productivity. Contaminated food is also a hindrance to trade, as food that fails to meet safety standards can be rejected by importers, with implications at the country level. In low- and middle-income countries, food safety risks are intensified by many factors, such as increasing urbanization, shifting agricultural production practices, expanding and complex food systems, together with the dominance of informal food businesses. Although the infrastructure to support delivery of safe food is weak in many of these countries, attention to food safety has been increasing.

Food safety interventions can target one or multiple value chains and may involve multiple actors such as farmers, traders, vendors, or consumers. Interventions may include the adoption of new risk reduction technologies, practices, or behaviors. EatSafe is focused on behavior change interventions shaped by consumer or vendor knowledge and/or attitudes that can lead to action, or remove obstacles preventing action.

In traditional markets, multiple interventions can play a role in improving food safety. This review describes recent food safety interventions implemented in selected countries in Asia and Africa, with focus on informal market settings and on consumers who buy food in informal/traditional markets. For Asia, a total of 4049 articles were screened, 50 selected for full review, and data extracted from 19 publications. For Africa, findings from a previous systematic literature review (SLR) on food safety interventions in Africa (2000-2017) were complemented by a new review of papers published in 2017-2020, for a total of 23 articles considered for full review and data extraction. Most studies identified general hygiene practices that are relevant to many different food commodities. A few studies focused on specific supply chains.

While the evidence on food safety interventions specific to traditional markets is limited, this review uncovers a broad and rich landscape of interventions, tools and approaches successfully implemented in the recent past. A larger number of studies involved community members, compared to food vendors or handlers. Interventions involving group trainings, using a variety of media, group interaction, and types of trainers, were most often reported across countries and audience categories. Training interventions often included equipment (e.g., cooking utensils) or infrastructure that enabled participants to implement better food safety practices. Interventions targeting community members focused on cultural acceptance, integration with daily routines, and participatory approaches. They also included a larger variety of training media, and more directly leveraged emotions and values, including those related to childcare. Most studies assessed changes in knowledge, attitudes, or behaviors, and only very few measured hazards or risk. Most studies reported positive outcomes over a relatively short time frame (a few months to a year), but long-term impacts were not monitored.

A synthesis of findings from the implemented interventions is provided in this report, with a focus on those most relevant for intervention design in traditional markets.

I. INTRODUCTION

Thought access to safe food is a basic human right, many people continue to suffer from foodborne illnesses worldwide. Using 2010 data, the World Health Organization (WHO) analyzed 31 foodborne disease hazards and found the disease burden of 33 million disability-adjusted life years (DALYs) to be similar to that of major diseases including malaria and tuberculosis (1). It is estimated that annually 600 million people became sick and 420,000 die from foodborne hazards.

The African Region (AFR), South-East Asia Region (SEAR) and Eastern Mediterranean Region (EMR) are affected most (1). Diarrheal disease is the most common form of foodborne illnesses and children under the age of 5 years are affected most when food is not safe (1) (2). The cost of unsafe food can be extremely high especially in countries where food safety is not a priority and infrastructure is not adequate. The World Bank provided an estimate of \$110 billion for low–and middle-income countries (LMICs) (3), which is likely an under estimate for countries where disease reporting is poor and data are unavailable.

Food handling at each stage of the supply chain influences the quality and safety of the food consumed. Foodborne hazards (chemical, biological, radiological, or physical) can enter food at many points: during transportation, storage, display; handling at the point of sale; at preparation and consumption (4). Some food hazards enter at one point of the food chain at low levels and grow to level that cause foodborne illnesses prior to consumption. Although interventions are needed to reduce the incidence of FBD, there is limited evidence on which interventions are effective, sustainable, and scalable (5).

Food safety interventions can take different forms (6) (7), be designed to target one or several value chains, and involve multiple actors. Interventions that have been implemented in LMICs have mainly focused on three stages of value chain levels - production, aggregation and household (8), though a combination of strategies is likely to be required to effectively address a single health problem. As an example, control of *T. solium* may be achieved by improved pig husbandry practices, vaccination of pigs, meat inspection, public education on hygiene and sanitation, and treatment of infected human carriers (9).

The EatSafe project is focused on improving the safety of foods sold through traditional markets, many of which are locally sourced. Low income and nutritionally vulnerable people often rely on food sold in traditional markets, as it is cheap and affordable for low income earners (10). A significant proportion of FBDs reportedly result from consumption of fresh foods that are sourced from informal markets (5).

Those markets are essential to ensure access to nutritious fresh foods. Animal sourced foods (ASF) and fruits and vegetables (FV) provide essential nutrients, both macro- and micro-nutrients (11). In addition to vitamins and minerals, fruits and vegetables (FV) also provide dietary fiber and phytochemicals that are essential for good health and wellbeing (12). Both ASF and FV are perishable products prone to contamination and can transmit important FBD pathogens (13). For other food categories, such as cereals and other staples, mycotoxins are the main challenge (14) (15) both for health, nutrition, and trade, especially in the tropics where climatic conditions favor their occurrence. Interventions to ensure quality and safety of food sold through these markets are urgently required.

Food handlers, including vendors at markets and consumers preparing food at home, can play a key role in both increasing or reducing food contamination, and hence interventions that target them have the potential to reduce risk. One common approach is training, which can take a broad range of formats including lectures, dissemination of materials, or practical demonstrations (16). Mass media is another powerful content delivery tool that can influence consumers and promote demand for safe food and best practices (17). Food safety behavior is influenced by several factors (18) implying that training on its own may not be adequate to improve food safety (19). Multisectoral approaches that layer, sequence and integrate interventions may be appropriate. New diagnostics for food testing are also becoming available and can be utilized in the verification of food safety interventions (5,20), although their cost and availability needs to match local resources.

The goal of this review is to compile and synthesize food safety interventions carried out from 2000 to 2020 in LMICs in Asia and Africa, with focus on settings relevant to EatSafe, i.e., food handlers and vendors in traditional informal markets, and consumers that may shop at those markets.

2. METHODOLOGY

Two reviews on food safety interventions were done, using slightly different methodology. The Asia review followed the established “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) guidelines. The Africa review started with papers identified in a previous SLR, and a further search identified papers published in recent years. Findings from both reviews are presented in this report. Both sought to address two questions:

- Which interventions have been used to support food safety in Asia / Africa?
- What effects did those interventions have?

2.1 Asia literature review

The SLR for Asia was based on criteria presented in Appendix 1 and was meant to identify food safety interventions implemented in the selected countries, relevant to the goals of the EatSafe project. Key words were defined and combined into a syntax (Appendix 2) that was used in the search. The focus was on selected low- and middle-income countries, also listed in the search criteria. An initial search (that included all countries in Asia) yielded a large number of papers; because of this, the search was refined to include a smaller number of countries, focusing on South and Southeast Asia and on low-income countries. Food safety interventions implemented in the period between 2000-2020 were considered. The exclusion criteria included interventions not related to foodborne hazards, studies conducted only in laboratories or research farms (on-farm trials), those focusing on prevalence or risk factor analysis, and the ones not implemented in the selected Asian countries. Street food vendors, while not usually under the management purview of markets, were included as successful interventions for this group could be applicable to market vendors. Searches were carried out using the CabDirect and PubMed databases.

The review was led by two people (reviewer 1 and 2) supported by a third reviewer (reviewer 3). For each database, the first stage was a download of titles and abstracts from search results and exporting the outputs to Mendeley - to first convert the files to "ris" format (from bibtex) and this was considered a necessary step before proceeding to Rayyan QCRI software (<https://rayyan.qcri.org/>). The files were uploaded from where duplicates were identified and removed. Screening of titles and abstracts was subsequently done. Reviewer 1 hosted the review while reviewer 2 was added as a collaborator, to independently screen the articles. Reviewer three was invited to monitor the screening process and respond to any questions raised by the primary reviewers. Areas of conflict were identified and resolved by reviewer 1 and 2. Reviewer 3 came in to address articles that the two could not agree on. Accepted abstracts were those judged as acceptable by at least two of the reviewers.

Full paper screening was aided by *Rayyan QCRI software*. Publications were sought, downloaded, and uploaded in the program, and independently reviewed by the two main reviewers. A reason was given for every excluded article. As for the abstracts, any discordance in decision was addressed by the third reviewer. For review papers, the reference section of review papers was analyzed with the aim of identifying relevant papers cited in the publications, and adding these where found, if they had not already been captured by the search. Accepted full publications were those judged as acceptable by at least two of the reviewers. As the list of the included and excluded papers was not long, it was possible for reviewer 3 to scan through the publications and confirm the decisions made, prior to data extraction.

2.2 Africa literature review

Dataset with findings from a previous SLR by ILRI was made available (7). These 67 papers were reviewed, and interventions thought to be relevant for EatSafe were identified. Among the excluded papers were those on assessing willingness to pay, complete WASH interventions that were focused on specific groups (e.g., pregnant women), and those implemented elsewhere in the value chain (farm, slaughter, etc.). A similar syntax was used to capture more recent papers (published in the 2017–2020-time window). An Excel® sheet with 2158 articles was generated. These included interventions involving vendors or implemented in market settings and at the community and household level. However, two interventions applied at the slaughter stage were included: one because the HACCP process was used, which is a tool that can also be promoted in markets and possibly homes, and one on meat inspection for *T. solium* cysticercosis, as it highlights the role of inspections, an intervention that has not been highlighted in studies targeting markets but has potential in these contexts.

2.3 Quality assessment

A subjective quality assessment criterion (applied by ILRI in previous food safety reviews) was used to determine suitability of studies for inclusion (Table 1). Papers were classified as having either good, medium, or poor quality. For the Asia review, quality assessment was carried out as a final step and this ensured that data were only extracted from publications perceived to be of either good or medium quality.

Table 1. Publication Quality Assessment Criteria

Good	Medium	Poor
Unbiased selection of subjects/samples (probabilistic sampling)	Biased sampling acknowledged and accounted for	No acknowledgement of biased sampling process
Methods are scientifically sound and accurately described	Limitations in data analysis are acknowledged and accounted for	Data analysis inappropriate for research question proposed
Data analysis judged to be appropriate for the research question	Some details on methods are lacking but methods are understandable and sound	Methods unclear or incomplete
Reported results are complete and appear to be valid	Reported results appear to be valid, although may not be fully complete	Reported results are incomplete or obviously inaccurate

2.4 Data extraction and analyses

An Excel® template designed for a previous Africa intervention review project was modified and used for the Asia review. It was pre-tested by first entering data from four publications.

Data extraction was done by two reviewers, and at the end, entries were combined into one database, and checked for completeness and any errors. A summary of the extracted data is given in Table 2. An Excel file with data from the previous SLR by ILRI (Africa) was provided. Papers relevant for EatSafe were identified and synthesized. A follow up search was applied to capture papers published after 2017. The Excel with the outputs of the search was screened by one reviewer and papers perceived to be relevant for EatSafe were identified, reviewed, and synthesized.

Table 2. Types of Information Extracted from most Relevant Articles in this Review

Variable name	Additional description
Paper description / details	<i>Paper ID, author, title, year of publication, year study was done</i>
Country where the study was done	<i>Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, Cambodia, Laos, Myanmar, Thailand, Vietnam, Brunei, Indonesia, Malaysia, Papa New Guinea, New Guinea, Philippines, Timor-Leste</i>
Did the intervention target specific value chains	<i>Yes, no</i>
If yes, which value chains	<i>Livestock, fish, cereals, vegetables, other</i>
Describe the intervention	<i>Description of what was done</i>
Hazard group addressed	<i>Biological, chemical</i>
Specific hazard	<i>Name of the hazard</i>
Study design	<i>RCT, before and after, with and without, adoption, review, conjoint, ex-ante, diagnostic validation</i>
Level where the intervention was applied	<i>Farm, transport, market/retail, processing, consumption, human population, product storage</i>
Sector of intervention	<i>Formal, informal</i>
Outcome measure used	<i>Knowledge, attitude, practice; Hazard level or presence; Indicator; Willingness to pay; Health; Compliance; Quality attribute; Infrastructure; Livelihoods; economic impact</i>
Health outcome observed	<i>Describe</i>
If self-reported	<i>Yes, no</i>
Sample size used	<i>Number</i>
If the intervention was successful	<i>Yes, no, partially (at least significance reported for one outcome), inconclusive</i>
Measure of success and confidence interval	<i>Number and CI estimate</i>
Quality of the paper	<i>Good, moderate, poor</i>

3. REVIEW FINDINGS

3.1 Description of reviewed papers (Asia)

The PRISMA chart with the number of papers included at each stage of the Asia review is shown in Figure 1. A summary of study features is presented, for each article on Asia reviewed, in Appendix 4. A total of 4049 abstracts were screened. From these, a total of 50 full papers were reviewed, and data extracted from 19 publications deemed most relevant. The number of papers with conflicts during screening, which required the help of the third reviewer was 14 and 2, for the abstract and full papers, respectively. A detailed list of articles whose full text was considered in the review is given as Appendix 2.

The papers (n=19) were published between 2004 and 2019 with the majority (68%, 13 of 19) being published between 2015-2020 i.e., the last 5 years (Figure 2). They present outputs from interventions implemented in Bangladesh (2), India (6), Indonesia (5), Malaysia (2), Nepal (1), Thailand (1) and Vietnam (2). Five papers (24%) considered interventions that targeted specific value chains, all ASF: fish in Vietnam, pigs in Thailand and Nepal, cattle and poultry in Indonesia. The main study designs adopted were “before and after” (52%, 10 of 19) and randomized controlled trials (15%, 3 of 19). The remaining five (33%) included quasi-experimental approaches, adoption assessments, and a microbial survey. Studied outcomes included changes in knowledge, attitudes, and practices (KAP) (57%), health outcomes (37%), and hazard occurrence in foods (10%). Five studies had outcomes related to human health, and in two of these health outcomes were self-reported. The most frequently reported intervention was training of food handlers (73%; 14 of 19). The other five included implementing new processes or technology.

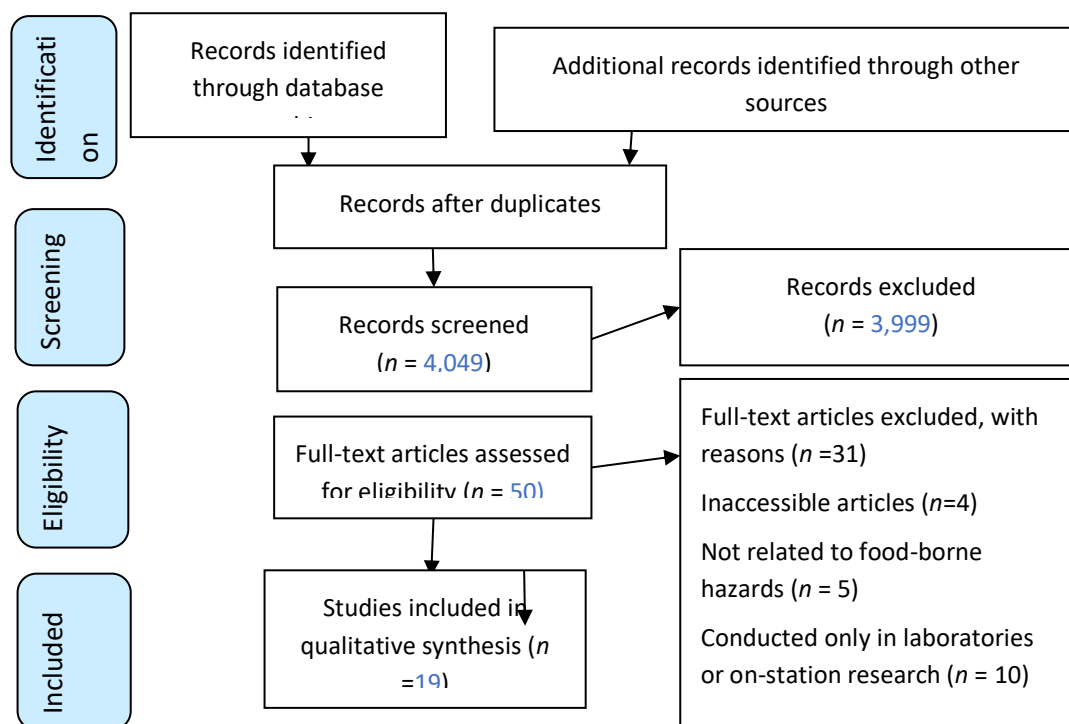


Figure 1. PRISMA Flow Chart for the Asia SLR

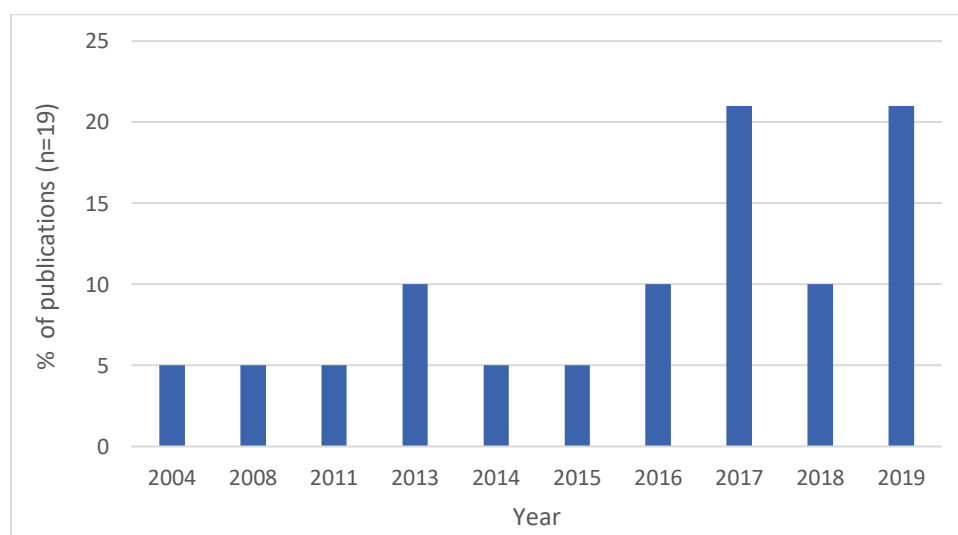


Figure 2. Number of Eligible Papers Considered in the Asia Review, 2000-2020

3.2 Description of reviewed papers (Africa)

This component was based on findings from a previous SLR prepared by ILRI that had papers published in the period 2000-2017 (7). This earlier review screened 3,470 titles, retained and screened 498 abstracts, identified 84 relevant papers, and retained 67. A further review was

done to capture articles published in 2017-2020. A summary of study features, for each article on Africa reviewed, is presented in Appendix 5.

The most relevant papers (n=23) were published between 2009 and 2020, the majority in the period between 2018-2020 (Figure 3). They presented outputs from interventions done in Burkina Faso (n=1), Egypt (2), Ethiopia (1), Ghana (2), Kenya (2), Malawi (5), Mali (1), Nigeria (2), South Africa (1), Tanzania (1), Uganda (1) and Zambia (1). Eight papers (33%) targeted specific supply chains: 3 livestock papers (all pigs), 3 cereal papers, and one paper on garri (cassava food). No article specifically targeting fresh fruits or vegetables was identified. The pig papers assessed interventions to control *Taenia solium* using education approaches. The cereal papers were on maize and all focused-on aflatoxins (trainings and detection method).

Review of data from the previous SLR (n=10) found training and awareness creation to be the most frequently reported interventions (50%), followed by new processes or practices (40%) and technology (10%). From the 2000-2017 SLR, only 15% (10 of 67) food safety intervention studies were in settings relevant to informal food markets or their consumers.

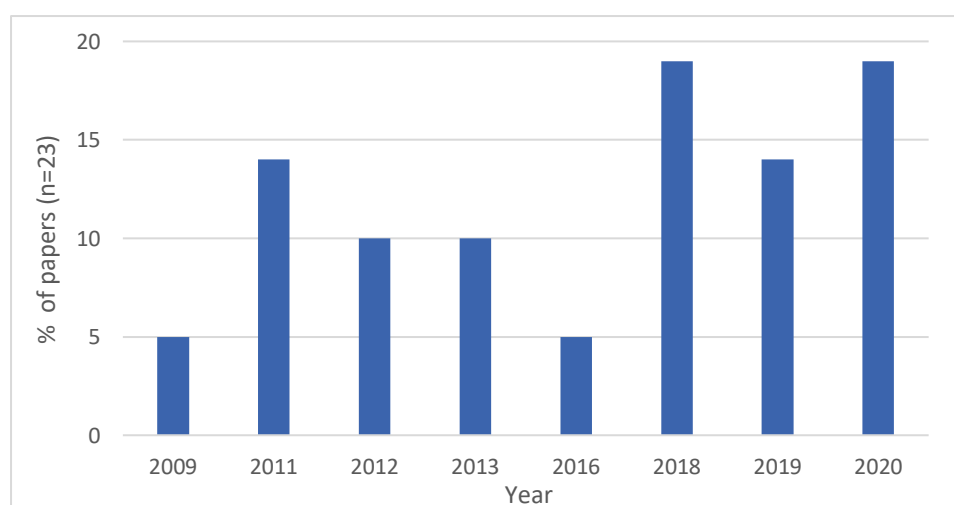


Figure 3. Number of Eligible Papers Considered in Africa Review, 2000-2020.

3.3 Synthesis of findings from the Asia review

3.3.1 Food safety interventions involving market operators (Asia)

A summary of the 3 studies, including the impact of interventions, is provided in Table 3. Additional study details are summarized in this section.

Riyanto et al. (21) studied street food vendors operating near schools in urban Southern Indonesia, where food poisoning cases had been reported in school children. Vendors in the intervention group, selected randomly, underwent an education program on food safety, each week for 20-30 minutes for a period of 6 months. Vendors were educated by a sanitarian officer on different topics including proper food processing, processing equipment, proper cooking, safe storage of food (at appropriate temperatures), safety of raw materials, and the

importance of not using expired ingredients. Food samples were examined for bacteriological and chemical contaminants to assess the impact of the intervention.

Samaan et al. (22) focused on the control of avian influenza in markets. This topic was included as several intervention measures could also be effective in controlling foodborne zoonotic pathogens in markets. Two live bird markets were considered over 18-month period. Intervention involved a combination of infrastructural improvement and behavior change to implement WHO guidelines for avian influenza control (23). Monthly 2-hour training sessions (18 sessions) addressed waste management and food safety, as well as detection of signs of H5N1 infection in birds and infection notification. Batch processing was the only WHO control measure (of the 10) practiced at the start. The guideline was customized to the local settings using participatory approaches. Changes in vendor knowledge, attitudes and behavior were assessed before and after the intervention.

Singh et al. (19) rated food vendors' hygiene and sanitation using a tool (a score-based questionnaire) informed by the Bureau of Indian Standards (BIS). The tool had 12 domains including raw materials, transportation, reception and storage of inputs, vending location, vending cart, utensils and cutting tools, hygiene practices, personal hygiene and habits, food preparation, cooking, handling and serving of food, disposal of waste, pest control and training on food safety. Health education was done in two phases, an initial phase that was implemented in two sessions of one-to-one counseling and was tailor-made to the needs of each vendor. Food safety posters were displayed in the second phase. Baseline and endline scores were computed for each vendor.

Two of these interventions were reported as fully successful. A significant number of street food vendors in urban Indonesia, studied by **Riyanto et al.** (21), had food that met standards for both bacteriology and chemical contaminants, after the training intervention. **Samaan et al.** (22) reported improvements in KAP following the intervention, which included a food safety component (e.g., using soap when cleaning chopping boards, knives, defeathering machines). Conversely, not all factors monitored by **Singh et al.** (19) significantly changed following the intervention. As indicated in Table 3, only the mean scores in the domains of personal habits, hygiene and food handling practices improved significantly after intervention ($p < 0.05$).

Table 3. Interventions Implemented at Vendor or Market Level (Asia)

First author	Study objective(s)	Findings from the study	Relevance to EatSafe
Riyanto (21)	Assess the efficacy of an <u>education program</u> to improve bacteriological and chemical safety of the food served by vendors around public schools	<ul style="list-style-type: none"> 70% of vendors in the intervention group had food that met bacteriological standards for coliform, <i>E. coli</i>, and total plate count at the end of the study, compared to 11% observed at the start (p=0.001). In the control 14% had safe food both pre- and post-the intervention For chemicals, after the intervention, 100% of the food samples were safe (no borax, formaldehyde, rhodamine B, or yellow methanol) compared to 70.4% at the start (p=0.008); 11% of controls were unsafe before and after 	<ul style="list-style-type: none"> Guidelines used to implement the training can be applied to training of other food handlers
Samaan (22)	Assess implementation of recommended <u>measures to control H5N1</u> in markets (infrastructural and behavioral)	<ul style="list-style-type: none"> Improvements in knowledge and attitude reported after intervention: awareness about H5N1 transmission (24% versus 62%); use of plastic aprons (15% versus 55%); cleaning cages daily (82% versus 100%); and using soap when cleaning chopping board, knives, defeathering machines (38% versus 62%) Correct identification of avian influenza signs post-intervention Majority of the vendors (86%; n=29) were satisfied with the intervention 	<ul style="list-style-type: none"> Similar practices are applicable to control other foodborne hazards Key role of markets in zoonotic disease transmission
Singh (19)	Assess the impact of <u>food safety training</u> on hygiene and sanitation practices of street vendors	<ul style="list-style-type: none"> No significant improvement in overall score of vendors (baseline and end line) Mean scores in the domains of personal habits, hygiene and food handling practices improved significantly after intervention (p<5%) 	<ul style="list-style-type: none"> Highlights the need to consider the role of contextual factors when implementing educational interventions

3.3.2 Food safety interventions implemented at household or community level (Asia)

A summary of the 11 studies selected for full review is provided in Table 4.

Several studies employed trainings or awareness-raising campaigns. For instance **Riaz et al.** (24) used Courtyard Counselling Meetings (CCM) to raise awareness about food safety. Information, Education and Communication (IEC) materials used in their information and training intervention included two leaflets, one flip chart, and two posters. Two workshops involving frontline health workers were done prior to the intervention. Participants were trained on food safety using the WHO five keys to safer food (25) and the WHO 10 golden rules for safer food preparation (26); and were issued with IEC materials. After the workshop, the workers were asked to include food safety messages in their regular CCM teaching. A total of 60 CCMs were done. IEC were distributed at each CCM and the study team ensured the dissemination was done. The impact of the intervention was assessed in terms of adequate knowledge and good practices, defined as correctly answering $\geq 60\%$ of knowledge items and good practice items.

The intervention by **Takanashi et al.** (27) targeted caregivers of children aged 6 months to 4 years. They assessed changes in childhood diarrhea prevalence, IEC coverage, and food safety behaviors over a two-year period. Food Hygiene and Food Safety (FHFS) messages were provided through five IEC channels that included workshops, newsletters, loudspeaker announcements, bulletin boards, and flip chart communication. Two evaluations were done. A program to sustain the IEC activities and caregivers' FHFS behaviors following the program period was also designed. This study provides an example of how intervention on adult caregivers can result in FBD reduction in children.

Community workers can be instrumental in the success of interventions employing information campaigns or trainings. For example, **Sheth and Obrah** (28) worked with mothers of children aged 6-24 months, through an intervention implemented through trained Anganwadi (community) workers. Three food safety messages were considered: washing of hands with soap and water, avoiding feeding of leftover foods, and keeping the surrounding areas clean. Lectures, slogans, posters, charts, flash cards, and role-play were used. Diarrhea profile in children, KAPs, and presence of enterococci in hand rinse water samples was determined.

Food safety interventions can also involve children directly. **Sesanelvira et al.** (29) describes an intervention where food safety education was given to school-age children using the mind map approach. The intervention was delivered in three stages: stage 1 (introduction); stage 2- (reading booklet, providing A3 paper, pens, markers, colored pencils, and picture paper, explaining the mind map technique, and making a mind map); and stage 3 which evaluated the results of the mind map picture approach. In another study by **Riyanto et al.** (30) involving elementary school children in urban West Java, Indonesia, students were given 10 kinds of book covers (to cover 10 books- math, science, social, civic, Sundanese, art and culture, sport, English, and Moslem religion). The covers had content on food safety. Education was given every week. Videos were taken from official site of Indonesia National Agency of Drug and

Food Control and included content on getting to know safe street food; purchasing safe street food; reading street food packaging labels; and learning about foodborne diseases.

The established HACCP risk management system was used, as part of a training, in a study by **Islam et al.** (31), which focused on applying a Hazard Analysis Critical Control Point (HACCP) protocol to identify intervention points and reduce fecal bacteria in weaning foods. The intervention was a four-week training of mothers on how to apply HACCP; resulting recommendations included were to wash their hands with safe water and soap in critical times, use of safe water to wash utensils and prepare food, cook and reheat foods until boiling; and covering food during storage. Levels of contamination were determined before and after the intervention.

Interventions targeting zoonotic diseases could leverage motivators to improve both human health as well as animal health, and hence livelihood. **Takeuchi** (32) carried out a food safety campaign that was focused on the zoonotic pathogen *Streptococcus suis*. A *S. suis* surveillance network was used to enroll patients into the study. Trained healthcare volunteers were expected to take the training to residents in the villages. Campaign materials included pamphlets (pathogen transmission and control practices); public display banners (that depicted the former minister of the Ministry of Public Health in Thailand explaining the health effects associated with consuming raw pork products); and posters (that explained the pathogen transmission route and major symptoms of the disease). The pamphlets were distributed to health-care volunteers and to the local residents while the banners were displayed at district and municipality offices, retail markets, schools, and some villages. The incidence of the disease was determined before and after the educational intervention.

Community-level intervention can also involve pharmaceutical treatment. For example, **Lier et al.** (33) followed a cohort of 396 people with a history of consuming raw fish. At baseline, they took stool samples and examined them for presence of trematode eggs. The intervention was a preventive chemotherapy dose of the drug praziquantel. Stools were sampled 2, 16, 29, and 60 weeks after the intervention. In a different study by **Poudel et al.** (34), the intervention sought to control *Taenia solium*, a zoonotic helminth, by vaccinating pigs with the TSOL18 recombinant vaccine in combination with an oral treatment with oxfendazole. The study had a duration of 12 months. The prevalence of porcine cysticercosis was determined in a random sample of slaughter-age pigs. Postmortem assessments were undertaken both at the start and at the end of the intervention.

While set in school canteens and not households, a study by **Nik Rosmawati et al.** (35) studied food handlers working in school canteens in Malaysia. It was a 2-year food safety education program that included: the role of food handlers and food managers in preventing food poisoning (60 min), simple measures to prevent foodborne diseases (50 min), and the hand washing procedure (85 min). Training on these topics was shared in three sessions, offered over the weekend. Hand washing practices were assessed at baseline, 6-weeks, and 12-weeks after the intervention.

Information that vendors or consumers receive, regarding how food is processed before it reaches the market, can also be leveraged in interventions. As an example, **Warhana and**

Diyantoro (36) analyzed meat samples from 10 beef slaughterhouses practicing halal slaughter, and determined the impact of halal practices on bacterial loads in the meat. While impacts at market or consumer level were not covered in this study, this study highlights the point that in addition to technical effectiveness, clear and reliable knowledge that effective food safety practices are implemented can help consumer chose safer food at the market and can help vendors select safer suppliers. Established and trusted cultural or religious practices, such as halal or kosher protocols, can be leveraged to build trust in safer supply chains and in vendors that use practices trusted by consumers for cultural reasons.

All the 11 studies reported intervention success, except one by **Lier** (33) which reported high re-infection rates following the chemotherapy intervention. **Riaz et al.** (24) reported significant changes in mean knowledge and practice scores. Studies by **Sheth et al.** (28) and **Takanashi et al.** (27) reported reduced cases of reported diarrhea in children and changes in KAP. The intervention by **Takeuchi** and colleagues (32) led to a reduction in the incidence of *S. suis* infection in a community in Thailand. No infection was found after vaccinating pigs with TSOL18 vaccine in the study by **Poudel et al.** (34). The mind map method used in the intervention by **Sesanelvira et al.** (29) resulted to significant changes in knowledge, attitude and skills of the studied children. KAP significantly improved following a six month education program involving elementary school children (30). Better hand washing practices were reported by **Nik Rosmawati et al.** (35). Weaning foods analyzed by **Islam et al.** (31) were of better quality following the training of mothers taking care of 6-18 month old children.

Table 4. Interventions Implemented at Household or Community Level (Asia)

First author	Study objective(s)	Findings from the study	Relevance to EatSafe project
Riaz (24)	Assess the role of courtyard counselling meeting (CCM) in improving household food safety knowledge and practices among household food handlers in Bangladesh	<ul style="list-style-type: none"> • Improved practices: mean knowledge before was 23.7 (± 5.7) and 25.6(± 5.3) after (difference of 1.6) • Practices where significant changes were reported following the intervention included hand washing before eating, after handling fish, meat after cooking food; drying hands after wash with clean clothes; cleaning utensils with soap and water, drying by clean clothes; cleanliness of kitchen and waste disposal; use of separate knife for cutting raw meat, fish, vegetables; eating within 2 hours of preparing food; wash hands with soap before meal by all family; washing raw fruits and vegetables • Improved knowledge: 20.5 (± 3.4) and 22.1(± 3.9) (by a difference of 1.9) • Adequate score on knowledge (before 55%; after 70%), good practices (30% vs. 47%) 	<ul style="list-style-type: none"> • Study highlights that food safety measures can be embedded into ongoing work (e.g., health CCMs in Bangladesh) • The training was based on WHO 5 keys to food safety
Sheth and Obrah (28)	Assess the impact of food safety <u>training</u> on KAP of mothers on safe feeding and reduction of diarrhea in children aged 6-24 months	<ul style="list-style-type: none"> • Reduction in the number of children with diarrhea (92% - 39.5%) • Total reduction in diarrhea incidence of 52% • Poor rating of environmental sanitation reduced from 50-14% • Personal hygiene of mothers • Enterococci (from 90% to 25%) • Severity of diarrheas reduced from 24%-19% 	<ul style="list-style-type: none"> • Yes, capacity building of health personal and engaging them to implement food safety education at the community level

		<ul style="list-style-type: none"> • KAP scored differences, pre- and post-intervention – for diarrhea, sanitation, hygiene, feeding practices 	
Takanashi (27)	Assess the long-term impact of a <u>community-based education program</u> on food hygiene and food safety (FHFS) behaviors of caregivers of children aged 6 months – 4 years	<ul style="list-style-type: none"> • Reduction in childhood diarrhea [baseline (21.6%), first evaluation (7.6%) and second evaluation (5.9%)] • Improvement in food hygiene and food safety behaviors (11 of the 17 behaviors measured by second evaluation) • Handwashing after visiting toilet significantly improved– 22% to 33% (first evaluation) and to 53% in third evaluation • Flip chart communication administered by community groups was identified to be the most effective IEC channel for effecting behavior change (P = 0.018) 	<ul style="list-style-type: none"> • Community based information, education, and communication initiative • Providence of variables that were improved after both the first and second evaluation
Takeuchi (32)	Evaluate the effect of a <u>training campaign</u> on <i>Streptococcus suis</i> on the incidence of the disease in humans in Thailand	<ul style="list-style-type: none"> • Reduction in the number of cases (13 in 2011 and 10 in 2012) • Reduction in the annual incidence/person (6.4/100,000 in 2010; 2.7/100,000 in 2011; 2.0/100,000 in 2012) • A significant increase in the proportion of serotype 2 strains and a significant decrease of serotype 14 strains after the food safety campaign • In MLST analysis, ST105-infected cases decreased after the campaign 	<ul style="list-style-type: none"> • Engaged the community in the control of <i>Streptococcus suis</i> which is an important zoonotic foodborne pathogen • Education strategy used can also be apply to campaigns meant to address other infections
Lier (33)	Investigate the effectiveness of <u>preventive chemotherapy</u> to control fishborne zoonotic trematodes (FZT) in Northern Vietnam (an endemic area)	<ul style="list-style-type: none"> • High rates of re-infection observed • Prevalence before chemotherapy was 40.2%; it was 2.3 (2 weeks post), 10.9% (16 weeks), 18.2% (29 weeks) and 29.8% (60 weeks) 	<ul style="list-style-type: none"> • Foodborne zoonotic trematodes are important for public health

			<ul style="list-style-type: none"> No evidence was found to support the effectiveness of this preventive chemotherapy intervention
Poudel (34)	Assess the impact of a 3-monthly pig <u>vaccination</u> and treatment program on <i>T. solium</i> transmission in pigs in Banke District of Nepal	<ul style="list-style-type: none"> At the start, the prevalence of porcine cysticercosis was 23.6% (control) and 34.5% (intervention) No significant change was observed in the control after the intervention No infection was detected in animals from the intervention area 	<ul style="list-style-type: none"> The intervention was applied at the production (farm) level Vaccination is one strategy of mitigating the risk but there are options Use of latrines and hygiene on food hygiene can apply at market and consumer levels
Sesanelvira (29)	Measure the effect of <u>mind map interventions</u> on improving food safety behavior in school-age children	<ul style="list-style-type: none"> Significant difference in knowledge, attitude, and skills before and after the intervention Pooled results showed significant differences between the control and treatment groups; intervention (control) knowledge 13.39 (6.57), attitude: 37.5 (25.2), skills 9.2 (4.95) 	<ul style="list-style-type: none"> Mind map approach was successful in increasing both knowledge and skills of school-aged children Behavior change interventions in children may positively impact their household
Riyanto (30)	Assess the use of <u>book covers and videos</u> to improve knowledge, attitude, and practice of street food safety of elementary school students	<ul style="list-style-type: none"> Book covers explained once a week, videos shown 3 times over 6 months Knowledge improvement from 5.4% (pre intervention) to 91.1% (post intervention) Attitude from 69.6% (pre intervention) to 97.3% (post intervention) Practice from 21.4% (pre intervention) to 59.8% (post intervention) All differences statistically significant 	<ul style="list-style-type: none"> Demonstrated use of videos and visual materials targeting children Knowledge, attitudes, and practices were monitored, and significantly improved after intervention
Nik Rosmawati (35)	Assess the effectiveness of a newly developed food safety <u>education</u> to improve the handwashing practices of food handlers in school canteens	<ul style="list-style-type: none"> The trained food handlers practiced better handwashing 4-weeks after the FSEP compared to the baseline A significant increase in the total observed handwashing practices (baseline value of 29% to 50.8% at Post1) 	<ul style="list-style-type: none"> Indirectly, as study involved food handlers in schools Content used can be considered for use in other settings, e.g., training in markets and for consumers

Wardhana (36)	Effect of <u>halal slaughtering</u> on beef meat safety; potential impact of testing information	<ul style="list-style-type: none"> All the city slaughterhouses had an average total bacterial plate counts (TPC) lower than 1×10^6 CFU/g (the acceptable limit) 	<ul style="list-style-type: none"> Indirectly, as the intervention was at slaughterhouses It can impact vendors: knowing that halal-handled meat has contamination levels within acceptable limits can help butchers select safer products Information on contamination levels may encourage selling and consuming product that has been inspected (regardless of the approach used)
Islam (31)	Measure the impact of a <u>training</u> of mothers (on avoidance contamination of weaning food during storage and feeding) on contamination levels	<ul style="list-style-type: none"> Significant reduction ($p < 0.001$) in contamination levels following the intervention: faecal coliforms (1.84 log₁₀ to 0.10 log₁₀) and faecal streptococci (from 1.92 log₁₀ to 0.09 log₁₀ cfu/g) 	<ul style="list-style-type: none"> HACCP is a recognized food safety management system that can be applied in food safety training in LMICs It is applicable to vendors operating in markets, and markets as a whole

3.3.3 Food safety interventions implemented in healthcare or hospital settings (Asia)

A summary of the 5 studies reviewed is provided in Table 5.

While food handling in healthcare settings is clearly different than at food markets, this context was included in the Asia review since content and delivery approaches for some interventions could be applicable to market or consumer settings.

Knowledge sharing or training using a range of media was a common intervention among the studies reviewed, sometime accompanied by the provision of hygiene tools or supplies. For example, **Deneja et al.** (37) studied food handlers (n=270) working in a tertiary care hospital in India. The intervention package included a self-instructional manual, a short sensitization film, and a short documentary on safe food practice. A final survey was done after two months. The intervention package in the study by **Bhattacharya** and colleagues (38) included a video-based interactive training, booklet to educate food handlers, as well as the provision of items to support personal hygiene (soap, nail cutters), display of expected behaviors (do's and don'ts), and promotion of zero-tolerance activities (including long hair, long nail, dirty hairs). The study by **Malhotra and Lal** (39) was implemented in a medical college facility in Delhi, India. The intervention followed a baseline KAP survey and included a health education plan using a flip chart and two posters.

One study by **Dudeja and Singh** (40) leveraged existing standards and used sanitary inspections as an intervention tool. In a tertiary care hospital setting, the conformity of eating establishments to India's Food Safety and Standard's regulations (FSSR) were assessed by visiting the establishments each month. Corrective actions were provided, where required.

As an example of food safety technology intervention, **Siagian et al.** (41) analyzed the effects of irradiating foods (fish, red meat, and chicken) eaten by a sample of immuno-compromised individuals randomized into three groups, each receiving a different kind of food over a 21-day period. The control group received regular foods from National Narcotic Board kitchen, a second group received unirradiated food, and a third group received irradiated foods. General health metrics were tracked as outcome. While this particular technology is likely not applicable to food sold in traditional market settings at this time, it provides an example of a purely technical intervention. Such interventions need to be tested for appropriateness and user acceptance in the target context.

Table 5. Food Safety Interventions Implemented in Healthcare or Hospital Setting (Asia)

First author	Study objective(s)	Findings from the study	Relevance to EatSafe project
Dudeja (37)	Assess effectiveness of <u>food handler training</u> on their KAP of in a hospital establishment	<ul style="list-style-type: none"> • Significant differences in mean scores pre/ post intervention for both knowledge and practices • Food handlers were found to have satisfactory knowledge and practice following the intervention • Median scores for attitude were significantly higher post-intervention 	<ul style="list-style-type: none"> • The educational package can be used in capacity building on food safety elsewhere. Some food outlets serving hospital employees may be open to the public (especially in urban areas)
Bhattacharya (38)	Assess impact of a <u>video-based educational intervention</u> and <u>administrative measures</u> on improving hygiene of food handlers in hospitals	<ul style="list-style-type: none"> • Hygiene scores increased – from a mean of 23.76 (score -1), to 34.04 (score -2) and 42.57 (score-3). • The scores were found to be influenced by state (of the food handler), education level, and previous work experience 	<ul style="list-style-type: none"> • Combination of different approaches • Video component with “do`s” - and “don’ts” and zero tolerance for certain behaviors
Dudeja (40)	Assess role of sanitary <u>inspections</u> on food safety in hospital settings	<ul style="list-style-type: none"> • Significant change in scores post- intervention 	<ul style="list-style-type: none"> • How regular inspection can lead to improved food safety
Malhotra (39)	Assess effect of a <u>health education</u> on food handlers’ KAP in a training facility	<ul style="list-style-type: none"> • Improvements in knowledge (diseases, measures to control), attitude - significant positive change for aprons, covering head, not keeping raw and cooked food in contact, and practices (hand washing, use of soap at the workplace) 	<ul style="list-style-type: none"> • Involved food handlers in a medical college facility; approach and tool used can be relevant to markets • Some facilities may be involved in offering short term health training (to food handlers) and can serve as good examples
Siagian (41)	Analyze effects of <u>irradiation</u> on ready to eat foods	<ul style="list-style-type: none"> • Increases in serum albumin in group 3 (irradiated foods) between pre- and post-treatment • Lymphocyte count was maintained • No effect of intervention on Body mass index 	<ul style="list-style-type: none"> • Irradiation is a technological option for sterilizing food • May not be appropriate in low-resource settings

3.4 Synthesis of findings from the Africa review

The dataset from the previous SLR conducted by ILRI included a total of 67 publications. We reviewed these and found 10 to be relevant for the EatSafe project; these 10 articles are synthesized here. The comprehensive results from the past review are described in the report by Grace et al. (7). A follow up search identified additional 13 papers that were deemed relevant and included in the full-content review. Hence, a total of 23 articles were considered in detail in this review: 8 targeting market operators, and 15 involving community or household interventions.

3.4.1 Food safety interventions involving market operators (Africa)

A summary of the 8 papers involving market operators is provided in Table 6.

Several interventions involved education or capacity building. For example, an intervention where vendors were trained using the WHO keys of safer food is described by **Donkor et al.** (42). The “Five keys to food safety” tool developed by the WHO in 2001 and used widely to support training on food safety (25,43) was used in this training. The five messages included in the tool are: (1) keep clean; (2) separate raw and cooked; (3) cook thoroughly; (4) keep food at safe temperatures; and (5) use safe water and raw materials (43). In addition to the WHO five keys, vendors were given lessons on several other topics including food and personal hygiene, environment and food safety, transmission and transmission of foodborne infections, and economics of food safety. The training was interactive. In the study by **Latif et al.** (44) a random sample of food handlers presenting for their annual health screening was selected. They were visited at their place of work for environmental sanitation & practice assessment. Comparisons were done before and after the educational intervention. In a study in Ghana by **Ababio et al.** (45), 68 personnel working in the food industry received training on several topics including food hygiene, personal hygiene, food legislation and how it affects the food handler, and “fitness at work” based on International Food Standards. Methods used included lectures, discussions, and demonstrations.

Several interventions involved the use of technology or infrastructure, often in conjunction with training components. **Ogugbue and Obi** (46) assessed the bioburden of garri, a staple flour prepared from cassava and popular in West Africa, stored in different packaging materials and under tropical market conditions in West Africa. Samples were taken and stored in four different bags: burlap bags, high density polyethylene (HDPE) thermoplastic bags, low density polyethylene (LDPE) thermoplastic bags and thermoset plastic containers (TPC). They were kept under market sheds at ambient temperature ($28\pm 2^{\circ}\text{C}$) for 60 days. In another intervention studied by **Heilman et al.**, an insecticide treated net (ZeroFly[®]) was put on pork outlets (windows and doors) (47). The product is a 100% polyethylene and contains 270–280 mg deltamethrin per square meter. The outlets were monitored for fly abundance using non-attractant sticky traps. In a different project to improve safety of street foods in Ghana by **Tortoe et al.** (48), vendors were trained on improved methods of cooking, food safety and

management. Evaluation of the training is mentioned but the article does not detail the findings. An intervention reported by **Olumakaiye and Bakare** (49) focused on sellers of street foods (High Density Food Service Outlets, HDFSO) and fast foods (Low Density Food Service Outlets, LDFSO). A 3-day food safety workshop was organized, and Spot Check Observation (SCO) visits were done, during which the overall cleanliness of the environment was scored.

Some interventions included technology to detect or measure foodborne hazards. For example, **Wacoo et al.** (50) studied the feasibility of a novel on-site detection method, that was used to test aflatoxin in maize flour at markets and households in Uganda. Controls included testing random samples using both HPLC (n=15) and ELISA approaches (n=30). On-site testing can be a powerful tool to provide specific and -in some cases- real-time feedback to consumers about the contamination status of the food they are buying. While most studies on food testing approaches are implemented in government laboratories or at production or processing stages in the formal sector (e.g. proficiency testing studies for aflatoxin in maize in Kenya, (51)), simpler and portable methods exist that can make testing possible in markets, albeit likely not routinely. This study (50) highlights the potential role of testing, and of communicating testing results, as a promising tool for market interventions to foster supply chain transparency and empower supply chain actors to preferentially choose safer food, as well as safer vendors or producers.

All 8 studies were successful. **Donkor et al.** (42) reported that 67.6% had acquired some knowledge and were putting it into practice. According to the authors, 42% of the vendors had shared with other people the knowledge they had acquired from the training. **Latif et al.** (44) reported significant knowledge and practice differences before and after the educational intervention. **Ababio et al.** (45) reported increases on knowledge among the trained food handlers (the modal mark reportedly moved from 60-69.99% to 70-79.99%). **Ogugbue et al.** (46) were able to identify the best packaging bag out of the various types tested, for garri. **Heilmann et al.** (47) reported decreases in fly burden in pork butcheries following the use of insecticide-treated netting materials as intervention. **Olumakaiye and Bakare** (49) reported improvement in cleanliness following the training of food vendors. Findings from the aflatoxin testing tool developed by **Wacoo et al.** (50) were highly correlated with those obtained when HPLC and ELISA tests were used. However, outcomes are not reported in **Tortoe et al.** (48) with sufficient detail to assess the effectiveness of interventions.

Table 6. Interventions Implemented at Vendor or Market Level (Africa)

First author	Study objective(s)	Findings from the study	Relevance to the EatSafe project
Donkor (42)	Provide <u>training on the WHO five keys</u> to safer food, to improve the safety of street foods	<ul style="list-style-type: none"> • Handwashing before food preparation (57% pre-training and 100% post-training); and refrigeration of stored food (45% that did not refrigerate food pre-training compared to 3% post-training) • High percentage of participants applied good practices after intervention: reheating of stored food (59%), sharing training experience with others (48%) and knowledge acquisition (67%) (determined only after the training) 	<ul style="list-style-type: none"> • Intervention involved street food vendors (some KAPs can be similar to market vendors) • The WHO keys to food safety is a recognized tool that can be utilized in food safety capacity building in various settings (25)
Latif (44)	Examine the impact of a food safety knowledge <u>educational program</u> on food handlers' knowledge and practice	<ul style="list-style-type: none"> • Significant knowledge differences pre- and post-educational program intervention (sub-scores: utensils and equipment, personal hygiene, food handling process, total knowledge) • Significant practice differences pre- and post-educational program intervention (sub-scores: cleaning and waste disposal, pest control, cleaning and sanitation of food utensils, personal hygiene, food handling, food cooking, and total practice) 	<ul style="list-style-type: none"> • Yes, as the study involved food handlers (sampled as they visited a health facility for screening as required by authorities) • Specifics of what the training included is not well detailed • Lack of food safety equipment identified as major hindrance
Ababio (45)	Assess the impact of food hygiene <u>training</u> on the performance of food handlers in Ghana	<ul style="list-style-type: none"> • It is reported that their understanding and knowledge increased after the training 	<ul style="list-style-type: none"> • Yes, as the study involved food handlers (but no details on the specific categories of those exposed to the training)
Ogugbue (46)	Assess the impact of <u>packaging</u> on microbial content of Garri stored under tropical market conditions	<ul style="list-style-type: none"> • Highlights the importance of packaging (as opposed to open retailing of the product) • HDPE bags were found to be the best for garri packaging in markets as it showed the best microbial stability in stored product and minimal increase in moisture content 	<ul style="list-style-type: none"> • Technological option that can be used to protect some products at markets, for food safety and reduced postharvest losses
Heilmann (47)	Investigate the impact of a novel application of <u>insecticide-treated nets</u> (ZeroFly®) to	<ul style="list-style-type: none"> • Using nets in butcheries resulted in a significant reduction in the number of flies 	<ul style="list-style-type: none"> • Intervention engaged with butchers operating in a city setting. A similar intervention could be adapted for use by

	reduce flies in pork outlets in Kampala, Uganda	<ul style="list-style-type: none"> The net insecticidal activity slightly decreased over time but maintained its effectiveness over the 3-month observation period 	<p>sellers of other meats and fish, as well as RTE foods</p> <ul style="list-style-type: none"> Flies can transmit important food pathogen including drug resistant ones (52) Avoiding flies in meat improves its quality and prolongs shelf life
Tortoe (48)	Improve food safety in street-vended food in Ghana via comprehensive <u>training</u>	<ul style="list-style-type: none"> The project developed nine modules for the systematic management and control of food safety for the street-food vending sector in Ghana Modules included partnership, training of food vendors and regulators, improving consumer awareness, improving street food vendor livelihoods, infrastructure requirements, food safety, food inspection, legal requirements and the supply chain management Participatory development of training materials 	<ul style="list-style-type: none"> Nine modules can provide content applicable to traditional markets Findings not sufficiently detailed “On-spot” workshops were held where vendors work (e.g., markets, street corners, truck stops)
Olumakaiyo (49)	Investigate the impact of <u>training</u> of food providers on environmental conditions of food service outlets	<ul style="list-style-type: none"> Significant differences (in the environmental hygiene) between HDFSO (street foods) and LDFSO (fast food) After the training, increase in mean scores (for cleanliness of the environment), from 2.93 to 4.22 (HDFSO) and 4.32 to 5.41 (for LDFSO) 	<ul style="list-style-type: none"> Intervention involved street and fast-food sellers Scoring of the environment where food is sold may also be applied in informal markets
Wacoo (50)	Feasibility of a novel on-site <u>detection method</u> for aflatoxin in maize flour from markets and households	<ul style="list-style-type: none"> A limit of detection (LOD) of 0.7 µg/kg was reported: correlation coefficient of 0.94 (HPLC) and 0.98 (ELISA) Samples from markets had mean total aflatoxin concentration of 7.6 ± 2.3 µg/kg 	<ul style="list-style-type: none"> Innovations that facilitate food testing at market level would make it possible to remove unsafe product from the food supply chain or drive improvements

3.4.2 Food safety interventions implemented at household or community level (Africa)

A summary of the 15 studies reviewed is provided in Table 7.

Several interventions focused on training and education were found to positively impact food safety knowledge and practices. **Carabin et al.** (53) carried out a cluster randomized trial aimed at improving knowledge of *Taenia solium* transmission. The PRECEDE-PROCEED (54,55) implementation framework was used in the project. A 52-minute movie and comic book were developed and discussed in the villages. The primary outcome used to measure impacts was active cysticercosis, and construction of a new latrine or pig pens was the secondary outcome. **Chidziwisano et al.** (56) sought to improve complementary food hygiene practices in Malawi. The study targeted food hygiene behaviors including handwashing with soap at key times, washing kitchen utensils with soap, keeping kitchen utensils in a safe place, reheating of leftover food, and feeding of children by caregivers. The intervention was delivered over 9 months through group and household visits. Demonstrations, games, rewards, and songs were used. Trained women volunteers facilitated the work. Education sessions in the study by **Hobbs et al.** (57) included descriptions of *T. solium* life cycle and its transmission, and utilized visual aids including a large poster of the life cycle, a five-meter long ribbon to represent the adult tapeworm, and life-sized plasticine models of human stool demonstrating expelled tapeworm proglottids. Large color posters of the parasite's life cycle were permanently displayed at rural health centers. The final component was workshops in primary schools using the 'The Vicious Worm' computer program. A follow up session was arranged.

Some studies used a more active and participatory approach to trainings. For instance, the intervention by **Morse et al.** (58) was delivered through community-level open days, cluster meetings, and household visits. Cluster meetings included practical exercises, demonstrations, games, and celebrations of success. The primary outcome was self-reported diarrheal disease while the secondary one was respiratory infections. A food hygiene intervention (i.e., food hygiene and handwashing over 22 weeks, treatment 1, n=400) was compared to a longer food hygiene and water, sanitation, and hygiene intervention (i.e., food hygiene, handwashing, faeces management, and water management training over 31 weeks, treatment 2, n=400).

Some interventions took the approach of training mothers, in order to improve the safety of food for children. An intervention targeting mothers is described by **Toure et al** (59). It involved implementing a HACCP approach as the key content of a training intervention involving the preparation of two common weaning foods (moni and fish soup). The HACCP approach was used to develop simple hygiene measures which mothers could take in preparing and serving foods to their children, to prevent contamination. **Seetha et al.** (60) carried out a randomized control trial in Malawi and involved training of mothers on

appropriate complementary feeding, water, sanitation and hygiene (WASH) practices, and aflatoxin contamination in food (use of good quality grains, postharvest handling etc.). The training took 21 days during which information on disease incidences and food acceptability was collected every day and anthropometric measurements registered on day 7, day 14 and day 21. The training was held in a central place in the community, and mothers and their children attended. A similar study carried out in Dodoma region, Central Tanzania, by **Anitha et al.** (61) involved mothers with children aged 6- 24 months. Urine samples were collected from children during the baseline and endline for aflatoxin M1 (AFM1) quantification. The project implemented a 21-day intensive learning-by-doing process using a Positive Deviance approach (62,63) to deliver training on diversified food consumption, aflatoxin mitigation, and hygiene practices. The intervention was delivered by the community nutrition extension staff, health staff, and project scientists. The hygiene component emphasized boiling of cooking and drinking water, washing vessels before cooking, washing of hands (after visit to toilet, before cooking and feeding), and cleanliness of the food preparation environment.

Several interventions combined a training component together with the provision of relevant “hardware” tools or infrastructure. For example, the study by **Gizaw and Addisu** (64) was an uncontrolled before-and-after intervention study implemented in rural Dembiya, northwest Ethiopia. The intervention involved a health education intervention that was delivered to school children and rural communities. Sessions were interactive and included the use role-plays, demonstrations, group discussions, songs, games, question and answer, and lectures. Hand washing facilities were built in all schools using locally available materials. Leaflets were disseminated. A WASH committee was established to facilitate the training and for the handing over at the end of the project, also highlighting the importance of community involvement and buy-in in support of long-term adoption of improved practices.

Using different tools in combination with training, a study by **Slayton et al.** (65) engaged with mothers from households with children aged less than two years. Mothers received a demonstration on proper hand washing and were issued with antimicrobial hand towels which they were to use to dry their hands after handwashing. Hand rinse samples and towels were tested for *E. coli*. This intervention involved consumers at home; however, the use of towels could be considered for interventions targeting market vendors. In another study involving towels, **Kim et al.** (66) carried out two cross-over trials to determine *E.coli* levels found in mothers of children less than 2 years. One trial (trial 1) involved assigning mothers to use either an antimicrobial-treated towel or a placebo, and in the other (trial 2), the authors compared *E. coli* contamination associated with three different handwashing/drying procedures: soap and water plus treated towel, water only plus treated towel, and soap and water plus air dry. Neither study involving towels were able to establish evidence for the positive impact of the intervention.

Other studies provided cooking tools or hygiene items in conjunction with communications on best practices. A study carried out in Kenya, **Simiyu et al.** (67) used a “Trials of Improved

Practices (TIPs) methodology to design a food hygiene intervention in a group of caregivers of children. The intervention package included issuance of household items (“hardware”) and a behavior change communication campaign (“messaging”) that was designed to motivate adherence of target food hygiene behaviors. The hardware components included: 1) two shallow storage containers (for storage of solid food), 2) one deep storage container (for storage of liquid food), 3) feeding items (a bowl, cup, and pair of feeding spoons), 4) a 10-L bucket with tap (for handwashing), and 5) a soap dish. The messaging intervention had two components’) “Happy Baby”—with images and messages centered on how improved food hygiene could lead to a healthy and happy child and 2). “Successful Child”—with messages and images positioning food hygiene as “A Better Foundation for a Successful Child”. A wall calendar and stickers (tailored for the child’s gender) with the messages were given to households. Caregivers received text messages for 4 weeks with similar messages. Another training intervention by **Geresomo et al.** (68) focused on the recommended hygiene and food preparation practices. Sessions were done in 2 days and involved caregivers of children aged 6-23 months. The practical sessions included hand washing, proper washing of utensils for cooking and serving food, cleaning of cooking areas and child feeding. Training materials included cooking utensils and food ingredients obtained from the communities. The mothers were asked to indicate if their children had diarrhea 2 days before the interview. Evaluation was done after 6 months. **Russo et al.** (69) assessed the secondary effects of training for pregnant women. This study found improvements in the water and hand washing behaviors of friends and relatives of the pregnant women enrolled in a project that provided the pregnant women with free hygiene kits, water storage containers, water treatment solution, soap, and educational messages. At follow-up, the friends and relatives, who did not receive the intervention, were significantly more likely to demonstrate good handwashing practices and purchase water treatment liquids than at baseline. This study highlights how social networks can be leveraged for disseminating and scaling-up behavior change.

One intervention implemented in community settings aimed to scale up positive impacts using a Training of Trainers (TOT) approach. **Salem** and colleagues (70) implemented a community based intervention including health education sessions. The sessions, which used tools such as PowerPoint presentations, posters, and flashcards, focused on healthy diet, food safety, and food economics. Post-intervention assessment was done after 3 months.

Some training included simple detection approaches that could be used to recognize signs of contamination, which is possible only for some hazards. **Van Der Westhuizen et al.** (71) describe an intervention where subsistence farmers were trained on how to recognize and remove visibly mold-infected kernels and to wash the remaining ones. Subsamples of the sorted and washed maize of each participant were collected for aflatoxin FB1 concentration analysis. The rest was pooled for porridge preparation, which was consumed by the participants. Urine samples were collected and FB1 levels determined. More sophisticated hazard detection or measurement methods are used very rarely at market or household/community level, even in research studies, and are more commonly used in

government laboratories or in large production establishments (72). Hence, interventions focusing on the implementation of a detection method were not included in this review. However, it should be noted that information on hazard presence and levels originating from food sampling or inspections (as well as other inspection data) could be a powerful component of an awareness-raising intervention for consumers or vendors. Awareness that inspections occur could in and of itself impact trust in a supplier or a vendor. As such, the sensitivity or specificity of a specific assay, and hence the quality of the test data, can have a profound effect on consumers' trust.

Table 7. Interventions Implemented at Consumer or Community Level (Africa)

First author	Study objective	Findings from the study	Relevance to the Food Safety Programming
Carabin (53)	Estimate the effectiveness of a <u>community-based educational</u> intervention in reducing the frequency of human cysticercosis and increase community self-efficacy in implementation of cysticercosis control measures.	<ul style="list-style-type: none"> • High number of households with recently built latrines: 7.9% (n=1983; intervention) and 5.6% (n=1941; control) • Except in one village, cumulative incidence and prevalence was reduced after randomization (3.8% in the intervention) and (6.3% in the control) • The intervention was effective in reducing the prevalence and the cumulative incidence in Nayala and Sanguié (but not in Boulkiemdé) areas 	<ul style="list-style-type: none"> • Yes, the intervention targeted an important zoonotic parasite and poor hygiene, and sanitation can propagate its spread
Chidzvisano (56)	Assess the effectiveness of a combination of participatory activities to improve complementary food hygiene behaviors among child caregivers	<ul style="list-style-type: none"> • Statistical differences in targeted behaviors: handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils • Statistical differences for proxy measures of the targeted behaviors: presence of a handwashing facility, soap and water at the hand washing facility, presence of water and soap at the site where utensils were washed, and presence of a dish rack 	<ul style="list-style-type: none"> • Yes, to encourage hygienic handling of foods • These proxy measures can be used in assessment of food hygiene interventions • Grounded in the risk, attitude, norms, ability, and self-regulation (RANAS) model
Hobbs (57)	Evaluate the impact of a <u>computer-based education</u> program ‘The Vicious Worm’ on <i>T. solium</i> knowledge retention	<ul style="list-style-type: none"> • Significant changes in knowledge for multiple categories, following the training 	<ul style="list-style-type: none"> • Targeted <i>T. solium</i> and the form used to facilitate the education is innovative
Morse (58)	Measure the impact of different <u>food and general hygiene trainings</u>	<ul style="list-style-type: none"> • Proxy measures for sanitation and hygiene differed when control was compared with treatment 1 and with 2 (but no difference between treatments). Treatment 1: handwashing + 	<ul style="list-style-type: none"> • Yes, proper hand washing, and food hygiene can be promoted

		<p>food hygiene; Treatment 2: handwashing + food hygiene + feces management + household water management</p> <ul style="list-style-type: none"> • Both treatments significantly reduced self-reported diarrhea incidence (13% more than control) • The more comprehensive Treatment 2 had a slightly higher (0.5%) impact than Treatment 1 on diarrhea incidence, but the difference was not significant 	<ul style="list-style-type: none"> • Adding two additional WASH components did not provide significant results compared to handwashing and food hygiene only (for diarrhea outcome)
Toure (59)	Training impact on reducing contamination of children foods	<ul style="list-style-type: none"> • Reduction in fecal and thermotolerant coliform (TTC) contamination 	<ul style="list-style-type: none"> • Yes, improvements in household hygiene and less risks of food contamination
Seetha (60)	Assess impact of training on nutrition, hygiene, and food safety on indicators of undernutrition	<ul style="list-style-type: none"> • Decreases in incidence of diarrhea • The dietary diversity score increased from 2.0 to 4.0 • Z score increases, in 3 weeks by 0.85 for wasting (on day 14 and 21) and by 0.74 for underweight • Acceptability of recommended recipes (a rate of 82% was reported in the intervention group) 	<ul style="list-style-type: none"> • Yes, improvements at the household level, and demonstrates the effect of the training on nutrition indicators to children who are vulnerable to FBDs
Anitha (61)	Quantify the impact of mother training about dietary diversification, food safety, and hygiene on child undernutrition	<ul style="list-style-type: none"> • 64% (57.1 pg/ml - 20.3 pg/ml) decrease in mean aflatoxin M1 level in urine samples (intervention) compared to 11% (control) (60.3 pg/ml - 53.6 pg/ml) • Significant (positive) effects on wasting for all the three measurements taken • Z-Score for underweight increased by 0.493 over the 21-day intervention period. 	<ul style="list-style-type: none"> • Yes, given the intervention was focused on aflatoxins, and involved mothers who handle and prepare food at household level
Gizaw (64)	Assess effectiveness of a multi-pronged WASH intervention	<ul style="list-style-type: none"> • Improvements in the handling of drinking water (baseline 6.7% and 58% endline) • Access to adequate sanitation (43.1% at baseline and 50.7% at the endline) • Home treatment of water (baseline 7.6% and 47% endline) • Hand washing of mothers (24% and 68%) • Good food safety practices (52% and 69%) • Improvements in children hygiene (1.3% and 34%) • Improvements in food safety (52% and 69%) 	<ul style="list-style-type: none"> • Yes, improvement in household hygiene and food safety practices

Slayton (65)	Assess the health impact of reusable, <u>antimicrobial hand towels</u>	<ul style="list-style-type: none"> • Compared to the controls, there was no evidence that the use of the antimicrobial hand towels over a period of 1 year reduced the risk of diarrhea in children < 2 years • The rate of self-reported fever was lower in intervention than control households 	<ul style="list-style-type: none"> • No, as no evidence was established for the effectiveness of the considered intervention
Kim (66)	Evaluate effectiveness of using an <u>antimicrobial towel</u>	<ul style="list-style-type: none"> • Trial 1- no significant difference in <i>E. coli</i> (for treated / untreated towels) (OR=1.14) • Trial 2- no significant differences in <i>E. coli</i> contamination of maternal hands by handwashing/drying procedure 	<ul style="list-style-type: none"> • No significant impact was reported
Simiyu (67)	Improving weaning food safety in peri-urban Kenya via a combination of <u>messaging and household and feeding items</u>	<ul style="list-style-type: none"> • Used Trials of Improved Practices approach, participatory development of materials and messages • Combination of hardware (feeding items, custom calendar) and messaging • Reported improvement in food storage and handwashing; feeding items adopted following intervention; reheating food observed less; small sample size (21 of 40 completed all six visits) 	<ul style="list-style-type: none"> • Trials of Improved Practices approach • Study participants pilot-tested interventions in their own settings
Geresomo (68)	Assess effect of targeted <u>training</u> on uptake of hygiene practices by caregivers of children 6–23 months	<ul style="list-style-type: none"> • Significant changes in hygiene before and after the intervention • Decrease in reported prevalence of diarrhea (45% to 8.6%) 	<ul style="list-style-type: none"> • Yes, as it involved capacity building of caregivers and reported to have reduced cases of diarrhea
Russo (69)	Assess the impact of a handwashing and water treatment training on non-participants in the same communities	<ul style="list-style-type: none"> • 25% more likely ($p < 0.0001$) to purchase and use water treatment solution than at baseline (1%) • Friends and relatives of training participants demonstrated correct handwashing (60% versus) compared to 18% at baseline 	<ul style="list-style-type: none"> • Hygiene and water intervention
Salem (70)	Assess impact of information-sharing training on food safety	<ul style="list-style-type: none"> • Improved knowledge regarding food safety, healthy diets, and food economics 	<ul style="list-style-type: none"> • Community-based approach to training

	knowledge of mothers/ caregivers		<ul style="list-style-type: none"> • Food safety training was part of a larger nutrition literacy training also including food economics and healthy diets
Van Westhuizen (71)	Investigate the reduction in AFM1 exposure following a simple and culturally acceptable intervention (<u>sorting and washing grains</u>)	<ul style="list-style-type: none"> • Significant reduction (62%) in FB1 exposure following the intervention- baseline was 4.84 (2.87–8.14) and intervention was 1.87 (1.40–2.51) mgFB1/kg body weight/day 	<ul style="list-style-type: none"> • Yes, given the public health importance of mycotoxins. Maize is an important staple food and critical for food security and trade. Creating awareness about mycotoxins among the handlers of the produce at the market is one approach to mitigating the risk of the hazard

4. DISCUSSION

This review covers food safety interventions in Africa and Asia and highlights those potentially relevant for the EatSafe project, primarily considering interventions that targeted food handlers operating at markets as well as individual consumers at household or community level. The studies generally utilized an education or training component, illustrated a variety of approaches and targeted food handlers in different contexts. A few engaged children in schools, while others targeted adult caregivers in order to improve the safety of children's food. Several interventions combined the use of food safety equipment in combination with training. Compared to interventions tested at household or community settings, there were fewer interventions targeting food handlers or vendors, and those studies were more limited in the range of training tools employed. Food handler studies were often characterized as professional trainings and did not explicitly leverage values and emotions. In this respect, community studies showcase a wider range of approaches that could be newly tested in vendor groups.

Trainings primarily impact knowledge, which is expected to translate to improved food handling and consequently reduce the occurrence of FBD. In their meta-analysis, **Soon et al.** (73) reported increases in knowledge and improved attitudes about hand hygiene practices as a result of training. It has been noted that to be effective, training should:

- Focus on acquisition of knowledge that leads to behavioral change (17).
- Aim to change both the “behavioral setting” and the cognitive processes associated with that behavior (18) (67).
- Use a formative or baseline study to inform the training, so that it is tailored to the needs of the group being trained.

Additional observations include:

- The timing and duration of trainings have been found to influence the ability of traders to attend trainings; this aspect impacts women the most (74).
- Some authors remark that educational interventions, especially those involving groups, should be complemented by additional channels (radios, posters, etc.) (75).
- Refresher training and long-term reinforcement have been recommended to ensure the changed practices are sustained (73).

It should be noted that health education alone is not adequate to improve food safety levels (19) and contributions from other stakeholders and other component of food safety systems are usually required. For instance, access to key infrastructure, such as potable water, electricity, and transportation, are services that the government is usually better positioned to provide (76). In the articles reviewed here, it has been observed that food handlers working

in restaurants with piped water were more likely to follow good food hygiene practices than those without (77).

An enabling environment is necessary for any food safety intervention to succeed. An ILRI-led project on training and certification of milk vendors was meant to improve the safety of milk sold through informal market channels. The intervention was designed to progressively upgrade milk handling and hygiene practices of vendors in the dairy informal sector and at the same time, help support their livelihoods and their legitimization in front of authorities (74). A strong business enabling environment was key to the success of this intervention, e.g., Accredited Business Development Service (BDS) providers implemented the trainings and were authorized to issue certificates of competence to vendor completing the trainings. Although the project was first implemented in Kenya, it has been adapted and tested in other countries and value chains (78).

The need for an enabling environment was also highlighted in the work of **Grace et al.** (8), who evaluated the long term impacts from a food safety intervention in a case study of one abattoir in Nigeria. Although an evaluation done immediately after the pilot found the intervention was successful, a follow-up nine years later found a deteriorated situation. The case study observed the establishment of large and well-equipped abattoir and subsequent requirement that all butchers in the area move their operations to the new facility. This case study highlights the need for stakeholder engagement and buy-in for an intervention to be successful, including the need to consider the logistical and business environment in which the target group operates.

Several studies developed custom content. While a custom approach can include details relevant to the target setting, it should be balanced against the need to use content or approaches that have a record of successful use in food safety settings. The combination of established approaches and customization could leverage the advantages of both approaches. For example, the Hazard Analysis and Critical Control Points (HACCP) framework is an established food safety management approach that involves a systematic method for the identification, assessment, and control of safety hazards at different points in the supply chain or in a specific establishment (79). As highlighted by a study involving cottage food manufacturing companies in Nigeria, the majority of food production and handling establishments in LMICs do not utilize HACCP or have an alternative Food Safety Management System (FSMS) in place (80). **Gebru and Gebretinsae** (81) successfully employed a HACCP approach to improve hygiene in small-scale abattoir settings in Ethiopia. However, HACCP may require structural and behavioral changes to achieve risk reduction. The absence of facilities and personnel necessary for implementing HACCP, as reported in this study, can be a major obstacle to its successful use to improve food safety.

A few of the reviewed interventions targeted foodborne zoonotic pathogens such as *Taenia solium* (the organism responsible for cysticercosis) (53) (57), foodborne zoonotic trematodes (FZT) (33), and *Streptococcus suis* (32). The content and delivery interventions to control

foodborne zoonotic pathogens often leverage a broad range of technical options. For instance, control measures can target live animals and/or humans (82). For humans, options include treatment of tapeworm carriers, health education, improved sanitation, and mass drug administration, while for animals it includes meat inspection, improved husbandry management, and vaccination. A comprehensive review of interventions to control foodborne zoonotic hazards, in contexts relevant to the EatSafe project, is provided in a separate report (EatSafe Activity 1.13).

Specific foodborne hazards generally require different interventions at different supply chain stages. Studies that assessed interventions to control mycotoxins in the maize supply chain highlight how no single mitigation can effectively address the problem of aflatoxins. In particular, significant reduction in contamination prevalence or levels require upstream interventions in the supply chain from retail, for example through biocontrol applied to crop fields (83,84) or the use of mycotoxin binders added to the product during processing (85). However, markets actors and consumers, when equipped with appropriate information, may be able to avoid contaminated product and hence reduce their exposure. Simple testing methods, such as the on-site detection tool for aflatoxin testing in maize flour described in the study by **Wacoo** (50), could be employed to provide timely data to vendors and consumers to minimize sales of contaminated product (86). The promotion of certified aflatoxin-free products to consumers had mixed results, with uptake not sustained over time (87). Some solutions involving improved storage can apply across the supply chain, including at markets and homes. For example, hermetic bags have been shown to reduce postharvest loss and have been promoted as an alternative to chemicals (88–90). Similarly, to other interventions reviewed, behavior change, and training is needed in addition to availability of the bags, to make this solution effective. Scaling-up challenges observed include low awareness, inadequate market incentives, and poorly enforced policies (84).

Other economic and societal factors can influence the adoption and sustainability of interventions. For instance, cost can limit the upscaling of mitigation approaches (7,91,92). Additional factors that influence uptake of interventions, mentioned in the reviewed studies, include larger societal events such as civil unrest (75); acceptability by local communities (93), bias in intervention delivery (67), lack of facilities (42), and poor coverage especially for educational interventions. As an example of user acceptance, although insecticide-treated nets were shown to be successful in reducing flies in pork butcheries, consumers complained that pork meat looked darker through the net frame and could be perceived by consumers to be old and therefore of poor quality (47).

Other domains not covered in this review can also provide synergies with interventions directly targeting food safety. For instance, the water, sanitation, and hygiene (WASH) “sector” has tested and implemented many training and behavior change approaches in low-resources settings that can similarly apply to food safety. Since water is an essential part of food preparation, and hygiene in food handling and preparation environments is key to food safety, existing evidence on successful WASH solutions can offer insight to design food safety interventions in low-resource settings (64,94–97). For example, as observed by several

studies presented in this review, combinations of risk reduction technology and changes in behaviors or practices can achieve significant impacts that would not be possible by implementing only one component. Integrated approaches to food safety and hygiene have also been proposed (58,98).

5. CONCLUSIONS

This review presents the results of a systematic search of the peer-reviewed literature to understand what type of food safety interventions have been implemented in informal market or community settings in LMICs, as well as the degree of success for identified interventions. While the review identified a range of studies from many countries, the total number of relevant published studies was relatively small. This finding is notable in itself, as it highlights the paucity of evidence on effective interventions directly targeting food safety at the retail or consumer level, especially those involving traditional market settings. The methods used to scan the literature, in particular the inclusion of peer-reviewed literature only, the inclusion of two databases, and the strict criteria for relevance, may have led to the exclusion of otherwise insightful resources. In particular, evidence from the WASH and animal health or One Health sectors could complement the evidence discussed here.

Summary findings and observations emerging from this review include:

- There is a clear evidence gap for food safety interventions in market settings, for both consumers and vendors.
- As most interventions identified provided generalized food safety advice, only a minority of studies looked at specific supply chains. Data was specifically lacking for vegetables and fruits.
- Most interventions reviewed were at least partially successful in the timeframe of the study; only a small percent found no evidence of impacts. Most studies assessed changes in knowledge or practices as impact indicators.
- Training is the most common approach applied in the reviewed studies; reasons for this choice are usually not stated. It is possible that trainings, compared to other interventions, are more feasible logistically and financially for organizations with less resources.
- Training studies employed a broad range of approaches and media tools, from printed materials to videos and songs. In-person training or assessment visits were most common. Sophisticated information technology (e.g., mobile phones, internet) were historically not as widespread, so these media channels were not covered in the studies. It is unclear what the relative advantage of some tools or media is, compared to others. On the other hand, no tool appeared to be completely unsuccessful.

- Several studies carried out in community settings focus on capacity building of women and caregivers of children, in an effort to impact the entire household and children in particular. These approaches, which have often been found successful, could leverage different motivators than for the general population.
- Some studies leveraged community social networks to increase the dissemination and sustainability of an intervention. While the mechanics of social interaction are largely ignored in the reviewed publications, there is evidence that social networks play an important role and should be considered in intervention design.
- The published evidence often lacks adequate quality. Approximately half of otherwise relevant articles were discarded due to quality issues. Even for the articles included, it is common that the intervention is not described in sufficient detail to allow for either replication or a nuanced understanding. Also, intervention impacts are often not measured rigorously. There is a clear need for rigorous assessment of intervention effectiveness, as well as analysis of factors enabling or hindering success, to better inform evidence-based design.
- None of the reviewed publications used a true risk-based approach, i.e., based their choice of message on the potential for foodborne risk reduction. However, a couple of studies included a HACCP risk management approach, or other content that had been vetted by food safety organizations as most relevant (e.g., the WHO five keys).
- Overall, even within its limitations, the evidence reviewed offers a “menu” of intervention options that have been evaluated and demonstrated some level of success and which should be considered as future food safety interventions in LMICs.

Findings from this review will be discussed in stakeholder workshops and used to inform the choice of interventions to be piloted in phase two of the EatSafe project, for each country involved in the project. Summary findings and considerations most pertinent to intervention and program design, in the context of the EatSafe project, are presented in Box 1.

Box 1. Recommendations for Intervention Design and Future Studies under EatSafe

EatSafe aims to generate the evidence and knowledge on leveraging the potential for increased consumer demand for safe food to substantially improve the safety of nutritious foods in informal market settings. Central to EatSafe's work is understanding (and potentially shaping) the motivations, attitudes, beliefs, and practices of consumers and food vendors. Based on the results of this review, we recommend EatSafe consider the following findings and observations during the design of its interventions:

- Food safety interventions in Africa and Asia from the period 2000-2020 included in this review, which focused on those implemented in market, community/household, and healthcare settings, highlight the paucity of rigorous evidence on food safety interventions in these contexts.
- In particular, there are few interventions directly targeting markets, consumers and market operators. This is a clear knowledge gap, that EatSafe plans to address.
- While most articles reviewed report a positive impact of interventions, the magnitude of impacts is often not reported in sufficient detail, highlighting the need for rigorous evaluation of intervention effectiveness.
- Education interventions are common, and EatSafe could leverage the food safety content and established delivery approaches. A few innovative information-sharing methods were observed in the review. However, knowledge alone is not sufficient: the most effective interventions utilized knowledge sharing, practical skill building and behavior change, often in conjunction with physical tools needed for the targeted practices.
- The WHO keys to food safety are a recognized content tool that can be utilized in food safety capacity building in various settings.
- Applications of the HACCP processes have been successful in some studies in low-resource settings and are promising for use in market participatory approaches.
- In the settings considered in this review, there was a preference towards "software" training and information-sharing interventions. However, when used, combinations of technology and behavior change have proven successful.
- There is limited information on successful examples of interventions involving media such as films, documentaries, and video-based trainings, as well as songs. Most training interventions reviewed used more traditional printed materials, as well as in-person instruction.
- As well-established in other health fields, the role of trusted community actors such as local health workers may be an important factor in the success of an intervention. While several studies include trusted community actors, it appears that this factor or resource is underutilized in food safety interventions.
- Community social networks can be used to leverage dissemination and sustainability of an intervention. Therefore, identifying established trusted partners and/or cultural and religion practices that include food safety and hygiene can be leveraged to reinforce and promote trust in safer supply chains, including suppliers and vendors.

Box 1 (continued). Recommendations for Intervention Design and Future Studies under EatSafe

- While food contamination testing is often only discussed in the context of government inspections or laboratory performance, aflatoxin studies have shown testing methods can be applied in markets to provide reliable and relatable information. Furthermore, knowledge of test results (independently from where the assay is performed) can empower consumers and vendors in choosing safer options.
- Domains adjacent to food safety, such as WASH and animal health, can offer tools, evidence of impact, and lessons learned.
- Biosafety interventions to control animal diseases such as avian influenza include practices that can also contribute to controlling foodborne hazards and improve hygiene in markets. Measures to control zoonotic hazards in the context of EatSafe are reviewed in a separate report (Activity 1.13).
- Several community-based and household interventions were aimed at raising awareness of caregivers, so they can ensure the safety of foods consumed by children. While not involving children directly, EatSafe could consider interventions that also benefit their health and nutrition, e.g., by understanding how caregivers make choices about food for children in the household.
- Only a few studies account for contextual and business enabling environment in their assessment and outcome interpretation. More attention is warranted to business motivators and incentives for both market actors and consumers to achieve motivation and buy-in.

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APPENDIX I. PROTOCOL FOR SLR ON FOOD SAFETY INTERVENTIONS IN ASIA

Aim	To identify interventions that could be applied in the field
Research questions	<ol style="list-style-type: none"> 1. Which interventions have been used to support food safety in Asia? 2. What effects did those interventions have?
Scope	Interventions intended to improve food safety including general, technical, organizational, capacity building, and incentive-based
Intervention	Interventions in food production, affecting food safety
Control	
Outcome	Food safety in terms of hazards, risks, health effects, disease
Setting	Asia [selected countries – see syntax in Appendix 2]
Protocol registration	
Eligibility criteria	<p>Inclusion criteria:</p> <ul style="list-style-type: none"> • Timeline: 2000- 2020 • 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 Asia [see settings] • Intervention is clearly reported • Study is relevant to traditional market vendors and/or consumers <p>Exclusion criteria:</p> <ul style="list-style-type: none"> • Not related to food-borne hazards • Studies conducted only in laboratories or on-station research • Studies only focusing on prevalence or risk factor analysis • Studies outside the selected Asian countries • Studies focus exclusively on WASH technology (relevant but outside the scope of this review)
Information sources	PubMed, Cabdirect
Search	See literature search document for keywords
Study selection	Observational studies of interventions, secondary data analysis, or field experimental studies (i.e., excluding laboratory and “controlled environment” experiments) were included.

Data collection process	<ol style="list-style-type: none"> 1. Run the search and download titles and abstracts 2. Remove duplicates in Mendeley [from individual databases] 3. Double screening of titles and abstracts in Rayyan QCRI software. Two reviewers will independently screen the titles and abstracts. Duplicates will be identified, confirmed, and removed. Appropriate key words will be defined and used to guide article exclusion process. Reasons for exclusion will be specified. In case of any disagreements, a third reviewer will screen the abstracts, and a decision on the ones to accept will be made (i.e., those accepted by at least two reviewers). An excel sheet with the screening output will be generated. 4. Full papers linked to the accepted abstracts will be sought and available ones downloaded and uploaded in Rayyan. They will independently be screened by 2 reviewers and their eligibility determined. A third reviewer will determine eligibility in the case where disagreements arise. 5% of included and 5% of excluded papers will be reviewed by a third reviewer. 5. Full paper single review [for quality assessment, subjectively as poor, medium, good, see criteria used in previous ILRI reviews]. 6. Extraction of data from eligible papers into an Excel template (used in a similar review for interventions in Africa).
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APPENDIX 2. SYNTAX USED TO SEARCH FOOD SAFETY INTERVENTIONS IN ASIA

Database	Syntax
PubMed	((foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic") AND ("cluster random" OR Random OR "clinical trial" OR intervention OR trial OR experiment OR impact OR evaluation OR effect OR control* OR manag* OR improve OR achiev*) AND ("South Asia" OR "South East Asia" OR Afghanistan OR Bangladesh OR Bhutan OR India OR Maldives OR Nepal OR Pakistan OR Sri Lanka OR Cambodia OR Laos OR Myanmar OR Thailand OR Vietnam OR "Viet Nam" OR Brunei OR Indonesia OR Malaysia OR "Papa New Guinea" OR "New Guinea" OR Philippines OR "Timor-Leste") AND ("2000/01/01"[PDat] : "2020/08/01"[PDat]))
CabDirect	(title: (foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic") OR ab: (foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic")) AND (title: (intervention OR trial OR experiment OR impact OR evaluation OR effect OR control OR manag* OR

improve OR achiev*) OR ab: (intervention OR trial OR experiment OR impact OR evaluation OR effect OR control OR manag* OR improve OR achiev*)) AND (("South Asia" OR "South East Asia" OR Afghanistan OR Bangladesh OR Bhutan OR India OR Maldives OR Nepal OR Pakistan OR Sri Lanka OR Cambodia OR Laos OR Myanmar OR Thailand OR Vietnam OR "Viet Nam" OR Brunei OR Indonesia OR Malaysia OR "Papa New Guinea" OR "New Guinea" OR Philippines OR "Timor-Leste"))yr:[2000 TO 2020]

APPENDIX 3. SYNTAX USED TO UPDATE SEARCH FOOD SAFETY INTERVENTIONS IN AFRICA

Data base	Syntax
Pub med	((foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic") AND ("cluster random" OR Random OR "clinical trial" OR intervention OR trial OR experiment OR impact OR evaluation OR effect OR control* OR manag* OR improve OR achiev*) AND (Africa, Northern OR *sahara* OR Africa, Central OR Africa, Eastern OR Africa, Southern OR Africa, Western OR Algeria OR Angola OR Benin OR Botswana OR "Burkina Faso" OR Burundi OR Cameroon OR "Cape Verde" OR "Central African Republic" OR Chad OR Comoros OR Congo OR "Cote d'Ivoire" OR Djibouti OR "Democratic Republic of the Congo" OR Egypt OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Guinea-Bissau OR "Ivory Coast" OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Rwanda OR Senegal OR "western Sahara" OR Seychelles OR "Sierra Leone" OR Somalia OR "South Africa" OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR Zambia OR Zimbabwe) AND ("2017/09/29"[PDat] : "2020/08/01"[PDat]))
CAB Direct	(title: (foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic") OR ab: (foodborne OR "food safety" OR "safety label" OR "food hygiene" OR "food-borne" OR "food borne" OR "kitchen hygiene" OR "street food" OR abattoir OR slaughter* OR "willing* to pay" NOT "organic" NOT "indigenous" NOT "GMO" NOT "exotic")) AND (title: (intervention OR trial OR experiment OR impact OR evaluation OR effect OR control OR manag* OR improve OR achiev*) OR ab: (intervention OR trial OR experiment OR impact OR evaluation OR effect OR control OR manag* OR improve OR achiev*)) AND (Africa, Northern OR *sahara* OR Africa, Central OR Africa, Eastern OR Africa, Southern OR Africa, Western OR Algeria OR Angola OR Benin OR Botswana OR "Burkina Faso" OR Burundi OR Cameroon OR "Cape Verde" OR "Central African Republic" OR Chad OR Comoros OR Congo OR "Cote d'Ivoire" OR Djibouti OR "Democratic Republic of the Congo" OR Egypt OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Guinea-Bissau OR "Ivory Coast" OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Rwanda OR Senegal OR "western Sahara" OR Seychelles OR "Sierra Leone" OR Somalia OR "South Africa" OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR Zambia OR Zimbabwe))yr:[2017 TO 2020]

APPENDIX 4. SUMMARY OF THE REVIEWED PAPERS (ASIA)

First author and year of publication	Study area/ country	Hazard targeted	Study design	Intervention	Setting where implemented	What outcome was measured
Takeuchi (2017) (32)	Phayao, Thailand	<i>Streptococcus suis</i>	Before and after	Educational A <i>S. suis</i> surveillance network also established	Community	Number of disease cases
Samaan (2012) (22)	Makassar, Indonesia	Avian flu	Before and after	Infrastructural and behavioral change intervention, Monthly 2- hour training sessions (waste management, food safety etc.).	Live bird markets	KAP
Takanashi (2013) (27)	Hanoi, Vietnam	Non-specific	Longitudinal (baseline and two follow ups)	Educational messages linking diarrhoea to food hygiene and food safety	Caregivers of 6 month- 4-year children	childhood diarrhea; caregivers' food hygiene and safety behavior
Riyanto (2018) (21)	Simahi, Indonesia	<i>E. coli</i> , and chemicals (sodium borate/ borax, formaldehyde, rhodamin B	Quasi experiment (intervention and control groups; and pre- and post-test design)	Education – 20 to 30 minutes a week, for 6 months, and guidance during preparation.	Food vendors	Bacterial (<i>E. coli</i> , coliform, total plate count and chemicals

		and yellow methanol)				
Riyanto (2017) (30)	Indonesia	Non- specific	Quasi experiment with pretest–posttest control group design	Food safety education through book covers and videos on microbiology and chemical	Elementary school children	KAP
Nik Rosmawati (2017) (35)	Kelantan, Malaysia	Non-specific	Randomized control trial	Educational: Sessions done on weekends, 2 with interval of one week between the sessions.	Food handlers working in school canteens (n=110)	Hand washing practices (observations)
Poudel (2019) (34)	Banke, Nepal	<i>Taenia solium</i>	Randomized control trial	TSOL18 vaccination and oxfendazole treatment of pigs.	Market pigs	Cyst presence in slaughtered pigs
Siagian (2015) (41)	Indonesia	Not specified	Randomized control trial	Irradiation sterilization of ready to eat foods	Immunocompromised individuals	Biochemistry (albumin, lymphocyte); Body Mass Index
Riaz (2016) (24)	Munshiganj, Bangladesh	Non-specific	Baseline, intervention, end-line survey	Education that used community counselling meeting	Rural women	KAP
Singh (2016) (19)	urban slum Wanowrie, Pune, India	Non- specific	Before and after study	Health education intervention	Street vendors (n=20)	Conformance of street vendors to BIS for food safety and hygienic practices

Dudeja (2017) (37)	North India	Non-specific	Before and after	Educational	Food handlers working in the hospital (n=2)	KAP
Lier (2014) (33)	Communes in Nam Dinh, North Vietnam	Fish-borne zoonotic trematodes	Before and after	Preventive chemotherapy and follow up sampling	Random population of those that had history of consuming raw fish (n=396 included in the final analyses)	Number of eggs per gram stool (cpg)
Malhotra (2008) (39)	Maulana Azad Medical College, Delhi, India	Non-specific	Before and after	Education tailored to the needs of the study population	Food handlers in the hospital	Knowledge, attitude, and self-reported practices of washing
Bhattacharya (2019) (38)	Tertiary care hospital (Department of Dietetics and Nutrition), India	Non-specific	Single group before and after intervention	Educational	All food handlers working in the hospital (n=103)	Improvements in hygiene scores
Dudeja (2017) (40)	North India	Non-specific	Before and after	Monthly inspection done over a year and corrective actions given	Eating establishments in a tertiary hospital (n=36)	Conformance scores
Sesanelvira (2019) (29)	Karawang regency, Indonesia	Non-specific	Intervention and control with a pre- and post-assessment; quasi experimental	Education using mind map method	School-age children (n=88, 44 in each group)	Improvements on knowledge, attitude, and skills
Sheth (2004) (28)	India	Non-specific	Before and after	Educational using a variety of approaches	Mothers of underprivileged children (6-24 hours)	KAP/ reduction in the

					(n=200 mothers, through Anganwadi workers)	incidence of diarrhea
Wardhana (2019) (36)	Indonesia	Non-specific		Halal slaughter process	Slaughter	Total plate count
Islam (2013) (31)	Bangladesh	Fecal coliforms, fecal streptococci, <i>Clostridium perfringens</i>	Before and after	Process	Community	Hazard occurrence

APPENDIX 5. SUMMARY OF THE REVIEWED PAPERS (AFRICA)

First author and year of publication	Study area/country	Hazard targeted	Study design	Intervention	Setting where implemented	What outcome was measured
Donkor (2009) (42)	Ghana	Enteric pathogens and parasites	Before and after	Education	Food vendors	KAP
Latif (2013) (44)	Egypt	Non-specific	Before and after	Education	Food vendors	KAP
Ababio (2011) (45)	Ghana	Non-specific	Before and after	Education	Food vendors	KAP
Ogugbue (2011) (46)	Nigeria	Microbial	With and without (control was exposed to air)	New technology	Market	Hazard occurrence

Van Der Westhuizen (2011) (71)	South Africa	Fumonisin B1	Before and after	Education	Community	Reduction in FB1 exposure
Heilmann (2017) (47)	Uganda	Microbial	Intervention and control	New technology (insecticide treated nets)	Market	Reduction in the number of flies
Olumakaiye (2013) (49)	Nigeria	Non-specific	Before and after	Training	Market (food service outlets)	Environmental hygiene scores
Wacoo (2018) (50)	Uganda	Aflatoxins	Validation	Technology	Market	Concentration level of aflatoxins
Slayton (2016) (65)	Kenya	<i>E. coli</i>	Cluster randomized trial	New technology	Community	Hazard occurrence
Toure (2013) (59)	Mali	Thermotolerant coliform (TTC)	With and Without	Process	Community	Level of contamination
Gizah (2020) (64)	Ethiopia	Non-specific	Before and after	Training	Community	KAP
Seetha (2018) (60)	Malawi	Chemical and biological	RCT	Training	Community	Z scores for nutrition measures
Anitha (2020) (61)	Tanzania	Chemical and biological	RCT	Training	Community	Z scores for nutrition measures
Geresomo (2018) (68)	Malawi	Non-specific	Before and after	Training	Community	KAP
Salem (2019) (70)	Egypt	Non-specific	Before and after	Training	Community	KAP
Kim (2020) (66)	Kenya	<i>E. coli</i>	Cross over trial	Technology	Community	Hazard occurrence
Simiyu 2020 (67)	Kenya	Non-specific	Qualitative longitudinal	Training and Technology	Community	KAP

Morse (2018) (98)	Malawi	Non-specific	Randomized before and after	Training	Community	Reported diarrhea; respiratory infections
Carabin (2018) (53)	Burkina Faso	<i>T. solium</i>	Cluster randomized	Training	Community	Disease Incidence
Chidziwisano (2020) (56)	Malawi	Non-specific	RCT	Training	Community	KAP
Hobbs (2020) (57)	Malawi	<i>T. solium</i>	Longitudinal with 2 intervention arms	Training	Community	KAP
Russo (2012) (69)	Malawi	Non-specific	Friends and relatives of hygiene kit recipients	Training	Community	KAP