Food and Agriculture Organization of the United Nations

Structured Review and Expert Opinions on Early Warning and Rapid Alert Systems Applicable to Food Safety

Technical Report

26 September 2013

CCH Centre for Coastal Health

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Executive Summary

This technical report is an abridged version of the full report that documents the results of the project '*Structured Review and Expert Opinions on Early Warning and Rapid Alert Systems Applicable to Food Safety'* carried out by the Center for Coastal Health (CCH) in collaboration with the EMPRES Food Safety Unit. **The broad review question for the project was as follows: What is the current state of knowledge on EWRA (early warning and rapid alert) systems in terms of networks, programs and initiatives, databases, and data sources for identifying, notifying and sharing information on food safety events?** Specific project goals were to: 1) identify, evaluate and summarize evidence and opinion-based information presented in the scientific literature and opinion-based knowledge collected from experts about existing EWRA systems worldwide that are applicable to food safety; 2) evaluate the portability of existing EWRA systems to countries with limited resources; and 3) use information gained in this process to identify key principles, good practices, and essential framework elements to establish or enhance EWRA systems at the country level. We completed scoping interviews, a rapid literature review, an online survey of 140 experts, and semi-structured interviews with 11 key experts over a six month period from November 2012 to April 2013 to gather and synthesize knowledge relevant to the project goals.

Key findings of this review

- There is currently no uniform terminology for EWRA systems and their components used by food safety experts.
- EWRA systems for food safety exist along a continuum from predictive systems that use risk-based approaches to forecast where food safety events are likely to occur, through reactive systems that identify hazards in food products, to reactive systems that identify foodborne illness in people.
- EWRA systems incorporate a chain of concerns that include understanding and mapping hazards, monitoring and forecasting impending events, processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely action in response to those warnings. To do this, EWRA systems must be able to integrate data from multiple sources (human health, animal health, media reports, laboratory reports, international sources); be flexible and adaptable to integrate these various data sources and the technologies that drive them; have human resource and technological capacity to analyze data, validate signals and create action plans in real-time; and have surge capacity to investigate cases and take actions to reduce negative impacts in a timely manner.
- Surveillance approaches that can identify food safety events include the following: monitoring traditional or social media for news about unusual events that might be food safety events; syndromic surveillance for diarrheal disease or other relevant syndromes in food animals or people; laboratory surveillance for known food hazards in food animals and food products; laboratory testing of people with suspected foodborne illness to identify the cause; and on-site, instant testing of food products, animals or people for known hazards.

- This review identified *descriptions* of 40 EWRA systems applicable to food safety in the publically available literature. Seven of these EWRA systems attempt to predict food safety events, three monitor for contamination in foods before consumption, twenty monitor for foodborne illness, and ten monitor for both contamination and foodborne illness. In low-to-middle income countries (LMICs) specifically, one described system monitors for both contamination and foodborne illness and four described systems monitor for foodborne illness.

- In many countries, programs that monitor for food contamination and foodborne illness do not appear to be co-located within a named EWRA system; instead, pieces of EWRA systems reside within different sectors, agencies or ministries.

- **Because the published literature on evaluating EWRA systems for food safety is very limited, there is a lack of validated data about how best to set up, sustain and evaluate these systems.** From information presented in two published evaluations, it appears that technical (data management, laboratory capacity) and non-technical issues (simplicity, ease of use, trust, strength of interpersonal networks, and capacity for providing feedback) might be equally important to system success.

- Until more evaluations have been completed and published in the literature, key principles, good practices and framework elements that are essential to establish or enhance EWRA systems at the country level will need to be derived by analogy from related fields and by considering the opinions of experts with experience in EWRA and food safety.

- Expert opinion suggests there is not a single ideal combination of individuals and organizations necessary to develop, run and use EWRA systems. Therefore, best approaches to EWRA systems for food safety in different settings should be adapted to the needs, available infrastructure and established competencies of local agencies, which should be clearly identified before undertaking new initiatives. Whenever possible, new programs should be integrated with existing programs, and use inter-agency and multi-disciplinary collaboration. Certain stakeholders may be more highly involved at different times in developing, implementing, operating and evaluating different aspects of EWRA food safety systems.

- Gaps and recommendations derived from the opinions of experts writing in the literature about EWRA systems can be grouped into seven themes. These themes include the need to develop technology for properly functioning platforms and improving the speed of signal detection; the need to organize people and policies to ensure structural sustainability of EWRA systems; building the physical, financial, human, and technical capacities of systems; making timely and sustainable connections among people within EWRA systems and among different components or timespans of a system; the necessity for EWRA systems to have a functional response capability to distinguish real food safety events from false alarms; and the need to evaluate EWRA systems to determine how well systems detect food safety events and how acceptable and sustainable these systems are for users.

- At present, the efficacy of different surveillance approaches in achieving early warning of food safety events in LMICs has not been documented. Surveillance approaches used in LMICs are likely to be limited by available technology and human resources. There is some evidence that the use of more than one surveillance method is more effective than the use of a single method alone.

- It is currently not feasible to use any single existing EWRA system for food safety as a portable blueprint for low-to-middle income countries (LMICs) seeking to develop EWRA capacity. However, work from Malaysia (Soon, Sing & Baines, 2011) provides the best description of an integrated EWRA system for food safety in a middle income country, and evaluation (Paterson, Kool, Durrheim & Pavlin, 2012) and discussion (Chiller et al., 2005) about surveillance systems for diarrheal disease in the Pacific Island Countries and Territories (PICTs) provide guidance about creating effective and sustainable surveillance systems in LMICs.
- Key limitations that could impact EWRA systems for food safety in LMICs include the following: limited information on the burden of illness caused by food contamination; the presence of other competing local health priorities; inadequate laboratory and human resource capacity (due in part to lack of sustainable financial resources); weak or unstable information-sharing networks amongst experts working in various agencies, geographical regions or levels of government; and a lack of capacity to enforce regulations.
- Support from international organizations is likely to be an important component of success of EWRA systems for food safety, as are fostering collaboration between people working in various ministries and sectors within an LMIC, and supporting in-country food safety experts. The goal of producing food for export can be an important driver of interest in learning about prevention of food safety events in LMICs.
- Logistical constraints and time restrictions placed on aspects of the research activities resulted in limitations to this report, which may need to be addressed with additional research activities. The first limitation is that many of the publications returned by the literature search strategy focused on foodborne illness or disease surveillance, rather than detection of food contamination events. Secondly, experts who participated in the online survey and semi-structured interviews appeared to have more experience in surveillance for biological hazards and foodborne illness than chemical or nuclear contamination events. Finally, the literature search found only English language publications, the majority of which were peer-reviewed, so knowledge discussed in other languages or in the grey literature was unavailable for the report.

Introduction

Consumption of unsafe foods is an important cause of morbidity and mortality worldwide; however, impacts have been inadequately measured in many regions. The Center for Disease Control (CDC) reported that in the United States in 2011, one in six persons were affected by foodborne disease[1]; and estimates are similar in other high income (HIC) countries. In low and middle income (LMIC) countries, the burden of disease might be expected to be larger as the ability to monitor and maintain safe food production practices and report food safety events is more limited. Growth in international trade has increased the potential for food safety hazards to cross borders and continents – this has necessitated the need for timely detection and response to food safety events to minimize their potential to harm human health and welfare globally.

Properly functioning **E**arly **W**arning and **R**apid **A**lert (EWRA) systems should have the capacity to rapidly predict or detect events with serious consequences, and facilitate the rapid exchange of information amongst appropriate stakeholders to create a timely, effective response that eliminates or reduces negative impacts. EWRA systems for food safety should be able to reduce the impact of biological, chemical and radiological food safety events from "farm to fork", and prevent the escalation of these events into serious national and international emergencies. Although systems for food safety currently exist at local, national and international levels, only a few countries or regions have robust EWRA systems for food safety that are integrated at the national level or with key international and global initiatives. Unfortunately, there is limited publically available information about the scope, structure, methods, performance and portability of these existing EWRA systems.

The Emergency Prevention System for Food Safety (EMPRES Food Safety) unit of the Food and Agriculture Organization of the United Nations (FAO) works with FAO members and other partners to prevent and manage global food safety events and emergencies[2]. The main aim of EMPRES Food Safety is to prevent and control food safety risks. In collaboration with their World Health Organization (WHO) counterparts, the EMPRES Food Safety unit has been developing a five-year strategy to accomplish two key objectives: 1) to effectively assist countries in building and enhancing EWRA capacities in food safety, and 2) to establish global, sustainable and collaborative EWRA food safety networks and partnerships to guide and bring together country, regional and global-level initiatives and pilot projects. As a first step towards reaching these longer-term objectives, a review project entitled *Structured Review and Expert Opinions on Early Warning and Rapid Alert Systems Applicable to Food Safety* was initiated. This technical report is an abridged version of a full report that summarizes the key results of research undertaken by the Center for Coastal Health (CCH) in collaboration with the EMPRES Food Safety unit to document the current state of knowledge on EWRA systems. The goals of this review were to 1) identify, evaluate and summarize relevant data and empirical knowledge on existing food safety EWRA systems globally, 2) evaluate the portability of existing EWRA systems to other countries,

[1] http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html
[2] www.fao.org/food-safety-quality/empres-food-safety/en

and 3) identify key principles, good practices, and essential framework elements for establishing or enhancing EWRA systems at the country level.

Methods, Results and Discussion

EWRA Food Safety System Experts

To identify experts who might be willing to assist us with our online survey and semi-structured interviews, we needed to define an EWRA food safety system "expert". Our initial definition of such an expert was an individual or institution that had recently been or continued to be involved in decision making, generating new knowledge, making policies, developing programs and strategies, and/or applying knowledge to practice in the fields of food safety, food defense and/or food security. The expert should also be recognized as a leader, manager or content expert and/or have sufficient 'content experience' in EWRA systems, based on pre-identified criteria for research output, demonstrated experience or occupation. It became apparent during the initial recruitment of experts that this definition was too limiting, and that it was impractical to assign the pre-identified criteria to each individual based on general correspondence and Google searches alone; as a result, we broadened our definition to also include individuals with experience in disease surveillance. All identified experts were asked to nominate additional food safety/security experts from their own professional networks, and were asked to name or describe EWRA systems that they had been involved in or were aware of. An effort was made to identify one or more experts from each country, with an even continental distribution.

Individuals who responded positively to our initial request were provided with additional information about the project and were automatically included in the online survey; those that identified themselves as not being an expert in EWRA were asked if they had experience in food safety. If in their reply they asked not to be involved in this project, or they stated that their level of experience was outside of our definitions of EWRA and food safety, they were kindly thanked for their time and removed from further correspondence.

We identified 850 individuals from a variety of sources who fit our search criteria for expertise in early warning and rapid alert systems. These sources included EWRA program or website contacts (450), names provided by either our FAO project collaborators or individuals who responded to our initial email (187); authors identified in published papers relevant to EWRA systems; food safety and surveillance people identified on the attendance list of the 13th Conference of the International Society for Veterinary Epidemiology and Economics held in Maastricht (70), and internal references from the CCH (10). The source was not recorded for 68 contacts. Many (53%) of these individuals were located in Europe (n=235) and North America (n=216). Of the 850 experts, 700 had a functional email contact; 161 responded to our initial request for information; and 79 of the 161 people who responded to our initial request for information were either directly or indirectly involved in EWRA systems.

Rapid literature review

We searched the multi-disciplinary bibliographic electronic databases CAB Direct, Agricola, Science Direct and BIOSIS Reviews because of their international coverage of the literature; their focus on agriculture, public health, food science and life science; and their accessibility through our associated university library holdings. Although the search parameters varied slightly across the databases, the refined search string that consistently identified the most relevant articles contained the following key words: food, foodborne disease, safety, surveillance, outbreak, early detection, early warning and response.

Papers identified through electronic database searches were initially screened by a single person (SI) on the basis of the title and abstract for the following **inclusion criteria**: published after 1991, combination of words/phrases relevant to the description and or evaluation of food safety surveillance and response, emerging infectious disease intelligence systems, named EWRA program, any language or geography, and any form of print or electronic document/website. Papers that passed primary screening were imported into RefWorks 2.0 (ProQuest, LLC), a reference and citations management tool.

All papers that passed primary screening were then reviewed by two team members (CR and TS) specifically for relevance to one or more of the 20 questions pre-identified by our FAO collaborators. Papers that were unlikely to answer any of these 20 questions on the basis of the title or abstract, papers for which the abstract was missing, and papers that described food safety incidences/cases within a geographic region and specified time period, were excluded at this time. Full papers were sought for all titles that passed secondary screening.

Forward citation searches using the Web of Science database were conducted on key priority papers to identify additional relevant papers with a more recent publication date. These papers were then screened using the primary inclusion criteria as previously described; papers that passed primary screening were then examined by team members TS and CR by way of secondary screening.

Google and Google Scholar searches were conducted on all named EWRA systems identified by contacts or in the peer-reviewed literature to identify grey-literature and government reports produced on behalf of or in association with these systems; we also sought more detailed information regarding mandates, key contacts, relevant websites and geographic locations of operation for these systems. A few contacts volunteered the title of, or a full paper to, government reports and papers in which they were author/co-author. Grey literature was subjected to the same screening process already described.

The papers that passed secondary screening were randomly assigned amongst five reviewers, along with a standardized form (MS Word 2010) that was returned to author SI once completed. Reviewers were asked to provide basic information such as author, paper title, journal, publication type, and the names of any EWRA system(s) referenced in section 1 of the form. In section 2, reviewers answered nine questions about the methodology used in the paper. In section 3, reviewers identified whether the paper answered any of the 20 questions pre-identified by our FAO collaborators (later collated into 8 key themes, as presented in Table 1 below; the final section allowed the reviewers to provide their opinion as to the relevance of the paper to this project and more generally to EWRA food safety systems.

Reviewers' answers to the nine section 2 questions allowed us to classify the methodology used by the papers' authors. If the authors described a trial or a systematic evaluation of one or more EWRA systems, compared an EWRA system with another concurrent detection method, or carried out a prospective or retrospective analysis of the connection between signals, symptoms and food hazard (or safety) outcomes, we classified the paper as ***evaluative***. Papers that explicitly defined the attributes of an EWRA system and associated this description with measurable outcomes were also classified as evaluative. Those papers that described the attributes and goals of EWRA systems but did not offer any systematic evaluation or opinion of those systems were classified as ***descriptive***. Papers containing authors' opinions of EWRA systems with little else by way of description or evaluation were categorized as ***opinion-based*** papers.

Our subsequent review efforts focused on the evaluative category of papers, looking in particular for evidence that named EWRA systems were effective as evaluated by some standard, or in comparison to another system. We used the descriptive papers and descriptive components of papers in the evaluative category to build an inventory of EWRA systems specific to food safety. Opinions provided by the authors of papers in the opinion category were also documented. Although not the result of formal evaluations of EWRA systems, these opinions do represent the results of considered thought by authors who have experience in the field.

Table 1 – List of 8 themes identified from the original 20 FAO questions

Section	Theme
1	Defining EWRA systems
2	Descriptions of existing EWRA systems
3	Common and potential future EWRA platforms
4	Builders, users and jurisdictional context for EWRA systems
5	Components needed to build EWRA systems for different resource contexts
6	Scope and use of EWRA systems
7	Evaluating EWRA systems
8	Gaps, limitations, future trends, and recommendations

Each of the eight themes identified from the original 20 FAO questions was assigned to one of four team members (CR, TS, JD, TB) for detailed analysis. Team members worked first with the reviewer's notes relevant to a section in order to gather and organize the major ideas discussed in the literature. They then reread the papers relevant to the section to ensure that no important information had been missed in the initial review. Finally, they integrated findings from the online expert survey to create a comprehensive synthesis of the literature and expert opinion relevant to each section.

The formal literature search identified 98 unique papers from the online databases Science Direct, BIOSIS Reviews, CAB Direct and Agricola that passed primary screening, 28 (29%) of which also passed secondary screening. Although language was not a limiting criterion in the search strategy, only English language papers passed secondary screening.

The informal literature search identified an additional 1065 English-language papers from key contacts, Google scholar searches and Web-of-Science forward citation searches. Of these, 117 (11%) passed secondary screening, resulting in a total of 145 papers eligible for full review. The five reviewers (CR, TS, TB, JD, and SI) completed reviews on 54 papers before time constraints necessitated the re-prioritization of remaining papers (by CS and TS) based upon relevance to the review questions. The five reviewers then read a further 36 papers starting with the highest priority papers. A third author (TB) independently reviewed all unread titles and identified two additional papers of interest. A total of 90 papers were fully reviewed. A full schematic of our literature search process is provided in Appendix 1.

The geographic locations of each reviewed system, if identified by the author, was used to classify the EWRA location of operation as HIC, LMIC or Global – the majority of the systems described were located in HICs. Approximately one-third of the papers were evaluative; only 4% of papers evaluated systems with a food safety focus. Those papers that were both applicable to EWRA food safety and evaluative were reviewed in much greater detail.

We present next our findings from the literature review for the eight themes identified in Table 1, beginning with defining EWRA systems and ending with a presentation of the major recommendations based upon authors' experiences. Where findings from the expert opinions gathered in the online survey carried out for this review are relevant to one of these eight themes, we include our findings from the survey along with the literature review. A specific report on the online survey findings can be found after the literature review discussion.

Defining EWRA systems

The primary goal of this review was to evaluate systems that were designed to, as quickly as possible, identify food safety events that had already occurred so that early warning can be accomplished and a rapid alert initiated. According to Marvin, Kleter, Prandini, Dekkers, & Bolton's (2009a) terminology, this describes **<u>reactive</u> early warning systems**, which may be based upon (but not restricted to), monitoring known hazards. The definitions used in this project, therefore, consisted of the following:

Early warning and rapid alert systems rapidly predict (potential) and/or detect food safety events of potential serious socioeconomic and/or public health consequences, allowing rapid and effective exchange of information among appropriate stakeholders (and with public, when applicable), and adequate and timely response. These systems are essential to prevent the escalation of a food safety event into a serious foodborne disease outbreak or other type of food safety emergencies.

Food safety events are events associated with biological, physical or chemical hazards and food (food chain) with potential public health and/or trade ramifications. This definition might need to be expanded to capture broader, but still well-defined public health context, if information pertaining to food safety events is insufficient.

In the introductory email to our expert online survey of EWRA experts, we provided the following slightly modified definitions:

Food safety events include contamination of food or food products by micro-organisms, toxins, foreign matter, chemicals; excess moisture content; degradation of the nutritional value or pest infestation.

Early warning is the detection and recognition of a public health or food safety event that comes early enough to allow for adequate preparation to prevent or minimize the negative impacts of the event

A **rapid alert system** is a tool that allows for the timely exchange of information so that rapid and coordinated responses can be initiated.

Public health activities are those with a primary goal of preventing or reducing illness and maintaining or increasing health in human populations. Public health events are situations that create a risk of increased illness in a human population.

The European Food Safety Authority (EFSA, 2011) suggests that "the vast majority of early warning systems are reactive systems that collect, analyze and interpret data from running hazard or disease monitoring and surveillance programs." They present the European **R**apid **A**lert **S**ystem for **F**ood and **F**eed (RASFF) as an example of such a hazards-based reactive early warning system. Reactive early warning systems are designed "to collect, analyse and interpret data from hazard or disease surveillance programs after they have occurred" (EFSA, 2012). They contrast this with EFSA's Emerging Risks unit (EMRISK), an emerging risk system that is designed to "detect signals of potential food and feed safety risks at an earlier stage, ideally before they have developed…" EFSA (2012) defines emerging risk as "an emerging risk to human, animal and/or plant health is understood as a risk resulting from a newly identified hazard to which a significant exposure may occur or from an unexpected new or increased significant exposure and/or susceptibility to a known hazard." Braks et al. (2010) provides the most encompassing definition that includes both an early warning and a rapid alert component. They suggest that "early warning systems include a chain of concerns, namely: understanding and mapping the hazard (read: threat); monitoring and forecasting impending events; processing and disseminating understandable warnings to political authorities and the population and undertaking appropriate and timely action in response to the warnings."

Our goal was to examine whole systems that contained both early warning and rapid alert components and any associated sub-components. We received advice from at least one participant of our expert online survey that it may have been better to split the early warning and rapid alert components into two, and to explore these components separately. It also became apparent from the literature that many of the described systems consisted of only one or two components (e.g. syndromic, complaint-based and event-based surveillance) from among a larger number of potential EWRA sub-components.

We did not specifically ask participants of our expert online survey to define an EWRA system. In fact, we provided them with the definitions listed above for a 'reactive' EWRA system. Most of the participants in the expert online survey appeared to have worked with the definition of EWRA that was provided, and used that definition to answer the survey questions. At the end of the expert online survey, we asked participants to provide any comments or questions they might have about the development, implementation, management and evaluation of EWRA food safety systems. Fourteen of 140 participants (10%) made comments that were relevant to the issue of EWRA definitions, and several participants expressed concerns over how terminology associated with EWRA for food safety was used and understood amongst experts. One participant in the survey commented that the "terms passive, active and event-based surveillance are not well defined and can have very different meanings to different individuals. 'Surveillance' is the new buzz word and is often used inappropriately."

Three of the participants made comments that seem to touch on the issue of why our literature search identified few papers that specifically used the term EWRA. One indicated that our Expert online survey questions assumed that EWRA systems are implemented in these countries when, to their knowledge, the majority of countries they deal with are limited to the application of food inspections services rather than EWRA systems. The second noted that some of the expert online questions were making the assumption that "there is in reality somewhere a good functioning EWRA." They go on to observe that "this is not the case in any jurisdiction that I have worked in or with." The third presented the opinion that "current EWRA systems are not effective or efficient", suggesting that the cause of 50% of foodborne outbreaks is undetermined, they are identified too late, and good information for the public is lacking. One participant indicated that they worked in a food safety rapid alert system that was not integrated with an early warning system, so they had trouble evaluating the early warning component of the questions; another suggested that these two components should have been presented separately because they are two different processes. Eight of the participants made comments about the survey definition being directed towards reactive or hazards-based systems. Several suggested the survey was biased towards these kinds of EWRA systems.

In summary, it appears there is not a commonly understood definition for the term 'EWRA' in the literature and amongst experts. In some cases complete EWRA systems for food safety are not called EWRA systems. Examples would be the combined food inspections, laboratory, active surveillance, and rapid alert systems that reside within the Canadian Food Inspection Agency (CFIA), or the United States Department of Agriculture (USDA). In other cases, single components (e.g. a syndromic surveillance system or an event-based surveillance system) are referred to as EWRA systems. In addition, some experts consider early warning and rapid alert to be separate systems. Also, the term early warning might be used in reference to either predictive or reactive systems. Finally, there is variability in the literature and amongst experts regarding naming different surveillance approaches that are used as the early warning components of some EWRA systems.

While the definitions we provide above are adequate working definitions, they are not likely to be understood uniformly by stakeholders without discussion. Therefore, it is important that the terms are discussed amongst, and clearly defined by, stakeholders at the start of any efforts to modify, assess or implement EWRA systems for food safety. To guide this discussion, it is useful to consider early warning systems for food safety as existing along a continuum (Chiller et al., 2005), which we present schematically in Figure 1 on the following page. The systems that provide the earliest warning of food safety events use predictive risk-based approaches to forecast the likelihood of food safety events, while further along the continuum, reactive systems identify hazards in food products at points prior to human consumption, and finally, other reactive systems identify cases or outbreaks of foodborne disease in people. Of the various surveillance approaches (event-based, laboratory, syndromic), some can be used on multiple points along the continuum, while others are useful only at one specific point.

Rapid alert activities can follow prediction or identification of a food safety hazard at any stage of the continuum.

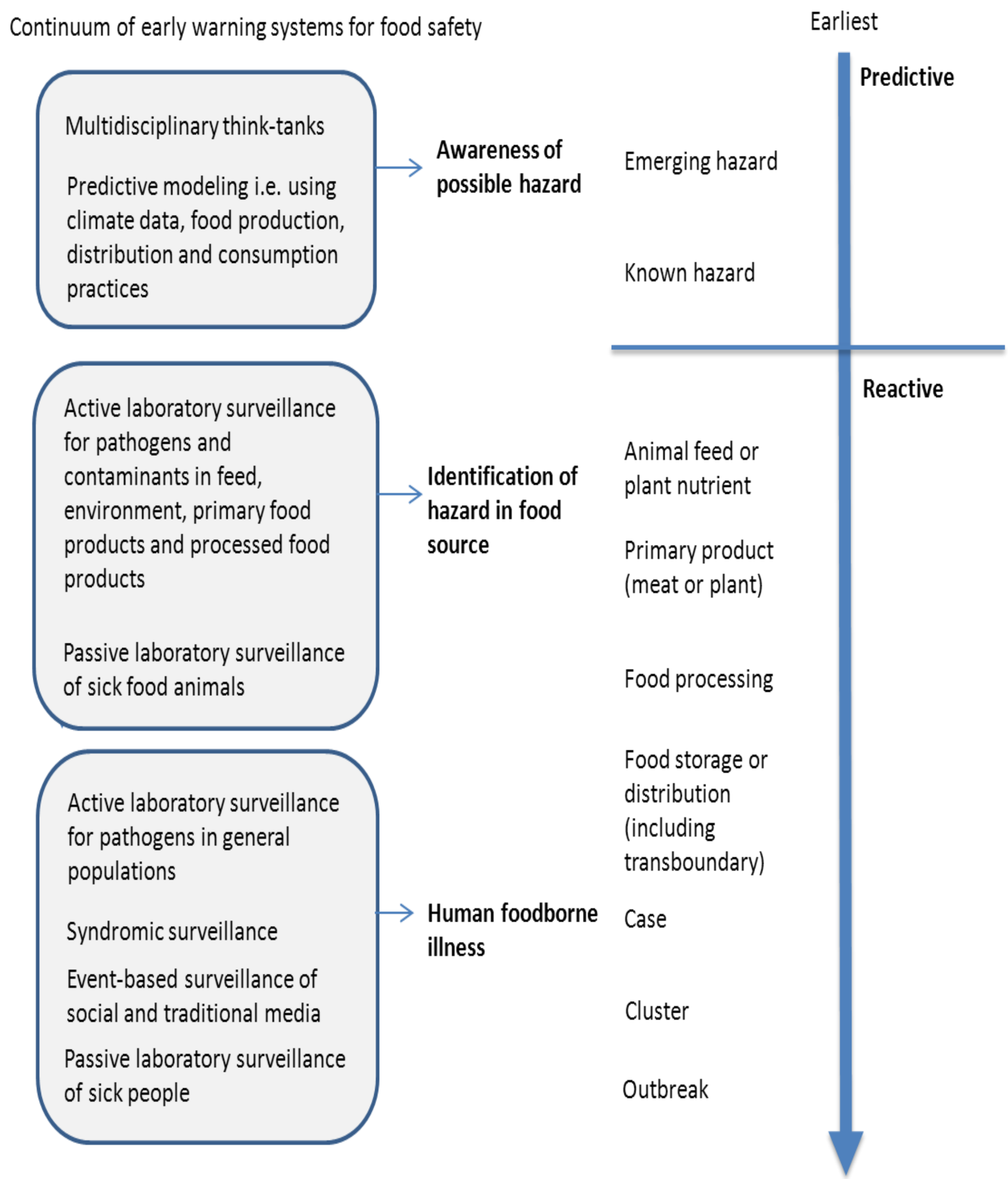


Figure 1: How early warning systems for food safety exist along a continuum

Descriptions of existing EWRA systems

Many of the systems described in the publically available literature consist of only one or two components from among a larger number of potential EWRA sub-components. The majority of early warning systems are reactive systems that collect, analyze and interpret data from running hazard or disease monitoring and surveillance programs.

Common and potential future EWRA platforms

Programs that are reliant on technological solutions may not be successful even though there is a perception from the published literature that technology is necessary for an EWRA food safety system. EWRA programs will need to focus surveillance at critical points and be tailored to make use of local technologies and strengths.

Expert online respondents identified active surveillance in humans for known foodborne pathogens as the most effective way to obtain early warning of food safety events, followed by event-based surveillance and syndromic surveillance. There may be a role for syndromic surveillance in LMICs where access to a strong public health infrastructure and specialized laboratories are limited.

Builders, users and jurisdictional context for EWRA systems

There was no consistency with respect to the ideal combination of individuals and organizations necessary to develop, run and use EWRA systems. As a result of known and anticipated differences between regions and countries, we cannot expect there to be one best practice or approach with regards to who (individual and organization) should be involved in building and sustaining EWRA systems. We therefore recommend that EWRA systems strive to identify and utilize locally available expertise, established competencies, resources and networks with the goal of supporting inter-agency and multi-disciplinary collaboration.

Components needed to build an EWRA system

Key factors identified in the literature with regards to improving or contributing to the success of public health surveillance systems, including EWRA systems for food safety, mirror those attributes that have been proposed as important considerations for the evaluation of public health surveillance systems.

Key limiting factors identified in the literature that could hinder the success of public health surveillance systems in LMIC's, including EWRA systems for food safety, include 1) a gulf in surveillance capacity between HICs and LMICs as a result of access to and use of high-tech surveillance applications (e.g. smartphone technologies) in the former, 2) a lack of tangible benefits to the affected populations, such as feedback and beneficial responses to mitigate disease problems, 3) a lack of capacity to enforce regulations, and 4) poor communication between institutions at the national level. Expert online survey respondents suggested that the most limiting factors for effective EWRA systems include 1) reporting speed and the timely sharing of information amongst stakeholders, 2) consensus on what early warning indicators to monitor for and when to act on that information, 3) data management and 4) financial support for EWRA systems. With specific regards to LMIC's or countries with limited financial resources, the limited information on foodborne disease burden of illness and the presence of other competing local health priorities will likely relegate early warning and rapid alert systems for foodborne disease in LMICs to a lesser priority against these other public health issues.

There is unlikely to be a “one-size-fits-all” EWRA system that can be used across varying geographic, political, social and economic regions. A more appropriate goal might be to work with individual countries to identify gaps in their current surveillance systems, and then adapt or implement the key factors that are feasible given that unique situation.

Scope and use of EWRA systems

The integration of multiple surveillance approaches is more likely to identify a greater number of events than is possible through the use of a single surveillance method. EWRA systems for detecting food safety events should therefore integrate all readily available information gathering methods in a given region or country, including person-to-person networks as well as more complex laboratory and media-based methods. Nevertheless, specific surveillance approaches might be better suited for certain situations, such as:

- Geographically disseminated outbreaks of known pathogens that occur when food from a single source is distributed over large areas, such as in the North America food distribution system, might best be detected by careful laboratory characterization of pathogens.

- Small localized outbreaks and those involving non-reportable pathogens might be best detected by consumer-driven or complaint-based syndromic surveillance using a simple network-based approach in which people report events to a well-known, easy to access local contact point.

- For countries that lack laboratory capacity and food safety systems, syndromic surveillance of internet sources (i.e. news services, ProMedMail), and testing of sick travelers returning to countries with more developed health infrastructure might provide warning of changes in foodborne disease patterns.

Evaluating EWRA systems

One key *systematic* review paper (Drewe et al., 2012) examined 99 other papers with a focus on evaluation of surveillance systems for human and animal diseases, and found that the specific criteria used to evaluate surveillance systems was not consistent between these papers. However, quantitative evaluation (sensitivity [ability to detect events], timeliness and data completeness) were the most commonly reported criteria for evaluation.

Our literature search returned six evaluations of EWRA systems that included both qualitative and quantitative criteria; none were assessments of food safety systems, and only one focused on enteric illness including foodborne disease (Cretikos et al., 2008).

Because optimal evaluation criteria and approaches are specific to the objectives of an EWRA system, clear objectives and benchmarks for efficacy should be set by stakeholders during system design and must be understood by evaluators. During evaluation, the performance of the system can be compared to these objectives and benchmarks. Frameworks, in particular those produced by the CDC and WHO, have been developed for evaluating the efficacy of surveillance systems – these evaluative criteria are relevant to EWRA systems for food safety. Both quantitative and qualitative approaches, as presented in these frameworks, are necessary to fully evaluate an EWRA system.

Gaps and recommendations identified in the literature

The literature review identified 35 papers that discussed gaps and needs in current EWRA systems, and 33 that provided recommendations to develop or improve EWRA systems. Slightly over half of these papers focused on EWRA systems for food safety events, primarily outbreaks of foodborne illness, while the others focused on EWRA systems for other types of health events. Gaps, needs and recommendations were primarily made on the basis of author experiential knowledge, rather than on empirical evidence. After review of the literature, we determined that findings related to gaps, needs and recommendations fell under one or more of seven thematic areas. The seven themes and their main sub-components are as follows:

Themes	Sub-components	
Developing Technology	• Hardware • Platforms	• Software • Timeliness
Organizing	• Policy ➢ Jurisdiction ➢ Regulations ➢ Support	• Resourcing • Responsibility • System structure
Building Capacity	• Financial • Human	• Physical • Technical
Standardizing	• Common definitions • Databases • Hazards to be monitored	• Laboratory techniques • Sampling strategies
Connecting	• Barriers ➢ Feedback ➢ Financial costs ➢ Privacy concerns ➢ Proprietary information ➢ Threat of sanctions ➢ Trust	• People, systems, system components and timespans • Sustaining • Timeliness
Responding	• Human capacity • Protocols and procedures • Timeliness	• Signal ➢ Background noise ➢ Real event
Evaluating	• Standardizing	

A bulleted summary of the gaps, limitations and needs, and the recommendations for improving capacity gathered during the review of the public domain literature follows. An in-depth discussion of these thematic areas can be found in the full report.

Developing technology

- Build on the success of the existing platforms i.e. FoodNet, the Salmonella network
- Address costs for hardware, software and laboratories in developing countries
- Ensure that web-based data mining platforms and systems utilize languages other than English
- Use front-line workers and mobile-phone based surveillance as a supplement to diagnostic laboratory-based surveillance
- Understand evolving use of social media platforms
- Improve and use web-based daily questionnaires for health (WDQH) for syndromic surveillance to collect data from healthy as well as diseased individuals

Organizing

- Identify responsibility for costs and financial support
- Identify jurisdictional responsibility
- Identify or create regulation to support data collection and response activity
- Identify responsibility for International Health Regulation obligations
- Ensure surveillance officers are available within health programs
- Purposefully organize expert and data sharing networks

Building Capacity

- Ensure adequate human resource capacity for investigating and reporting foodborne illness
- Ensure financial support to facilitate integrated surveillance of *Salmonella* along the food chain
- Reduce financial barriers to test for and control foodborne infections in humans when health care is cost prohibitive
- Plan for capacity needs in local health departments for dealing with large foodborne illness outbreaks

Standardizing

- Standardize and build awareness of terminology related to EWRA systems for food safety
- Standardize definitions of syndromes across syndromic surveillance studies
- Standardize techniques to evaluate whether syndromic surveillance systems provide an early warning of outbreaks of food safety events
- Optimize surveillance system and diagnostic laboratory data sharing worldwide by overcoming barriers to laboratory data standardization

Connecting

- Create timely information exchange amongst experts and to reporting agencies
- Link systems and databases across geography and institutions
- Link experts across geography and institutions

- Find sustainable ways to collect and process clinical data from practitioners for use in surveillance
- Incorporate local knowledge from front line health care workers
- Integrate existing scientific and technological components and data sources to generate real-time intelligence
- Work to overcome barriers related to reporting which may include lack of trust, threat of sanctions, absence of direct or tangible benefits and lack of feedback or beneficial response
- Provide accessible information to the public

Responding

- Develop protocols and procedures for preventing identified hazards from causing food safety events
- Minimize time between the date of the first event or the first case of illness and the final date of summary reports
- Have a predetermined process for aberration follow-up in syndromic surveillance systems
- Have investigative teams in place to respond to alarms

Evaluating

- Develop consistent techniques to evaluate whether syndromic surveillance systems provide an early warning of events such as food safety events
- Evaluate how to optimize algorithms for automated surveillance using both naturally occurring outbreaks and simulation studies

Expert Online Survey

An online English language survey (Fluid Surveys[3]) was conducted to gather expert opinion about EWRA systems for food safety, specifically about the role of EWRA systems in improving food safety, critical elements for EWRA systems, limitations to developing reliable EWRA systems, how best to assess EWRA systems, and how all of these subjects might vary by organizational or resource levels. Although we asked survey respondents to provide their name for feedback and correspondence, responses were not analyzed in association with expert's names and all respondents had the option to respond anonymously.

The survey questions were developed from a subset of the 20 questions initially supplied by the FAO collaborators and from preliminary results of the scoping interviews and literature review. We provided as complete a selection of response options as possible so that participants would be able to focus on the more subtle aspects of the issues at hand rather than having to identify any missing elements. A draft of the survey questionnaire was reviewed by our FAO collaborators and tested on our full study

[3] www.fluidsurveys.com

team and selected professional contacts (n=10). This process allowed us to refine the online survey, identify significant gaps or redundancies, and confirm clarity of the questions.

Survey timeframe and participant profiles

Between December 4, 2012 and January 2, 2013, 645 individuals were invited to participate in the survey. Three hundred-thirty-three individuals opened the online survey, of whom 149 (45%) submitted partially or fully completed surveys. Nine of the 149 survey submissions responded to less than 50% of the questions and were omitted from analysis, resulting in 140 submissions that were included for further analysis. The median survey completion time was 31 minutes (Quartile 1 = 23 min; Quartile 3 = 48 min). The survey ended on January 7 at 5 pm GMT.

Survey participants were asked to record the country(ies) in which they have worked in food safety, surveillance or allied activities (for example, food science, laboratory diagnostics, animal health or zoonotic pathogen surveillance systems) within the past 10 years. One-hundred-eight (108) countries or regions (i.e. “European Union” or “Central America”) were represented. In some instances respondents reported working in more than one country. While there was high representation of experts working in North America and Europe, 31 LMIC countries were also represented. The 10 countries named most often are presented in Table 2.

Table 2: Top 10 most reported countries in Q2 of the online survey. Because some respondents named multiple countries, the total was 281.

Country	Frequency	% of Total Frequency	Country	Frequency	% of Total Frequency
Canada	32	11	Australia	7	2
USA	28	10	Europe	6	2
United Kingdom	10	4	Switzerland	6	2
Italy	9	3	France	6	2
The Netherlands	8	3	Germany	6	2
Egypt	7	2	**Total Frequency**	**281**	**43**

Respondents were asked to self-identify as experts or non-experts in *food safety*. Fifty-nine percent of respondents (79/135) self-identified as experts and 41% did not. Self-identified food safety experts had a median of 16 years of experience (Quartile 1 = 10; Quartile 3 = 23; n = 78). Respondents also self-identified as having experience in EWRA, which we defined as ‘a system(s) that enables the early recognition of an animal health, public health or food safety event, and that uses tools to allow for the rapid and coordinated response to prevent the further spread of a foodborne disease’. Seventy-four percent self-identified as experts. Self-identified experts had a median of 10 years of experience in EWRA (Quartile 1 = 5; Quartile 3 = 12), approximately 5 years less than the median years of experience in food safety. The majority (59%, N = 98) worked in EWRA practice/service delivery, and 21% had worked as system evaluators.

Respondents were asked to indicate which of the listed surveillance systems are used to monitor for food safety events in the country in which they were working at the time of the survey. The majority

(>80%) indicated that passive surveillance was used to monitor for food safety events in animals, humans, and food samples. Event-based surveillance and syndromic surveillance were used less often, at 73% and 60%, respectively. Active surveillance for known foodborne pathogens in animals was used more frequently than active surveillance in humans for known foodborne pathogens (75% and 53%, respectively). However, there were many comments by participants at the end of the survey that although some surveillance was occurring, there was not a complete, functional EWRA system in place.

Roles and uses of EWRA systems for food safety

This section of the expert online survey asked experts for their opinions about the roles of EWRA systems for food safety, including their usefulness for meeting various food safety goals, the types of events they are most likely to detect, and expected differences between HICs and LMICs. Results show that most respondents were of the opinion that EWRA systems are useful or very useful for meeting food safety goals.

Experts believed that the food safety events that are of highest priority to detect are those that increased burdens of disease (outbreaks, increased numbers of deaths) and those that involve unsafe food products moving between countries. However, the results also show that experts believed it is important to detect all types of food safety events, with > 60% of experts agreeing or strongly agreeing that EWRA systems should detect even the events that were collectively ranked as the least important to detect (for example, the index cases of human and animal origin).

Experts believed EWRA systems were most useful for detecting food safety events involving reportable pathogens, and hazards in livestock and aquatic animals, but were still useful for detecting non-reportable pathogens and food contamination events. Experts believed that more significant events, including events affecting more people, events causing severe health impacts, and events affecting large geographic regions, were most likely to be detected by EWRA systems. This might indicate that experts believe the existing EWRA systems they have worked with lack the mandate or capacity to detect food contamination or foodborne illness occurring on a smaller scale.

To examine how the role of EWRA systems for food safety may be similar or different in high versus low-to-middle income countries, we asked respondents to rank eight objectives in each setting (HIC versus LMIC). Respondents were to answer only for settings in which they had first-hand experience. More experts had experience in HIC (n=103) than LMIC (n=88) situations. Experts prioritized roles similarly in both settings, except that for LMICs respondents ranked reducing endemic infections (LMIC-rank 1 (tie), HIC-rank 3) and decreasing the economic cost of lost production (LMIC-rank 6 (tie), HIC-rank 8 (tie)) higher than for HICs (Table 3).

We asked experts how effective EWRA systems for food safety are at detecting events of different hazards, scales, sources, and settings. Experts rated them as most effective for detecting food safety events involving reportable pathogens, occurring at a national or supranational level or causing disease outbreaks. They felt that EWRA systems were equally effective for intentional and non-intentional hazards.

In all systems that require identification of events, in this case EWRA systems for food safety events, there is a choice to be made between 1) detecting all true events but wrongly classifying normal periods as problematic events relatively frequently (higher sensitivity, lower specificity) and 2) missing some true events but wrongly classifying normal periods as problematic events less often (higher specificity,

Table 3: Expert ranking of roles of EWRA systems for food safety in high income countries (HICs) and low to middle income countries (LMICs). Numbers are presented as HIC / LMIC.

Role of EWRA for food safety	n	median	Rank	% rank
Decrease burden of disease/ death	103 / 83	2 / 2	1 / 1	44 / 48
Reduce the number and frequency of foodborne outbreaks	102 / 83	2 / 2	2 / 2	29 / 28
Reduce endemic foodborne infections and disease in people	102 / 83	4 / 3	3 / 1	21 / 23
Identify hazards in products prior to shipment to the consumer	102 / 83	4 / 4	4 / 3	22 / 18
Prevent the distribution of affected products	102 / 83	4 / 4	5 / 4	19 / 22
Maintain in-country consumer confidence in food safety	101 / 83	6 / 6	6 / 6	31 / 25
Decrease the economic cost of loss production	101 / 83	6 / 6	8 / 6	24 / 25
Protect international export markets	101 / 83	7 / 6	8 / 8	31 / 31

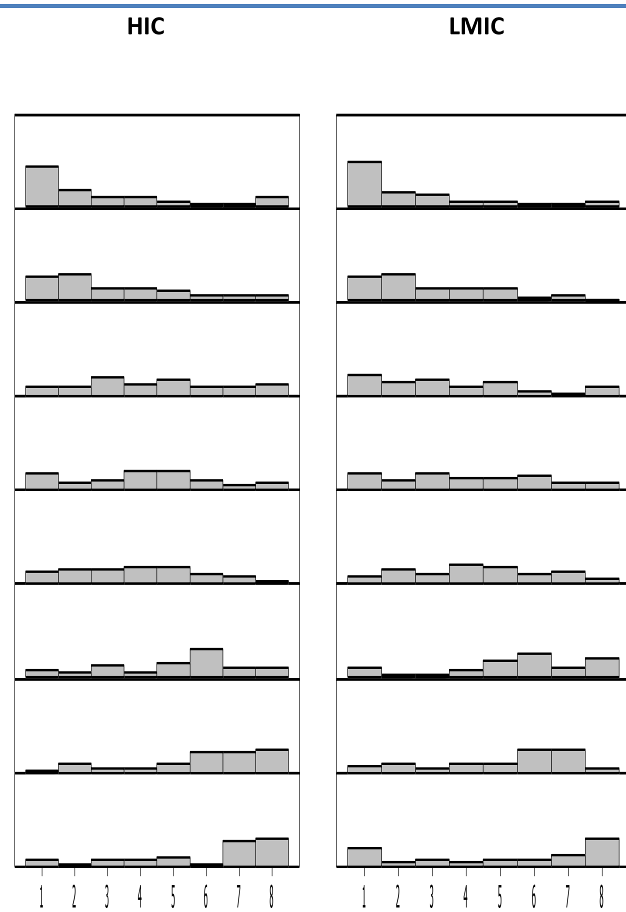
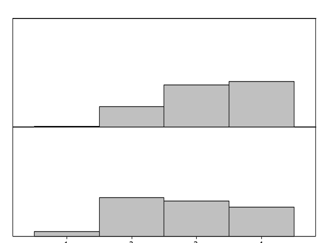


Table 4: Expert opinion of the importance of EWRA for food safety relative to other health priorities (1=not important, 2=somewhat important, 3=very important, 4=essential)

	n	Do not know	Med	mode	% mode
HIC	119	3	3	4	42
LMIC	92	9	3	2	36



lower sensitivity). We asked experts to choose how sensitive and specific they would like an EWRA for food safety to be. The majority of respondents preferred a more sensitive, less specific system (n=93) versus an equal (n=9), or a more specific, less sensitive system (n=38).

Finally, we examined experts' opinions about the priority of EWRA systems for food safety when compared to other health issues that might be competing for similar resources in both HIC and LMIC settings. In both settings the median choice was 'very important'; however, for HICs most respondents (represented by the mode) rated EWRA systems for food safety as 'essential', while for LMICs most respondents rated these systems as 'somewhat important' (see histograms in Table 4). In other words, food safety, foodborne illness and EWRA systems for food safety tended to be of lower priority in LMICs than HICs.

Components of an EWRA system

We asked the online survey participants about the importance of various public policy components of EWRA systems for food safety at international, national and within-country regional levels [1(not at all important) through 5 (very important)]. All components had a median rank of 4 or 5, indicating that experts felt that adequate public policy support at all levels was necessary for EWRA systems to function. Policy support at the national level and legislation to stop production and distribution of contaminated products were considered most critical.

All types of surveillance methods or systems were ranked as likely or very likely to provide early warning of food safety events, indicating that as a group, they did not favor one surveillance method strongly.

We provided a list of potential stakeholders in EWRA systems for food safety and asked when each stakeholder group should be involved in a national level system. Most experts saw a role for most stakeholder groups in all levels of designing, operating and evaluating systems, suggesting that EWRA systems must integrate a variety of viewpoints in order to function effectively. Interestingly 23% and 18% of experts felt that the lay public and politicians respectively should never be involved in EWRA systems for food safety.

All skill sets were ranked as essential or very important for running an EWRA system for food safety, suggesting that EWRA systems cannot rely on a single skill set but must integrate a variety of skill sets in order to function effectively. All physical capacity components (other than fax) were ranked as 'very important' or 'essential'. Access to both technology (internet, communications, and computers) and to classical microbiology laboratories were considered essential.

We asked the experts, based on their experience, to distribute 100 units of resources to potential components of a national EWRA system for food safety in a hypothetical HIC and a hypothetical LMIC. One hundred and seven experts self-identified as having sufficient experience to answer the question for a HIC situation, while 82 had sufficient experience to answer the question for a LMIC situation. Most participants chose to distribute resources fairly uniformly in both high and low resource settings (Table 5), which might indicate that they value a 'whole system' approach to EWRA. However, some individuals chose to provide zero or few resources to some components, suggesting that some components could be sacrificed to improve resources available for other components. In LMIC settings, data management and data sharing were the components that ‘lost’ the most resources compared to HIC scenarios. These resources appeared to go instead to increasing laboratory capacity, food inspections systems, and education and outreach on food safety standards. Laboratory capacity and food inspections systems ranked 1-2 in both situations, with participants distributing a higher proportion of total resources to both in the LMIC situation. These two categories also had the widest distribution of responses among the choices provided. The largest change was a 51% increase in resources apportioned to education and outreach on food safety in the LMIC scenario as compared to the HIC scenario (Table 6). Education and outreach moved from 8^{th} in HIC to 3^{rd} in LMIC; data management fell from 4^{th} in HIC to 8^{th} in LMIC; and active surveillance dropped from 3^{rd} in HIC to 4^{th} in the LMIC setting.

Placing a greater proportion of resources into laboratory capacity, food inspection systems, and active surveillance appears to be consistent with participant answers to another online survey question, where they ranked active surveillance for foodborne pathogens in humans and in animals as the first and third most effective surveillance methods to provide early warning of food safety events.

Table 5: Expert opinions about allocation of resources in EWRA systems for food safety in high income countries (HIC’s) and low-to-middle income countries (LMIC’s) (means are % of 100 units of resources)

	HIC N=107		**LMIC N=82**	
Allocation	mean	Se mean	Mean	Se mean
Laboratory capacity	16.6	0.7	20.6	1.3
Food inspection systems	13.7	0.8	15.1	1.1
Active surveillance	12.3	0.7	10.3	0.6
Data management	10.7	0.5	8.3	0.6
Event-based surveillance	10.1	0.5	9.3	0.6
Field investigation	9.7	0.4	9.0	0.6
Passive surveillance	9.1	0.5	8.5	0.7
Education and outreach on food safety hazards	9.0	0.5	13.6	1.0
Data sharing	8.6	0.6	5.4	0.4

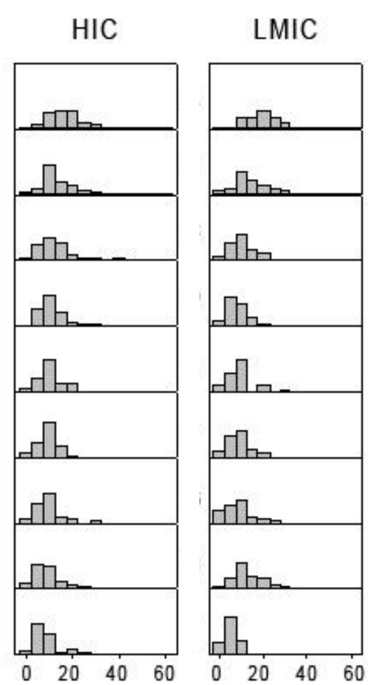


Table 6: Expert ranking of needs in EWRA systems for food safety in high income countries (HIC's) and low-to-middle income countries (LMIC's)

Allocation	HIC Rank	LMIC Rank	Resource change (%)
Laboratory capacity	1	1	+24
Food inspection systems	2	2	+10
Active surveillance	3	***4***	-16
Data management	4	***8***	-22
Event-based surveillance	5	5	-7
Field investigation	6	6	-8
Passive surveillance	7	7	-7
Education and outreach on food safety hazards	8	***3***	+51
Data sharing	9	9	-37

Limitations of an EWRA system

We asked experts what limited the effectiveness of EWRA systems for food safety in countries in which they had worked in the last 10 years. We examined limitations caused by gaps in various components including technology, expertise, public policy, capacity to react to events and stakeholder involvement. Overall, data sharing, data management, data reporting speed and timely information sharing amongst stakeholders were considered to be the most limiting factors, followed by financial support, both as an ongoing public policy priority, and as a limiting factor to the capacity to react to events. Technical capacity such as ability to detect hazards and pathogens, and expertise were seen to be less limiting factors. Together this seems to suggest that the necessary scientific capacity to detect and react to food safety events exists, but that funding, data management and communication are limitations to system success.

Semi-structured interviews

Semi-structured interviews took place after the results of previous research activities had been analyzed and synthesized. The interviews were used to collect in-depth knowledge and commentary on three topics specific to EWRA systems for food safety in LMICs that were repeatedly presented in the literature and/or in our communication with experts and about which there was no clear consensus of evidence or opinion.

The three topics were as follows:

- Options for supporting EWRA systems for food safety in the presence of other competing public health problems where financial resources are limited.
- Options for providing early warning of food safety events in countries where laboratory infrastructure is lacking or poorly developed/funded.

- Options to build and sustain human resource capacity and connect those working in EWRA systems for food safety within individual LMICs.

Fifteen experts were selected as candidates for the semi-structured interviews based upon professional information provided to us or publically available, or because they were authors of key papers identified during the literature review. All 15 candidates had expertise in food safety and EWRA systems and practical experience working in LMICs. Candidates were invited to respond in writing or through conversation by telephone or Skype. We solicited open-ended responses in order to collect rich and detailed data; written responses supplied by participants and notes recorded during phone-based interviews were then analyzed to examine where experts shared similar opinions, where their opinions differed, and what solutions they suggested for maximizing the effectiveness of EWRA systems for food safety in LMIC settings. Eleven of the contacted key experts participated in the semi-structured interviews.

Ways to support EWRA systems for food safety in LMICs

The key experts agreed with our finding that food safety and foodborne illness are of low priority for many governments and general populations in LMICs. Limited budgets and donor-driven funding likely encourage governments to focus on other problems such as food security and HIV, Tuberculosis and Malaria. In many areas, data on the burden of food safety events is not available for evidence-based decisions towards food safety. The need to develop EWRA systems for food safety is likely to be incompletely understood and accepted by stakeholders without significant collaborative groundwork.

Participants (n=8) also attributed the low priority given to EWRA systems for food safety to lack of consumer awareness of or interest in food safety and foodborne illness. This was in part attributed to citizen habituation to chronic and/or intermittent diarrhea and the inability to attribute diarrhea to foodborne illness, due to physician reluctance to submit samples or lack of laboratory infrastructure to perform testing. In addition, participants discussed the lack of education about or understanding of food safety and foodborne illness in the general population of many LMICs. One participant noted that where women do not have access to education infrastructure, this creates a barrier to knowledge sharing about food safety. Participants (n=5) also identified a lack of accountability of food producers for food safety as a probable reason for the low priority given to EWRA systems for food safety in LMICs.

Another important point to emerge from the discussion was that it is critical to identify what information is valuable to each stakeholder at the beginning of any program and enlist high levels of support. It is also essential to provide high levels of feedback on an ongoing basis, particularly because stakeholders might have been exposed to failed efforts driven by the international community in the past.

A final, unexpected point emerging from the expert responses to this question was the difference in priority targets for EWRA systems for food safety between LMICs and HICs. An example was provided by one participant who said, *"In the US, microbial food safety is the greatest concern; we have controls in place to regulate other hazards like pesticide residues. In some other countries, systems to regulate chemicals, such as pesticides may be absent or ineffective. On a Good Agricultural Practices training trip* *to an LMIC, I spoke with a national GAPs certifier. Hand washing didn't even make their list of criteria – their number 1 issue was the unregulated and inappropriate use of pesticides."*

While no participants identified specific EWRA systems for food safety in LMICs that were not already discussed in this report, some participants had insights into factors that might assist systems to function effectively. Four participants discussed the export of food products as a driver for creating food control systems in LMICs. One participant provided the following example of how education about food safety, driven by export requirements, improved health in workers at food processing facilities in an LMIC. "*A number of firms that implemented food safety practices, including worker health and hygiene training and providing clean kitchens for workers to prepare food, noted an improvement in worker health and health in the community, with workers either taking their new knowledge home or the firm reaching out to the community (recognizing the kids could be their future workforce). With education and awareness, and improved conditions and health, also came a pride in having accomplished these things*". Five participants reported that support from international organizations was an important contributor to the success of EWRA systems for food safety in which they had worked. Most participants agreed that evidence about the impact of food safety events on health in LMICs is a prerequisite for increasing the priority given to EWRA systems for food safety.

Ways to provide early warning of food safety events in countries where laboratory infrastructure is lacking or poorly developed/funded

The interviewed experts did not agree on one best approach to detecting food safety events in countries where laboratory infrastructure is inadequate. Where long-term funding and training are available, in-country laboratories are preferred. However, where this is not probable, developing partnerships with adequately resourced, quality-controlled laboratories in other countries may be preferable to developing complex or expensive systems that are unlikely to be sustainable. As was our finding in the literature review and online expert survey, there was no consensus amongst the 11 key experts about the need for laboratory capacity in LMICs. Five experts discussed how laboratory capacity was a necessary component of EWRA systems for food safety. However, three other experts presented a divergent viewpoint. One argued, *"National experts almost always want more investments in laboratories although there is very little evidence that this is cost-effective or sustainable."* Three experts pointed out the importance of having quality control and accreditation for any laboratory performing food safety testing. One indicated that *"quality assurance is a big issue because of lack of oversight and incentives."*

Participants discussed a variety of options to make laboratory services cost-efficient and sustainable, such as the sharing of laboratory services between countries and better collaboration among multiple sectors within a country (e.g. human health, animal health, plant health, environmental monitoring) to share diagnostic and surveillance resources. However, participants mentioned that policy barriers may make these options difficult to implement.

Five participants discussed using surveillance methods, such as syndromic surveillance, that did not require laboratory services as an option for providing early warning of food safety events. One participant stated, "*Syndromic surveillance is a low-cost option that can certainly be beneficial if the* *alternative is nothing and if interventions will be unspecific. However, in the case of specific interventions, e.g. use of antimicrobials, responsible therapy will always require a specific diagnosis."* Participants discussed using media to share information about food safety events. Specific suggestions included *"utilising mobile phones to inform district or public health centres when food safety incidents start appearing within a community"* and *"utilising local mass media to inform the local community of potential food contamination and ways to take precautionary measures."* Although syndromic surveillance systems, particularly those that use mobile technology, were identified as important for the early detection of events, a number of participants cautioned that syndromic surveillance does not eliminate the need for laboratory capacity.

Two participants discussed on-site testing using molecular technology (e.g. snap tests) as an approach to disease diagnosis and monitoring in LMICs. One said *"the development of rapid on-site tests for major pathogens probably represents the best option."* The other stated *"I think focus should be on pen-side use of molecular technologies that could provide efficient diagnosis in non-lab environments to inform evidence-based treatment."*

Ways for LMICs to build and sustain human resource capacity for EWRA food safety systems

The experts participating in the semi-structured interviews agreed with our finding that sustaining human resource capacity is an ongoing challenge in LMICs that have built components of EWRA systems for food safety. Providing mentorship, recognition of achievement and educational opportunities may reduce expert emigration from LMICs. Face-to-face interaction through methods such as in-person meetings and co-location of experts from different ministries are critical to creating collaborative networks. Including non-governmental organizations and universities as partners in EWRA systems might reduce destabilization of networks caused by changes in governments.

All participants stated that establishing strong interpersonal networks between experts was a key requirement for building and sustaining human resource capacity, and in-person meetings and workshops were seen as an important step to building these networks. The co-location of offices and people (even if they report to different ministries) was discussed as another powerful means of fostering relationships. Electronic methods were seen as supplementary means of maintaining networks which had been formed by in-person interactions. Two participants suggested that incentives were important drivers of collaborative efforts. One incentive discussed as a driver of collaboration was the opportunity to export food products.

Six participants related how supporting the effort of local food safety experts in LMICs was necessary to retain expertise and reduce turnover rate. Examples of training institutes that provide training to food safety experts from LMICs include the One Health training program run at Massey University for Asian countries[4] and the International Food Safety Training Lab at the University of Maryland[5]. Two

[4] http://www.onehealth.org.nz/index.php/oh-hubs
[5] http://ifstl.org

participants specifically mentioned the importance of providing support for young workers through mentorship programs. One said it is important to *"encourage new researchers to take up challenging projects and to apply for national and international grants in order to develop the EWRA system."*

Changes in elected governments were identified by four participants as causing negative impacts on human resource capacity for EWRA systems for food safety in LMICs. "*Every 6 years a presidential term ends and there are changes in the majority of staff. This makes it difficult to maintain the continuity of health programs."* Another said, *"In some countries there is a high turnover in national agencies; when a new administration takes over, resignations within the agency may reach down to the lower levels (often including the people who had been doing the day-to-day work and therefore had the expertise)."* As a solution, *"finding bodies, such as universities, with more stability and with expertise or the ability to build it . . . In some instances, industry associations have also been more stable and can be motivated by benefits to their reputation and livelihood."*

Methodological Limitations

Methodological limitations can be found in the full report, and will not be discussed in detail here. Nearly all of the identified limitations stem from the requirement to conduct within six months a literature review, an online survey with food safety experts from representative regions on all continents, and semi-structured interviews with key food safety experts. Although we recognized and tried to accommodate most limitations at the time of data collection, some limitations were only identified in hindsight during analysis of results.

Looking Forward

Despite the challenges in identifying Early Warning and Rapid Alert experts and programs globally, the findings from this rapid literature review and expert survey provide a useful first attempt at identifying the potential principles, components, and practices needed for establishing or enhancing EWRA systems for food safety. Based on our experience in conducting this research and writing this report, we recommend the following in order to better define those potential principles, components, and practices:

1) Our understanding of the identified EWRA systems is based on publically available written materials. Discussions with the developers of these systems may bring additional insight as to the mandates and technical/operating processes, as well as known challenges, of operational EWRA systems.
2) Our findings were unintentionally biased towards infectious and biological foodborne illnesses in humans and animals, with minimal findings relating to non-biological (e.g. chemical, toxic and radioactive) hazards in food and feed products. If this accurately reflects the current mandates of operational EWRA systems globally, we will need to explore ways to facilitate the early warning of non-biological hazards in these systems.

3) National food inspection agencies were not captured by this review as named EWRA systems. This was unfortunate, in that many of these inspection agencies function in the capacity as early warning (and in some cases rapid alert) systems. Including these agencies along with "named" EWRA systems in future reviews will be important to gain a full understanding of EWRA capacity at the country level. Efforts to identify and agree on a standard and uniform terminology for EWRA systems and their components might be useful as part of this process.
4) Competing health and social priorities in many countries can be expected to divert resources away from the implementation and running of EWRA systems. Systems and approaches that respect these competing priorities, and yet allow for EWRA capacity, should be explored.
5) Expert consensus as to the necessary principles, practices and framework elements of functional EWRA systems for food safety was not achievable within the constraints of this project. It would be useful to gather experts together to discuss the issues and share their experiences in order to develop a better understanding of the principles and practices that have the best opportunity to support developing and sustaining EWRAs in a variety of contexts.

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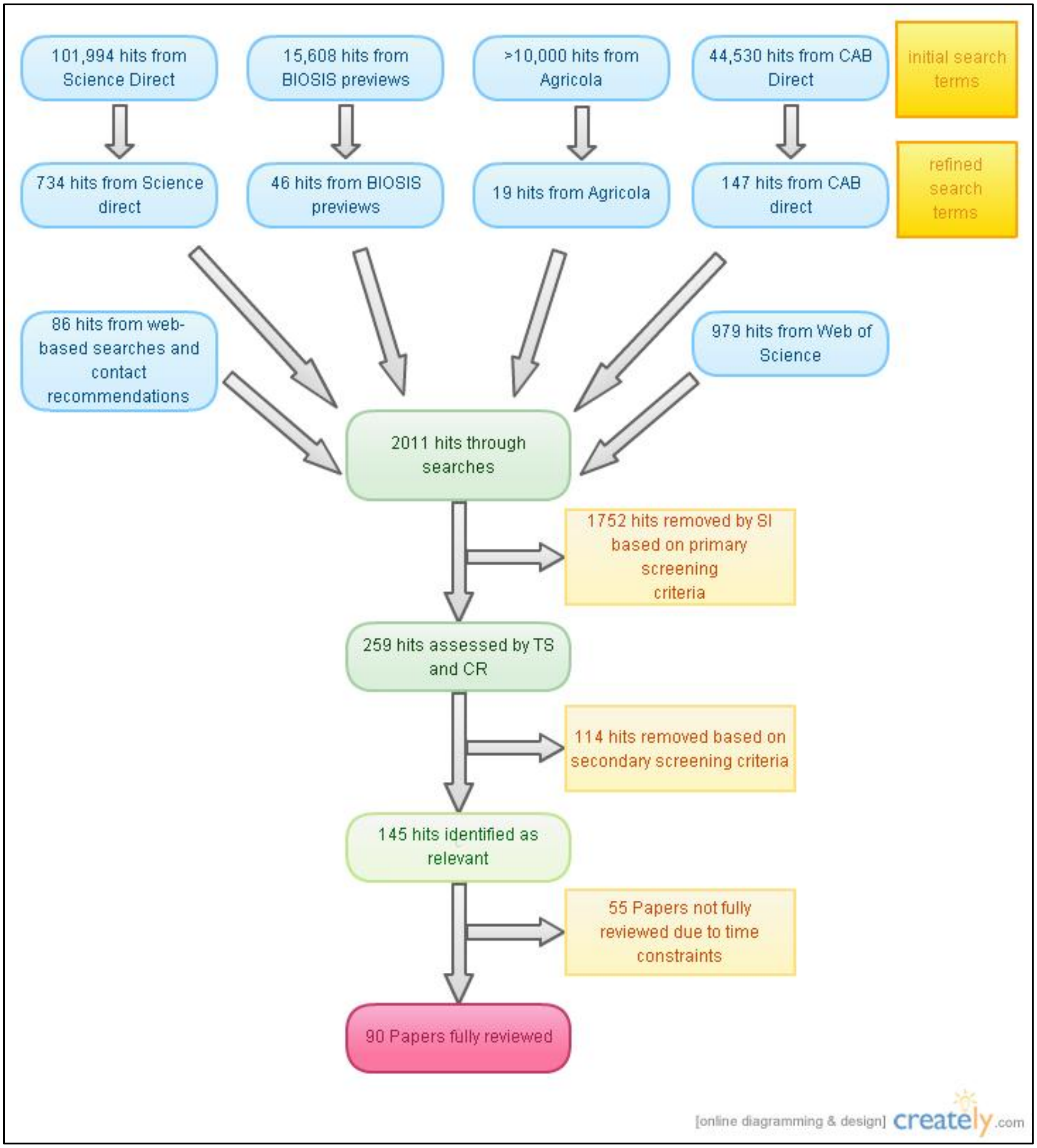
Appendix 1 – Results flow chart for the Literature Review



Appendix 2 - Primary capacity and scope of 33 reactive food EWRA systems

Reactive Food Alert and Warning Systems by Name & Acronym	Country	Complaint-based	Event-based	Food Inspection	Lab-based	Multiple	Syndromic	Grand Total
Early Warning		**4**	**3**			**4**		**11**
International			**2**					**2**
Global Public Health Intelligence Network – GPHIN	Canada		Y					
Health Map	United States		Y					
National		**1**	**1**			**4**		**6**
Electronic Foodborne Outbreak Reporting System (CDC) - eFORS	United States		Y					
French Food Safety Agency Salmonella Network	France					Y		
Health Protection Agency - Centre for Infections - HPA-CFI	England / Wales					Y		
Malaysian Foodborne Diseases Network – MyFoodNet	Malaysia					Y		
National Health Service Direct - NHS Direct	England / Wales	Y						
National Institute of Public Health - Epidemiology and Surveillance Unit – RIVM	Netherlands					Y		
Regional		**3**						**3**
Minnesota Foodborne Illness Complaint Line	United States	Y						
RUsick2 Forum	United States	Y						
Toxic Exposure Surveillance System	United States	Y						
Rapid Alert			**2**	**1**	**1**	**3**		**7**
International			**1**	**1**		**2**		**4**
International Food Safety Authorities Network – INFOSAN	Switzerland					Y		
MedISys (Europe Media Monitor) - MedISys (EMM)	Not Stated		Y					
Rapid Alert System for Food and Feed – RASFF	Italy					Y		
World Animal Health Information Database – WAHID	Not Stated			Y				
National			**1**					**1**
Computer Assisted Search for Epidemics – CASE	Sweden		Y					
Regional					**1**			**1**
New South Wales Enteric Disease Outbreak Surveillance System (OzFoodNet)	Australia				Y			
(blank)						**1**		**1**
Infectious Diseases Information System – ISIS	Not Stated					Y		
Early Warning & Rapid Alert			**2**	**1**	**7**	**4**	**1**	**15**
International			**2**	**1**	**2**	**1**		**6**
Semantic Processing and Integration of Distributed Electronic Resources for Epidemics – EpiSPIDER	United States		Y					

Reactive Food Alert and Warning Systems by Name & Acronym	Country	Complaint-based	Event-based	Food Inspection	Lab-based	Multiple	Syndromic	Grand Total
Global Framework for the Progressive Control of Transboundary Animal Diseases (OIE) - GF-TAD	Italy			Y				
Global Outbreak Alert & Response Network – GOARN	Switzerland					Y		
Program for Monitoring Emerging Disease – ProMed	United States		Y					
PulseNet International	United States				Y			
World Health Organization Global Salmonella Surveillance	Not Stated				Y			
National					**5**	**2**	**1**	**8**
CaliciNet (CDC)	United States				Y			
Early Warning Outbreak Recognition System – EWORS	Indonesia						Y	
Foodborne Diseases Active Surveillance Network – FoodNet	United States				Y			
National Outbreak Reporting System (CDC) – NORS	United States					Y		
National Salmonella Surveillance System – NSSS	United States				Y			
OzFoodNet	Australia				Y			
Public Health Laboratory Information System – PHLIS	United States				Y			
Robert Koch Institut – RKI	Germany					Y		
Regional						**1**		**1**
Integrated Salmonella Surveillance – ISS	Canada					Y		
Grand Total		**4**	**7**	**2**	**8**	**11**	**1**	**33**

I4082E/1/10.14