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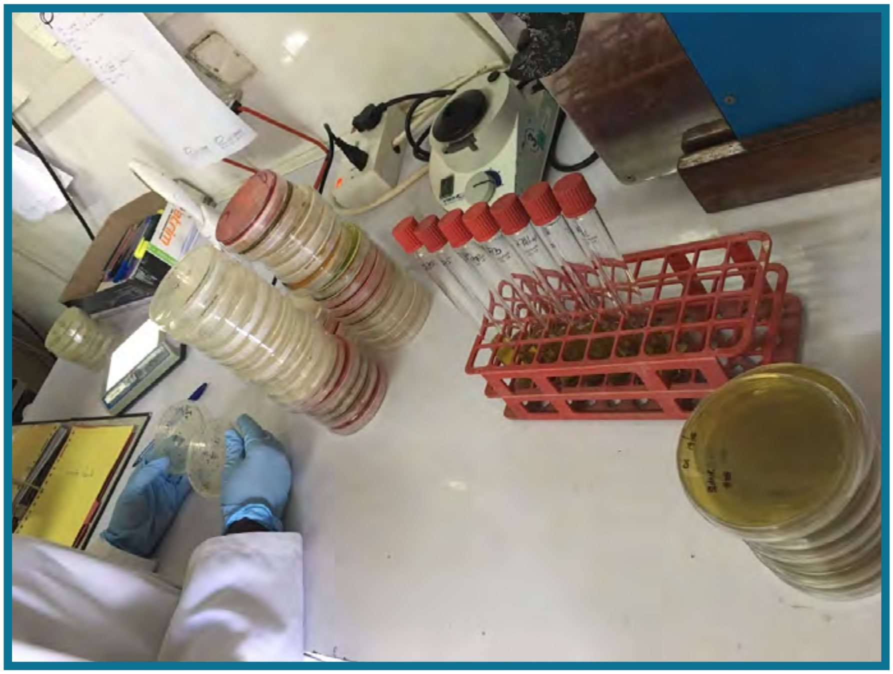

A Needs Assessment of Practices and Procedures in African Food Safety Testing Laboratories

ABSTRACT

A needs assessment was designed and disseminated to gather information on the behavior, attitude, knowledge, and skills of personnel in food safety testing laboratories in three African countries. Data were collected via a self-assessment (completed online) and during on-site visits (approximately 3 months later). The results demonstrated discrepancies between self-assessed and observed knowledge, behavior, attitudes, and skills/practices in the area of food safety. For example, answers to behavioral (10/24, 42%) and attitudinal (8/18, 44%) survey questions, by means of which participants self-assessed their agreement levels, were found to be contradicted during on-site visits. Similarly, discrepancies (self-assessed and observed) were observed in laboratory infrastructure (11/30; 37%), the number of samples analyzed (5/5; 100%), and general laboratory practices (4/8; 50%). Additionally, self-reported food safety knowledge and laboratory skills were found to be conflicting during on-site visits. As a result of this assessment, a number of issues and/or gaps were identified in the areas of laboratory infrastructure, sample handling, testing methodologies, data analyses, maintenance, troubleshooting, and training. The information from this assessment will be used to develop, deliver, and evaluate a curriculum that can be used to train food safety laboratory personnel in Africa.

INTRODUCTION

Consumption of unsafe food causes significant morbidity and mortality globally. Food may be contaminated by improper processing, becoming unsafe when it is time-temperature abused, cross-contaminated, handled improperly by employees with poor personal hygiene, or processed under unhygienic conditions *(22)*. As a result, bacteria, viruses, parasites, or chemical substances that come in contact with the food can make it unfit for consumption *(20)*. The World Health Organization (WHO) has estimated that Africa has the world's highest burden of foodborne diseases per capita. Despite recent advancements in food safety and other technological areas in the region, it is estimated that more than 91 million people fall ill and 137,000 die each year of foodborne diseases in Africa *(31)*.

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The death toll in the region, as a percentage of the total population (0.011%), is 12 times higher than in the United States (0.00093%) *(26, 31)*. The majority of the victims are infants, children, immunocompromised individuals, pregnant women, and the elderly. Diarrheal diseases cause 70% of foodborne illnesses in the African region where non-typhoidal *Salmonella* and *Escherichia coli* infections and cholera are the primary culprits, claiming almost 32,000 lives each year *(34)*.

In addition to the burden of microbiological foodborne illnesses in Africa, foodborne mycotoxins from grains are also of great importance. According to the Food and Agricultural Organization (FAO), 25 percent of the world's food crops are contaminated with different types of mycotoxins *(10)*. The most common mycotoxin in food is aflatoxin, which can cause chronic diseases such as cancer in humans *(6)*.

The involvement of the government in policy making for food safety standards and their role in the export and import of different commodities cannot be overlooked. If a country's food safety system is not rigorous enough or well-coordinated, exportation to other countries with more strict systems may be hindered *(8)*. Therefore, the establishment of a planned, well-organized food safety system and certification by national or international recognition bodies is warranted.

Research studies are insufficient regarding food safety and its importance in Africa. Past scientific studies were based on other developing countries' best food safety practices and the impact on the economy *(2, 14, 23, 28, 30)*. However, little is known about the characteristics of food safety testing laboratories or the food safety knowledge, attitude, behavior, and skills of laboratory personnel who work in Africa.

Using a self-assessment tool (on-line) and on-site visits, we evaluated the infrastructure of food safety testing laboratories in three African countries and collected data on a number of issues (lab safety, quality assurance, validation of test methods, sampling protocols, management, accreditation, methodologies, data analyses and interpretation, maintenance, troubleshooting, training needs, etc.) from lab personnel. The information from this assessment will be used to develop, deliver, and evaluate a curriculum that can be used to train food safety laboratory personnel in Africa.

MATERIALS AND METHODS

IRB approval

The Institutional Review Board (IRB) at the Pennsylvania State University approved the protocols (PSU; IRB #00004903) prepared for human subjects research. The approved protocols were used to assess the needs of laboratory personnel working in African food safety testing laboratories. A survey was used to assess the needs related to food safety knowledge, attitude, and behavior; laboratory infrastructure, accreditation, and mycotoxin testing efficiency; and laboratory worker's technical skills. Surveys/questionnaires were reviewed by Penn State faculty members in Food Science for clarity before delivery. Before the surveys were administered, consent forms were distributed to, signed by, and received from all participants.

Identified countries and testing laboratories

Initially, eight countries and fourteen food safety testing laboratories from East and South Africa were identified as potential participants. The contact information of each identified laboratory was obtained from their organization/bureau/testing laboratory website. At first, an invitation letter was sent via e-mail to managers or the person-in-charge of the food safety testing laboratories, encouraging them to participate in the project. After the e-mail invitation had been sent, identified participants were contacted via phone. Of the countries identified, Ethiopia, Uganda, and Mozambique responded to our request. From there, five food safety testing laboratories expressed an interest in participating in the project. Seven participants from the five labs participated in the online survey (self-assessment) and 19 participated during the on-site visits.

Food safety needs assessment survey

A food safety needs assessment survey was developed by adapting tools from the American Association for Laboratory Accreditation (A2LA), Food and Agriculture Organization (FAO), Food Safety and Inspection Service–United States Department of Agriculture (FSIS–USDA), and the World Health Organization (WHO) *(3, 11, 12, 33)*. The survey questionnaire was built in Excel (Microsoft Excel 2016, Redmond, WA), allowing participants to fill out and save their information quickly and at their own pace.

The resulting survey was administered at two different times, once as an online self-assessment and then via an external expert assessment. First, participants completed the survey online as a self-assessment and sent it back to the researcher via email for further analysis. Typically, respondents took 3 days to complete the survey. Second, a researcher visited the participants for a day in their respective laboratories and completed the survey on-site, using a tablet to collect data. Using this two-pronged approach, the researchers conducted a comprehensive needs assessment that examined the general practices and protocols performed by personnel who work in food safety testing laboratories (self-reported), while also collecting participants' demographic information, food safety attitudes, general behaviors, and knowledge, as well as a skill (handwashing). The survey also included questions regarding laboratory infrastructure and mycotoxin testing preparedness.

Laboratories were visited from May to June 2017 by a researcher from Penn State. A tablet (Verizon Ellipsis 8 HD, New York, NY) with the Food Safe Surveys® (AHG Inc., State College, PA) application [jointly developed by Penn State University and University of Rhode Island *(19)*] was used for data collection. The app uses a platform where questionnaires can be created through a website and the questions populate on a cell phone or tablet. This app was designed to capture data during direct concealed food safety observations, allowing researchers to monitor the unintended behavioral changes of food handlers *(19)*. During on-site visits to the participating African laboratories, questions were identical to the initial, online self-assessment that were answered earlier by the laboratory personnel. The rationale for asking the same questions was to determine if there were any discrepancies between answers provided during the self-assessments and those given during on-site visits. Using this approach, researchers can develop a needs-based curriculum to address specific issues that may impact the skills of laboratory personnel.

Evaluation of hand washing skills

An iPhone 6 (Apple Inc., Cupertino, CA) was used to capture a video of handwashing techniques performed by participating individuals. Laboratory personnel, one from each participating lab, were asked to demonstrate their typical handwashing technique. Before capturing the videos, participants were informed that the recording would show only their hands to avoid participant's identification and that the video would be deleted from the phone and stored encrypted and under password protection. Participants were advised to wash their hands as they usually do. The video was recorded close up to record the sounds produced by the hands while lathering and ended when participants signaled that they were finished. Data were saved in the iPhone until it was analyzed, as indicated in *Table 1* *(18)*.

A point system was used to evaluate handwashing skill *(17)*. Points were assigned to six different steps, taking into consideration how participants wet their hands, soap application, lather time and lather vigor, which was evaluated by the sound produced during lathering, rinsing, and drying. Each step was assigned a maximum of 2 points *(Table 1)*.

Data analysis

The statistical data analyses were limited to summary statistics. Participating laboratory personnel's knowledge, attitude, behavior, and skill were assessed in three ways: as a percentage (%), using a five-point Likert scale, or by 'yes' and 'no' questions. Microsoft Office-Excel 2013 (Microsoft Corporation, Redmond, WA) was used for compilation and storage, to summarize, and to calculate data points and basic descriptive statistics (e.g., mean, standard deviation, standard error of the mean, the percentage of responses, and observations). The data from self-assessments and on-site visits for food safety attitude and behavior and laboratory practices were compared by use of a percentage of responses and observations. Participating individuals' food safety knowledge and hand-washing skills were compared by use of percentages and descriptive statistics.

RESULTS

Demographic characteristics

The demographic characteristics of respondents from food safety testing laboratories in East and South Africa are listed in *Table 2*. The average age of participants was 39 years and most were males (5/7; 71%). Out of seven participants; two (2/7; 29%) had a Master's degree, four (4/7; 57%) had a Bachelor's degree, and one (1/7; 14%) had some college-level education. Only one member was attending college while working in the laboratory. With regard to respondents' educational background, more than half of the participants had biological/life sciences and agricultural degrees. Respondents lived with their families, where the average number of family members was 3.5. Besides English, respondents spoke Portuguese (3/7; 43%), Amharic (2/7; 29%), German (2/7; 29%), Changana (1/7; 14%), and Oromo (1/7; 14%).

Work environment

The work experience of respondents in food safety testing laboratories in East and South Africa, which was collected as self-assessment, is listed in *Table 3*. Many of the participants (3/7; 43%) had 7–10 years of laboratory experience, while some (2/7; 29%) had more than ten years of experience and some (2/7; 29%) had less than six years of experience. When asked about training and certification, almost half

TABLE 1. Steps evaluated during handwashing and assigned points

Steps	Action (points awarded)
1. Wet hands	No (0); Partial (1); All (2)
2. Soap application	No (0); Yes (2)
3. (i) Lather	(i) No vigor (0); Minimal vigor (1); Vigorous (2)
(ii) Lather time	(ii) 5 seconds or less (0); 6 to 10 sec. (1); more than 10 sec. (2)
4. Rinse	No (0); Partial (1); All (2)
5. Dry	No (0); Partial (1); All (2)

TABLE 2. Demographic characteristics of respondents from food safety testing laboratories in East and South Africa (n = 7)

Respondent characteristics		Responses	Total %
Average Age		39	
Gender			
	Male	5	71
	Female	2	29
Marital status			
	Single	4	57
	Married	3	43
Education, Language, Household Composition			
Highest level of education received			
	Some college level education but no degree	1	14
	Bachelor degree	4	57
	Master's degree	2	29
Educational background			
	Biological/life sciences	3	43
	Agriculture	2	29
	Health-related fields	1	14
	Chemistry	1	14
	Engineering	1	14
Attending college while working in the lab?			
	No	6	86
	Yes	1	14
Living situation			
	Number of family members (Average number for all participants)	3.5	
Spoken languages			
	English	7	100
	Portuguese	3	43
	Amharic	2	29
	German	2	29
	Changana	1	14
	Oromo	1	14

(3/7; 43%) of the participants had 'no response.' However, others reported having certification in one or more areas: HACCP (Hazard Analysis Critical Control Points), quality infrastructure for food safety, food safety management system, ISO 17025, and ISO 9001. When asked about use of laboratory instruments, all the participants answered that they were proficient in general laboratory techniques. Most of the laboratories perform microbiological, toxicological (mostly mycotoxin), and chemical testing.

Laboratory infrastructure

Information on the infrastructure of the participating laboratories is provided in *Tables 4 and 5*. Some discrepancies were observed between data from the self-assessment and from on-site visits. Out of 30 yes/no questions, 11 (37%) responses differed between data obtained from the self-assessments and that obtained from on-site visits. For example, self-assessments indicated that four laboratories had access to various rooms for different lab-based activities,

TABLE 3. Work environment of respondents in food safety training laboratories in East and South Africa (n = 7)

Work environment		Responses	Total %
Work experience			
	< 1 Year	0	0
	1–3 Years	1	14
	4–6 Years	1	14
	7–10 Years	3	43
	> 10 Years	2	29
Received training/certification			
	Hazard Analysis Critical Control Points	1	14
	Quality Infrastructure for Food Safety	1	14
	Food Safety Management System	1	14
	ISO 17025	2	29
	ISO 9001	1	14
	No response	3	43
Proficiency in laboratory instruments			
	I don't know	0	0
	Less proficient	0	0
	Proficient	5	71
	More proficient	2	29
Testing methods that are currently done in the laboratory			
	Microbiological	4	57
	Fungal	2	29
	Toxicological	3	43
	Chemical	4	57

and only one laboratory had only one room in common for all activities. During the on-site visits, the researcher found that only two laboratories out of five had different rooms for different activities.

With the exception of one laboratory that relies on refrigerators and freezers for temporary sample storage, the laboratories use wooden/steel racks to store received samples in the reception area. Data from the self-assessments also indicated that most of the labs have refrigerators and freezers for sample storage in the inoculation areas of the laboratories; however, the researcher found that only two labs had freezers for temporary sample storage. The finding was similar to other aspects of the food safety testing laboratory, where participants contradicted themselves during the on-site visit.

Similarly, during the self-assessments, participants indicated that their labs (4/5) were equipped with an air conditioning system, water-baths, incubators, microscopes, colony counters, and computers in the incubation or interpretation area; however, during on-site visits, only two of the five laboratories had all of the listed items, except for water-baths and incubators in the interpretation area. Self-assessments indicated that 2 of the 5 laboratories were equipped with biosafety cabinets, counting aids, an integrated system for sample entry and results entry, and refrigerators in the interpretation area; however, during on-site visits, counting aids were not visible to the researcher and did not appear to be used by the employees. The infrastructure of the observed food safety testing laboratories were found to be in good condition and adequate enough to perform some laboratory testing, but not enough for the necessary confirmatory tests.

Behavior

Results from questions addressing good laboratory practices assessed via the self-assessment and on-site visit are presented in *Table 6*. Seven individuals from five labs participated in the assessments. Answers to 42% (10/24) of the questions asked during the self-assessments had

TABLE 4. Laboratory infrastructure of food safety testing laboratories in East and South Africa (n = 5)

Self-Assessment

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
1. Laboratory access to different rooms for different activities	Yes	Yes	Yes	Yes	No, all activities happen in one room
2. Pass-through windows between different rooms	No, there are regular doors between rooms and technicians walk from one room to the next to transfer samples/plates	No, there are regular doors between rooms and technicians walk from one room to the next to transfer samples/plates	No, there are no direct connection between rooms and technicians use a corridor/hallway that connects all the rooms	No, there are no direct connection between rooms and technicians use a corridor/hallway that connects all the rooms	Only one room
3. One-way workflow to reduce the risk of contamination	Yes, and most lab processes are performed in separate rooms	Yes, and most lab processes are performed in separate rooms	Yes, and most lab processes are performed in separate rooms	Yes, and most lab processes are performed in separate rooms	Yes, but different lab processes are performed on different benches in the same room
4. Use of temperature control and log system for refrigerators	Yes, logged electronically on a daily basis	Yes, logged electronically on a daily basis	Yes, logged electronically twice a day	Yes, logged manually on a daily basis	Yes, logged electronically on a weekly basis
5. Use of temperature control and log system for freezers	Yes, logged electronically on a daily basis	Yes, logged electronically on a daily basis	Yes, logged electronically twice a day	Yes, logged manually on a daily basis	Yes, logged electronically on a weekly basis
6. Use of temperature control and log system for incubators	Yes, logged electronically on a daily basis	Yes, logged electronically on a daily basis	Yes, logged electronically twice a day	Yes, logged manually on a daily basis	Yes, logged electronically on a daily basis

(Continued on next page)

discrepancies with the behavior observed during the on-site visits.

During the self-assessment, most of the participants (5/7; 71%) indicated a belief that their level of knowledge of good laboratory practices affects the quality of the tests they conduct, yet a small percentage (1/7; 14%) 'strongly disagreed.'' In contrast, all participants (7/7; 100%) 'agreed' or 'strongly agreed' on the same question during the on-site visit. When asked about behavior with regard to laboratory practices and their effect on the quality of the tests conducted, most of the participants (6/7; 86%) 'agreed' or 'strongly agreed' during the self-assessment but 'disagreed' (4/7; 57%) during the on-site visit. Still, almost half of the participants (3/7; 43%) 'agreed' on the same behavioral statement. Likewise, the majority of the participants seemed unaware of the usefulness of lab coats or other personal protective equipment (PPE) designated for the laboratory testing area. Interestingly, almost all of the participants (6/7; 86%) 'strongly agreed' on the usefulness of lab coats and PPE during lab work during the on-site visit. Similar responses were observed with regard to questions about handwashing and other behavioral aspects during the on-site visit.

Participants agreed (7/7; 100%) on the importance of sanitizing the work area during the self-assessments; however, during the on-site visit, (5/7; 71%) some 'disagreed' on the importance of cleaning a work area. During the on-site visit,

TABLE 4. Laboratory infrastructure of food safety testing laboratories in East and South Africa (n = 5) (cont.)

On-site Visit

	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
1. Laboratory access to different rooms for different activities	Yes	No	Yes	No	No
2. Pass-through windows between different rooms	No, there are regular doors between rooms and technicians walk from one room to the next to transfer samples/plates	No, there are regular doors between rooms and technicians walk from one room to the next to transfer samples/plates	No, there are no direct connections between rooms and technicians use a corridor/ hallway that connects all the rooms	No, there are no direct connections between rooms and technicians use a corridor/hallway that connects all the rooms	Only one room
3. One-way workflow to reduce the risk of contamination	Yes, and most lab processes are performed in separate room (three separate rooms and one for sample reception)	Yes, and most lab processes are performed in separate room (three separate rooms and one for sample reception)	Yes, and each lab process is performed in a separate room	Yes, and most lab processes are performed in separate room (three separate rooms and one for sample reception)	Yes, but different lab processes are performed on different benches in the same room
4. Use of temperature control and log system for refrigerators	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged Electronically on a weekly basis
5. Use of temperature control and log system for freezers	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged Electronically on a weekly basis
6. Use of temperature control and log system for incubators	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically twice a day	Yes, logged electronically on a weekly basis

all of the participants (7/7; 100%) 'agreed' that the quality management system is cumbersome; however, the response was different during the self-assessment. A similar trend was observed from participants when asked about quality management systems and equipment calibration.

When asked about the importance of training on good laboratory practices before starting lab work, more than half of the participants (4/7; 57%) were 'neutral,' with one participant (14%) who 'disagreed.' However, during the on-site visit, more than half (4/7; 57%) 'agreed' and the rest (3/7; 43%) 'disagreed' on the importance of training question. During the self-assessment, most of the participants (4/7; 57%) 'agreed' or 'strongly agreed' on the importance of receiving refresher training yearly on good laboratory practices, but others (3/7; 43%) 'strongly disagreed' or 'disagreed' with this concept. During the on-site visit the concept was made clear. Although most of the participants desire to participate in the refresher training, the majority of the participants (6/7; 86%) did not have that opportunity or the institute did not provide the refresher training for good laboratory practices. Most of the participants (5/7; 71%) thought that refresher training on good laboratory practices was not a waste of time, even for an experienced technician, both during the self-assessment and during the on-site visits. Participants (6/7; 86%) appear to enjoy training new technicians, and the responses for this aspect were similar for both assessments.

During self-assessments, participants (6/7; 86%) claimed that they were confident enough to generate reliable results;

TABLE 5. Laboratory infrastructure of food safety testing laboratories in East and South Africa (n = 5)

	Self-Assessment				On-site Visit		
	Availability or presence of:	Yes (%)	No (%)	Not Applicable (%)	Yes (%)	No (%)	Not Applicable (%)
SN	**Reception area:**						
1.	Refrigerators for temporary sample storage	1/5 (20)	4/5 (80)	0	1/5 (20)	4/5 (80)	0
2.	Freezers for temporary sample storage	1/5 (20)	3/5 (60)	1/5 (20)	1/5 (20)	4/5 (80)	0
	Inoculation area:						
3.	Refrigerators for temporary sample storage	5/5 (100)	0	0	5/5 (100)	0	0
4.	Freezers for temporary sample storage	4/5 (80)	1/5 (20)	0	2/5 (40)	3/5 (60)	0
5.	Water-baths to keep agars molten	5/5 (100)	0	0	5/5 (100)	0	0
6.	Biosafety cabinet	5/5 (100)	0	0	5/5 (100)	0	0
7.	Stomachers to homogenize samples	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
8.	Membrane filtration system	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
9.	Air conditioning system	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
10.	Sink	5/5 (100)	0	0	5/5 (100)	0	0
11.	Clearly identified trash bins/bags for biohazardous materials	5/5 (100)	0	0	3/5 (60)	2/5 (40)	0
12.	Separate incubators for different temperatures	5/5 (100)	0	0	3/5 (60)	2/5 (40)	0
	Incubation area:						
13.	Water-baths	5/5 (100)	0	0	3/5 (60)	2/5 (40)	0
14.	Air conditioning system	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
	Interpretation area:						
15.	Water-baths	4/5 (80)	1/5 (20)	0	3/5 (60)	2/5 (40)	0
16.	Incubators	4/5 (80)	1/5 (20)	0	3/5 (60)	2/5 (40)	0
17.	Air conditioning system	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
18.	Microscope	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
19.	Colony counter	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
20.	Counting aid (e.g., tally counter)	2/5 (40)	3/5 (60)	0	0	5/5 (100)	0
21.	Biosafety cabinet	2/5 (40)	3/5 (60)	0	2/5 (40)	3/5 (60)	0
22.	Bunsen burners	5/5 (100)	0	0	5/5 (100)	0	0
23.	Sink	5/5 (100)	0	0	3/5 (60)	2/5 (40)	0
24.	Computers	4/5 (80)	1/5 (20)	0	4/5 (80)	1/5 (20)	0
25.	Integrated computer system for sample entry, results entry, etc.	2/5 (40)	3/5 (60)	0	2/5 (40)	3/5 (60)	0
26.	Clearly identified trash bins/bags for biohazardous materials	5/5 (100)	0	0	3/5 (60)	2/5 (40)	0
27.	Enough light (brightness)	5/5 (100)	0	0	4/5 (80)	1/5 (20)	0
28.	Refrigerators	2/5 (40)	3/5 (60)	0	2/5 (40)	3/5 (60)	0
29.	Freezers	1/5 (20)	4/5 (80)	0	1/5 (20)	4/5 (80)	0
30.	Automatic pipettes for use in the lab	5/5 (100)	0	0	5/5 (100)	0	0

TABLE 6. Behavior of participants toward good laboratory practices via a self-assessment and on-site visit (n = 7)

	Self-Assessment						On-site Visit					
Good Laboratory Practices	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)
1. My level of knowledge of good laboratory practices affects the quality of the tests I conduct.	1/7 (14)			1/7 (14)	5/7 (71)					3/7 (43)	4/7 (57)	
2. My behavior about laboratory practices does not affect the quality of the tests I conduct.	1/7 (14)			1/7 (14)	5/7 (71)			4/7 (57)		3/7 (43)		
3. Laboratory coats, or other outer coverings designated for the testing area only, do not help avoid result errors.	3/7 (43)			1/7 (14)		3/7 (43)		1/7 (14)		6/7 (86)		
4. Separate shoes, or shoe coverings designated for the testing area only, help avoid result errors.	1/7 (14)			1/7 (14)	5/7 (71)			6/7 (86)		1/7 (14)		
5. Use of gloves helps avoid result errors.	1/7 (14)			4/7 (57)	2/7 (29)			5/7 (71)		2/7 (29)		
6. Handwashing does not help avoid result errors.	4/7 (57)				3/7 (43)		1/7 (14)	1/7 (14)		5/7 (71)		
7. It is important to sanitize my working area before starting my activities.				1/7 (14)	6/7 (86)			5/7 (71)		2/7 (29)		
Quality Management Systems												
1. Quality management systems (e.g., ISO/IEC 17025) are cumbersome.	3/7 (43)			1/7 (14)	3/7 (43)					7/7 (100)		
2. Quality management systems (e.g., ISO/IEC 17025) are necessary.				1/7 (14)	6/7 (86)					1/7 (14)	6/7 (86)	
3. Quality management systems (e.g., ISO/IEC 17025) help avoid result errors.				1/7 (14)	6/7 (86)				5/7 (71)	2/7 (29)		
4. Equipment calibration helps avoid result errors.				1/7 (14)	6/7 (86)				5/7 (71)	2/7 (29)		
5. I follow all the instructions in the quality management system my laboratory have in place.				2/7 (29)	5/7 (71)			7/7 (100)				
6. My quality manager makes it clear which are the objectives of the quality management system.				5/7 (71)	2/7 (29)			6/7 (86)		1/7 (14)		
Training												
1. I received training on good laboratory practices before I started working in this laboratory.		1/7 (14)	4/7 (57)		2/7 (29)			3/7 (43)		4/7 (57)		
2. I receive refresher trainings on good laboratory practices yearly.	1/7 (14)	2/7 (29)		3/7 (43)	1/7 (14)			6/7 (86)	1/7 (14)			

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TABLE 6. Behavior of participants toward good laboratory practices via a self-assessment and on-site visit (n = 7) (cont.)

	Self-Assessment						On-site Visit					
Good Laboratory Practices	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)
3. Refresher trainings on good laboratory practices are a waste of time for experienced technicians.	5/7 (71)			2/7 (29)			1/7 (14)	5/7 (71)	1/7 (14)			
4. I enjoy training new technicians.					6/7 (86)	1/7 (14)				7/7 (100)		
5. I am confident in my ability to generate reliable results.				1/7 (14)	6/7 (86)			5/7 (71)		2/7 (29)		
6. I would like to receive more training than I do.		1/7 (14)			6/7 (86)					1/7 (14)	6/7 (86)	
International												
1. The work my laboratory conducts is important for the economic success of my country nationally.				1/7 (14)	6/7 (86)					7/7 (100)		
2. The work my laboratory conducts is important for the economic success of my country internationally.				2/7 (29)	5/7 (71)					7/7 (100)		
3. Reliable testing laboratories do not mean that the food products produced in the region are safe.				4/7 (57)	3/7 (43)						7/7 (100)	
4. Cooperation among countries, regarding testing-laboratories' standards and techniques, does not increase food safety.	3/7 (43)	2/7 (29)			2/7 (29)		7/7 (100)					
5. Reliable testing laboratories are important for food import and export.				1/7 (14)	6/7 (86)					4/7 (57)	3/7 (43)	

SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree; IDNK = I Do Not Know.

however, during the on-site visit, the majority of participants (5/7; 71%) were found to be less confident, because of the lack of quality training. The majority of the participants (5/7; 71%) during the self-assessment and all of the participants (7/7; 100%) during the on-site visits 'strongly agreed' or 'agreed' with the statements that 'cooperation among countries is required to increase food safety' and on the importance of reliable testing laboratories for food import and export.

Laboratory practices

Laboratory practices conducted in the East and South African laboratories are summarized in *Table 7*. The participating laboratories (n = 5) from East and South Africa provide food microbiology, food chemistry, and mycotoxin analysis. A few of them also conduct principal component (n = 3) and wastewater (n = 4) analyses. None of the participating laboratories conduct allergen testing or clinical/medical microbiological analyses. Discrepancies were observed in general laboratory practices (8 questions were asked), where participants 'agreed' during the self-assessment, but disagreed (4/8; 50%) during the on-site visits. The five most common products being analyzed in these laboratories were potable water, meat, cereals, fruit juice, and milk. Comparatively, the number of samples that were being analyzed per week differed considerably between labs. During the self-assessment, it was

TABLE 7. Laboratory practices conducted in the East and South African laboratories. Note: n represents participating laboratory personnel

General laboratory practices (n = 7)

1. Types of laboratory analyses:	Responses	%	
Food microbiology	7	100	
Food chemistry	7	100	
Principal component analysis	5	71	
Allergens	0	0	
Mycotoxins	7	100	
Clinical/medical microbiology	0	0	
Wastewater	6	86	

2. Five most common food products that are analyzed:
Potable water, meat, cereals, fruit juice, milk.

3. Average number of food samples analyzed per week:

	Self-Assessment	On-site Visit	
Laboratory 1	50–100/wk	60–80/wk	
Laboratory 2	40–50/wk	100/wk	
Laboratory 3	100–130/wk	70–80/wk	
Laboratory 4	100–130/wk	15–20/wk	
Laboratory 5	50–60/wk	10–12/wk	

4. Participating laboratories use standard methods (e.g., pour plate, spread plate, most probable number) as common food microbiology tests to identify microorganisms. The following are the 7 most common microorganisms analyzed in all participating labs:

Enterobacteriaceae			
Generic *E. coli*			
Total Coliforms			
Yeast and mold count			
Salmonella species			
Staphylococcus aureus			
Vibrio spp.			

5. Commonly used sanitizers in the laboratory (n = 5):

	Self-Assessment (%)	On-site Visit (%)	
Ethanol 70%	5/5 (100)	5/5 (100)	
Chlorine-based	0	0	
6. Sanitizer rotation system (n = 7):			
No	3/7 (43)	6/7 (86)	
Yes	4/7 (57)	1/7 (14)	
7. Use sanitizer before starting work (n = 7):			
No	0	0	
Yes, once a day	1/7 (14)	4/7 (57)	

(Continued on next page)

TABLE 7. Laboratory practices conducted in the East and South African laboratories. Note: n represents participating laboratory personnel (cont.)

General laboratory practices (n = 7)

	Self-Assessment (%)	On-site Visit (%)
7. Use sanitizer before starting work (n = 7):		
Yes, every time I believe my working area was contaminated	1/7 (14)	0
Yes, every time I start a new sample	3/7 (43)	3/7 (43)
I do not know	2/7 (29)	0
8. Laboratory clothing/shoe policy:		
No	0	4/7 (57)
Yes	7/7 (100)	3/7 (43)
9. Clothing changing room/area in the laboratory:		
No	0	7/7 (100)
Yes	7/7 (100)	0
10. Laboratory quality management system in place:		
ISO 9001 and ISO 17025	1/7 (14)	1/7 (14)
ISO 17025 only	6/7 (86)	6/7 (86)
11. Plan to renew a quality management system:		
No	0	0
Yes	5/7 (71)	5/7 (71)
Already renewed	2/7 (29)	2/7 (29)
12. Laboratory participation in proficiency testing:		
No	0	0
Yes (from one to six times/year)	7/7 (100)	7/7 (100)

	Frequencies				
13. General practices/experience:	**Lab 1**	**Lab 2**	**Lab 3**	**Lab 4**	**Lab 5**
1. Hand-washing frequency during a regular work day (times).	4–8	4–8	3–6	2–5	5
2. Changing gloves frequently during a regular work day (times).	15–20	10–15	2–6	3–6	1
3. Laboratory technician's experience in the lab (years).	4–10	4–10	4–10	4–10	1–3

14. Number of employees in testing, quality, and support categories:

	Testing/ Quality/ Support	Testing/ Quality	Testing/ Support	Quality/ Support	Testing	Quality	Support
Laboratory 1	4	4	4	4	4	4	4
Laboratory 2	4	3	4	4	2	2	2
Laboratory 3	1	2	1	3	16	2	8
Laboratory 4	19	3	24	9	17	2	7
Laboratory 5	5	3	8	4	5	5	3

noted that labs 3 and 4 had the highest number of samples processed per week, whereas lab 2 had the lowest number of samples; however, during the on-site visits, lab 2 had the highest number of samples, while labs 4 and 5 had the lowest number of samples processed per week.

The most common microorganisms analyzed in all participating labs were related to *Enterobacteriaceae* (generic *Escherichia coli*, total coliforms, and *Salmonella* spp.), yeast and mold counts, *Staphylococcus* spp., and *Vibrio* spp. For sanitation purposes, all of the laboratories (5/5; 100%) used 70% ethanol and half of the laboratories did not know about the sanitizer rotation system in self-assessment. Interestingly, during the on-site visits, all but one of the laboratories (6/7; 86%) were unaware of a sanitizer rotation system. Similar results were observed for shoe and clothing, hand washing, and glove changing policies, which most of the participants did not follow during on-site visits. Based on the self-assessments and on-site visits, all participating laboratories (7/7; 100%) have a quality management system (ex. ISO 17025) in place. Most of the participants (5/7; 71%) agreed on the importance of implementing other quality management systems. Additionally, all labs participated in proficiency tests once or twice a year, as indicated by the self-assessments and on-site visits.

Attitude

The attitude of participants toward good laboratory practices via self-assessments and on-site visits is reported in *Table 8*. During the on-site visits, the attitudes of the participating laboratory personnel was observed and noted at the same time. Some discrepancies were observed for almost half (8/18, 44%) of the attitudinal survey questions. In contrast, when the level of knowledge of standard operating procedures (SOPs) and the effect on tests conducted were assessed, responses were nearly similar between the self-assessments (6/7; 86%) and on-site responses (7/7; 100%). Similarly, there was agreement between the self-assessment (7/7; 100%) and on-site (5/7; 71%) data around personal hygiene and the impact on making food safer, running accurate tests, and the responsibility of the laboratory to train others.

Almost half of the employees (3/7; 43%) were unaware of the importance of recording which employee handles food allergens in the lab. Interestingly, during the on-site visit, no such records existed on allergen testing (7/7; 100%), nor was an individual designated for food allergen analyses. During the self-assessments, all participants (7/7; 100%) 'strongly agreed' on the need to have internal audits to observe the implementation of general food safety practices and felt equally responsible as others to produce the best results. Participants felt that the internal audits are necessary, but the researcher did not find such systems in place (4/7; 57%) during the on-site visits. Most participants (6/7; 86%) 'agreed' or 'strongly agreed' during the self-assessments that their testing should be accurate. However, during the on-site visits, few participants (2/7; 29%) agreed with the accuracy statements.

All of the participants (7/7; 100%) agreed on the importance of written SOPs and GMPs, training before employees start work and of having local/regional/state regulations to keep food safe via the self- and on-site assess-ments. Likewise, participants were in agreement (7/7; 100%) for both assessments when asked about the responsibility of food testing laboratories to train individual workers, having regular training sessions for all employees, and becoming certified by a local/regional/ international agency on the testing methods. However, half of the participants remained 'neutral' on the importance of having local/regional/state regulations to keep food safe (4/7; 57%) and of inspection of the facilities on a regular basis (3/7; 43%).

Knowledge of microbiological testing procedures

Results for the self-assessed knowledge and food safety testing methods are provided in *Table 9*. Out of seven participants from five different laboratories, four (4/7; 57%) were able to answer dilution-related questions correctly. However, only one participant (1/7; 14%) was able to answer correctly the number of tubes needed with known volume(s) to reach a certain dilution factor. Most of the participants (5/7; 71%) did not correctly list the necessary steps for serial dilutions. Similarly, when asked about plating techniques, only a few participants (2/7; 29%) answered correctly. Likewise, none of the employees (7/7; 100%) answered correctly on procedures for a spread plate technique. Few participants (2/7; 29%) knew how to calculate a correct dilution factor, conduct mathematical calculations for a given problem, or exhibit general problem-solving skills. Similarly, participants (6/7; 86%) also lacked critical thinking skills and the ability to devise a corrective action plan, should issues arise.

Hand washing skill assessment

Results for the handwashing skill assessment are presented in *Table 10*. One individual/ technician from each laboratory was recorded and the video was later analyzed for 12 maximum possible points *(17) (Table 1)*. The mean skill test score was 5.40, with a standard deviation of 4.60 and standard error of the mean of 2.04. Two participants scored 8.33% (1/12), which is the lowest possible score for handwashing technique. Out of five, only one participant was able to demonstrate excellent hand washing skills during the lab visit, scoring 91.67% (11/12).

Mycotoxin detection capabilities

The food samples being tested for mycotoxins by the participating labs were mostly beans, cereal crops, dairy products, meats, and fish *(Table 11)*. All five labs tested for aflatoxin in foods, and one of the visited labs also tested for ochratoxin, fumonisin, ciguatoxin, and zearalenone, as well as

TABLE 8. Attitude of participants toward good laboratory practices via a self-assessment and on-site visit (n = 7); note: n represents participating laboratory personnel

	Self-Assessment						On-site visit					
General food safety practices	**SD** (%)	**D** (%)	**N** (%)	**A** (%)	**SA** (%)	**IDNK** (%)	**SD** (%)	**D** (%)	**N** (%)	**A** (%)	**SA** (%)	**IDNK** (%)
1. My level of knowledge of standard operating procedures affects the quality of tests I conduct.		1/7 (14)		5/7 (71)	1/7 (14)					4/7 (57)	3/7 (43)	
2. Good personal hygiene practice helps make food safe to eat.				1/7 (14)	6/7 (86)		2/7 (29)	4/7 (57)		1/7 (14)		
3. Good personal hygiene is always important to run safe tests.				4/7 (57)	3/7 (43)		1/7 (14)	4/7 (57)		2/7 (29)		
4. I believe my decisions impact the test results that I conduct in this facility.			1/7 (14)	1/7 (14)	5/7 (71)			2/7 (29)		3/7 (43)	2/7 (29)	
5. This food testing laboratory has a responsibility to train individuals working in this lab on good personal hygiene.				1/7 (14)	6/7 (86)			4/7 (57)		3/7 (43)		
6. This food testing laboratory has a responsibility to train individuals working in this lab on standard operating procedure.					5/7 (71)	2/7 (29)		4/7 (57)		3/7 (43)		
7. It is important to record which employee handles food allergens.			1/7 (14)		3/7 (43)	3/7 (43)		7/7 (100)				
Implementation, policies, inspection, and training												
1. Internal audits are necessary to observe the implementation of general food safety practices.					7/7 (100)			4/7 (57)		2/7 (29)	1/7 (14)	
2. As a laboratory technician/manager, I am equally responsible as others to produce the best results.					7/7 (100)			2/7 (29)		3/7 (43)	2/7 (29)	
3. I am a certified technician/manager, so my food testing results should be accurate.				3/7 (43)	3/7 (43)	1/7 (14)		2/7 (29)		3/7 (43)	2/7 (29)	
4. The more I use the instruments in the laboratory, the more I increase my skills.					4/7 (57)	3/7 (43)				5/7 (71)	2/7 (29)	
5. Written SOPs and GMPs are equally important for the best results.					7/7 (100)					4/7 (57)	3/7 (43)	

Continued on next page

TABLE 8. Attitude of participants toward good laboratory practices via a self-assessment and on-site visit (n = 7); note: n represents participating laboratory personnel (cont.)

	Self-Assessment						On-site visit					
General food safety practices	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)	SD (%)	D (%)	N (%)	A (%)	SA (%)	IDNK (%)
6. Every employee/staff member should be trained before working in this laboratory.				3/7 (43)	4/7 (57)					3/7 (43)	4/7 (57)	
7. I am positive about having local/regional/state regulations to keep food safe.					7/7 (100)				4/7 (57)	3/7 (43)		
8. Local/regional/state regulatory authorities should inspect this facility on regular basis.			1/7 (14)		5/7 (71)	1/7 (14)			3/7 (43)	2/7 (29)	2/7 (29)	
9. The food testing laboratory has a responsibility to train individual workers.				1/7 (14)	6/7 (86)			1/7 (14)		4/7 (57)	2/7 (29)	
10. I believe it is important to have regular training sessions for all employees.				1/7 (14)	6/7 (86)			3/7 (43)		3/7 (43)	1/7 (14)	
11. It is important to get certified by a local/regional/international agency on our testing methods.					7/7 (100)					4/7 (57)	3/7 (43)	

SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree; IDNK = I Do Not Know

alkaloids. The majority of the visited labs (4/5) use High-Performance Liquid Chromatography (HPLC) for aflatoxin detection in food. Thin Layer Chromatography (TLC), Gas Chromatography (GC) triple quad technique, and some immunoassay-based methods also were used (3/5). Only two labs followed standardized mycotoxin sampling procedures. One followed the U.S. Food and Drug Administration (FDA) Bacteriological Analytical Manual (BAM) protocols, while another relied on the Codex Alimentarius Commission protocols. The frequency of mycotoxin analysis was every day (4/5), once a week (2/5), and occasionally for the remaining lab (1/5). Thus, the number of samples received by each laboratory was in the range of 5 to 20 per week, except for one lab, which received fewer than 5 samples per week. All of the labs (5/5) agreed that they lack quality lab supplies for necessary testing of mycotoxins. One lab was not accredited for mycotoxin testing, but the others were accredited by ISO 17025, and one was affiliated with the Ethiopian National Accreditation Office (ENAO). When asked about mycotoxin regulations, every lab replied 'not regulated', but one lab reported that their country has regulations for aflatoxin only. Based on the current survey, one of the participating labs (1/5) has surveillance or monitoring programs for mycotoxin-related issues.

DISCUSSION

The overall objective of this project was to assess the needs, proficiency, skills, and general infrastructure of food safety testing laboratories located in East and South Africa. While some labs had multiple rooms for different laboratory activities (which can reduce cross-contamination issues), other labs lacked necessary supplies, materials, and equipment. These conditions, combined with poorly skilled technicians, faulty sampling procedures, awkward work flow, and fewer designated areas to process multiple samples, could lead to faulty testing (e.g., false negatives, false positives) and biased reporting. These conditions, when combined with an underregulated food supply system and the possibility of cross contamination during production, processing, storage, and handling, also could result in issues and/or difficulties with reporting the true incidences of foodborne illness *(2)*.

The number of outbreaks occurring in Africa is due, in part, to an unhygienic food supply as well as contamination of commonly consumed foods by pathogens *(2)*. Conversely, decreases in foodborne illnesses or outbreaks have been attributed to improvements in a number of attributes, including employees' food safety knowledge, positive attitudes, and changes in behaviors and skills, along with the development and implementation of a food safety plan *(1, 15)*. In fact,

TABLE 9. Knowledge of participants from food safety testing laboratories in East and South Africa (n = 7).

Problems	Participants from 5 labs	
	Number of participants that answered correctly (%)	Number of participants that answered incorrectly (%)
1. Serial dilutions		
Volume of dilution used	4/7 (57)	3/7 (43)
Number of tubes needed with known volume to reach certain dilution factor	1/7 (14)	6/7 (86)
Listing of necessary steps for serial dilution	2/7 (29)	5/7 (71)
2. Plating techniques		
Pour plate	2/7 (29)	5/7 (71)
Spread plate	0	7/7 (100)
3. Mathematical calculations		
For example: CFU/ml for given bacterial counts	2/7 (29)	5/7 (71)
Dilution factor	2/7 (29)	5/7 (71)
4. Critical thinking	1/7 (14)	6/7 (86)
5. Problem solving	2/7 (29)	5/7 (71)
6. Data Interpretation	0	7/7 (100)
7. Corrective action	1/7 (14)	6/7 (86)

TABLE 10. Handwashing scores during on-site visit as an assessment of skill of personnel in food safety testing laboratories in East and South Africa (n = 5)

Laboratory	Max. possible points	Skill test score	Percent score
1	12	9.00	75.00
2	12	11.00	91.67
3	12	1.00	8.33
4	12	5.00	41.67
5	12	1.00	8.33
Mean		5.40	45.00
S.D.		4.60	
SEM		2.04	

although few studies *(24, 35)* have demonstrated that a positive correlation exists between food handler/employee training and their general food safety attitude, other studies *(4, 5, 18, 32)* have demonstrated that educational training interventions can improve the overall food safety attitude of these employees.

Laboratory technicians' behavior may impact cross-contamination and the transmission of foodborne pathogens under laboratory conditions. For example, washing hands before and after lab work, eating and drinking in a designated area, and a strict clothing policy can reduce the transmission of foodborne pathogens between lab workers and reduce the chance of cross contamination outside of the laboratory *(29)*. During the self-assessments conducted in this study, participants reported that proper behaviors in the labs were performed most of the time. However, on-site visits did not support this contention. These data also suggest that participants are likely to overestimate or inflate

TABLE 11. Mycotoxin detection capabilities determined during on-site visit of food safety testing laboratories in East and South Africa (n = 5)

		Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
1.	Types of samples that are being analyzed in the lab	Corn, soybean, beans, milk, peanuts, eggs, coca, fish	Corn, peanuts, wheat, soybean	Corn, peanuts, wheat, barley, oats, soybean	Corn, peanuts, wheat, barley, oats, soybean, oat, rye, dairy	Dairy products, milk, and poultry products
2.	Mycotoxins that are being tested in the lab	Aflatoxin, Ochratoxin, Fumonisin, Alkaloids, Ciguatoxin, Zearalenone	Aflatoxin	Aflatoxin and Alkaloids	Aflatoxin	Aflatoxin
3.	Types of aflatoxins being analyzed	B1, B2, G1, G2, M1, M2	B1, B2, G1, G2, M1, M2	B1, B2, G1, G2, M1, M2	B1, B2, G1, G2, M1, M2	B1, M1, M2
4.	Aflatoxin detection techniques used	HPLC, TLC, GC	HPLC	HPLC	HPLC, Triple quad LC-MS/MS	Immunoassay-based methods, GC
5.	Specific mycotoxin sampling procedure that is being practiced	BAM-based protocol	Customers bring the samples	Customers bring the samples	Customers bring the samples	Codex Alimentarius Commission
6.	Frequency of mycotoxin analysis	Everyday	Everyday	Once a week	Once a week	Occasionally
7.	Estimated number of samples processed per method of choice	5–20/wk	5–20/wk	5–20/wk	< 5/wk	5–20/wk
8.	Responsible person for reporting and storage of the results	Lab technician	Lab technician	Manager	Manager	Lab technician
9.	Lab efficiency for mycotoxin testing	Yes, but have a problem in consumables, accessories	Yes, but have a problem in consumables, accessories	No	Yes, but have a problem in consumables, accessories	No
10.	Lab lacks quality supplies for necessary testing	Yes, totally agree	Yes, totally agree	Yes, totally agree	Yes, totally agree	Yes, totally agree
11.	Lab accreditation	ISO 17025	ISO 17025	No	ISO 17025	ISO 17025, Ethiopian National Accreditation Office (ENAO)
12.	Trained personnel for mycotoxin testing	Yes	Yes	Yes	Yes	No
13.	Country's regulation regarding mycotoxins in foods	No	No	Yes, for Aflatoxin	No	No
14.	Any surveillance or monitoring program for mycotoxin related issues	No	No	No	Yes	No
15.	Laboratory's outreach program to address farmers' fungal-related issues	No	No	No	No	Yes, depending upon the budget availability

their skills and knowledge or report acceptable behaviors and/or attitudes during self-assessments. Therefore, on-site visits and witnessing the actual practices of participants becomes more relevant.

The discrepancies observed between participants' self-reported and observed practices suggest underlying issues that could impact the ability of the laboratories to adequately evaluate the safety of the food supply. Continuous monitoring of these laboratories by local authorities, third party audits, routine training of the laboratory personnel, and introduction to new and reliable food safety testing methodologies may be a step towards improving the safety of the food supply in Africa. Guidelines for food safety testing laboratories published by trusted government agencies, and also published material from a well-run laboratory, can be a point of reference for food safety testing laboratories.

The observed discrepancies between self-assessments and on-site visits in this study may be reflective of a number of issues, including an under-educated workforce, language barriers, lack of oversight by regulatory bodies, absence of internal audits, and/or apathetic attitudes toward food safety. In addition, the small number of participants is a limitation of this study and may minimize our ability to generalize the findings. Nonetheless, addressing issues such as appropriate personal hygiene and proper handwashing can minimize the risk of cross-contamination in the laboratory *(7, 13, 16–21)*. Given the exposure to potential pathogens in a laboratory setting, it is important to incorporate these skills and this knowledge into any laboratory training, which will have a long-term effect on reducing potential cross-contamination *(24)*. In fact, several studies *(9, 24, 25, 27, 36)* have demonstrated improvements to employees' or participants' food safety practices and behaviors as a result of educational interventions.

Participants' behavior, which reflects their cognitive attitude, did not correlate with assessed knowledge and skills in this study. During the self-assessments, participants appeared to be more aware of issues related to proper food handling and good laboratory practices; yet, at the same time, they lack required knowledge, skills, and training when observed on-site.

To address these gaps in knowledge, attitudes, behaviors, and skills, a needs-based curriculum could be developed for this audience. Such training may consist of face-to-face training modules with lectures, break-out sessions, and hands-on laboratory exercises. The curriculum could provide participating laboratory personnel with techniques and newly-adopted skills that can be incorporated into their daily activities and job responsibilities. The attributes which can be addressed in the curriculum may include, but are not limited to, general food safety principles, lab safety, quality assurance, validation of test methods, metrics, sampling protocols, data management, lab and personnel accreditation, methodologies, data analyses and interpretation, maintenance, and troubleshooting. The developed curriculum also must have the potential to improve the knowledge and skills of participating personnel employed in food testing/food microbiology/food safety laboratories in Africa.

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In Memory

Yasuyoshi Komoto

We extend our deepest sympathy to the family of Yasuyoshi Komoto who recently passed away. Mr. Komoto was a member of the Association since 2013. IAFP will always have sincere gratitude for his contribution to the Association and the profession.