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Hygiene practices and food contamination in managed food service facilities in Uganda

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A longitudinal study was conducted to examine individual worker and institutional hygiene practices and bacterial contamination in food service facilities at Makerere University. Questionnaires regarding food service knowledge, attitudes, and practices were administered to 94 individual and institutional respondents from 16 facilities through in-person interviews. A total of 48 samples (3 per facility) were analyzed for evidence of contamination (total aerobic mesophilic bacteria, coliforms, *Escherichia coli, Salmonella*). Respondents with higher education levels had better knowledge and attitudes regarding food safety, but knowledge in specific areas were varied. The majority of individual workers used safe food handling practices, but the majority of institutions did not practice good environmental hygiene. The majority of food samples tested had APC and total coliform levels higher than acceptable, but only two tested positive for *Salmonella.* Food service worker training and managerial improvement of environmental hygiene are needed to improve food safety in these facilities.

Key words: Food safety, food service workers, coliforms, *E. coli.*

INTRODUCTION

Foodborne diseases are a challenge for both developed and developing countries (Da Cunha et al., 2012), and are a leading cause of illness and death in developing countries (Hassan et al., 2010). Despite concerted efforts for several decades, foodborne diseases remain a major global public health issue with substantial morbidity and mortality associated with the consumption of contaminated foodstuffs (Havelaar et al., 2010).

The measurement of the safety of foods has relied on evaluation of the microbiological quality of foods (Havelaar et al., 2010; Jacxsens et al., 2010). Bacterial counts in prepared food or water is a key factor in assessing the quality and safety of food, and can reveal the hygiene level adopted by food handlers in the course of preparation of such foods (Nkere et al., 2011). In a recent review, *E. coli*, *Shigella, Salmonella,* and *Campylobacter* spp. were the most commonly reported causes of gastrointestinal disease in sub-Saharan Africa (Fletcher et al., 2011), and all have been associated with foodborne disease (FDA, 2012). One study conducted in Kampala, Uganda, concluded that the microbiological safety of salads was unsatisfactory due to high bacterial

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counts and the presence of *Staphylococcus aureus*, which were attributed to inappropriate food handling hygiene and sanitation during preparation (Oiko, 2000, unpublished). However, in developing countries, monitoring the microbial safety of foods is not routinely practiced, due to a lack of infrastructure and effective food safety regulations and standards (Nguz, 2007).

Outbreaks of foodborne illnesses have been linked to improper food handling practices at food serving establishments (Baş et al., 2006; Çakiroğlu and Uçar, 2008; Hassan et al., 2010; Da Cunha et al., 2012). The most commonly reported food preparation practices that contribute to foodborne diseases include poor environmental hygiene, inadequate cooking, contaminated equipment, improper holding temperatures and food from unsafe sources (Guzewich and Ross, 1999; Da Cunha et al., 2012).

Food handlers, the people who are employed directly in the production and preparation of foodstuffs, are integral to reducing food safety risks (De Sousa, 2008; Chapman, 2009). Lack of personal hygiene among food handlers is one of the most commonly reported practices that contribute to foodborne illness (Taulo et al., 2009). The majority of foodborne outbreaks associated with food workers have involved transmission of the pathogens to food by the food workers' hands (Guzewich and Ross, 1999; Çakiroğlu and Uçar, 2008), and ensuring personal hygiene, particularly hand washing, has been cited the most effective tool in preventing the spread of foodborne infections (NHS Plus, 2008).

Developing and educating a workforce knowledgeable in food safety and hygiene is necessary to improve food safety in food service establishments. Studies of the knowledge, attitudes and practices of food service workers in developing countries have been conducted, and several trends have been reported in this workforce. Factors that were associated with better food safety knowledge include the level of education of the worker (Zeru and Kumie, 2007; Kibret and Abera, 2012; Onyeheho and Hedberg, 2013), and training in food safety (Garin et al., 2002; Baş et al., 2006; Kibret and Abera, 2012; Olumankaiye and Bakare, 2013; Onyeheho and Hedberg, 2013). Workers in food service establishments in hospitals and schools were also found to have better food safety knowledge and practices than workers in other restaurants, street vendors, and other small food service establishments (Baş et al., 2006; Onyeheho and Hedberg, 2013). Training programs are effective, and improved environmental and worker hygiene practices in a study of fast food and street food vendors in Nigeria (Olumankaiye and Bakare, 2013). However, despite knowledge and awareness of safe food handling methods, several studies have found that food handlers often do not use safe food handling practices, based on observation and microbial food testing (Baş et al., 2006; Zeru and Kumie, 2007; Kibret and Abera, 2012).

Although there is a growing body of research on food safety and food worker hygiene and practices in developing countries, the majority of these studies focus on street food vendors rather than larger institutional food service establishments. Given the reported differences in food safety knowledge and practices between food service facilities in schools and restaurants, this study was conducted to test two research hypotheses: 1) food contamination levels will be significantly lower in facilities where kitchen staff or food handlers practice good hygiene than those that practice poor hygiene; and 2) food contamination levels will be lower in university food service establishments due to better worker hygiene and food safety practices. The objectives of the study were to: describe the knowledge, attitudes and practices of food handlers in food service facilities at a university campus (Makerere University, Kampala, Uganda) and restaurants in its neighborhood; measure levels of food contamination at these facilities through microbiological analyses; and determine the effect of individual hygiene practices on food contamination levels.

MATERIALS AND METHODS

A longitudinal study involving two groups of food service workers and facilities was conducted between September, 2012 and July, 2013. The kitchen staff at Makerere University, working in student halls of residence, comprised Group A (facilities A1-A9), and the neighborhood restaurants that operated in improvised makeshift structures comprised Group B (facilities B1-B7). A proportional random sample was selected for the study: 75 subjects were selected from 95 workers in nine different kitchens at Makerere University and 25 subjects were selected from 35 workers in seven restaurants outside the University. Food samples, consisting of all the items served at the time of sampling, were collected from each facility on three different points during the study period.

Data collection

Face-to-face interviews were conducted to collect information on workers' hygiene practices and attitudes using questions adopted from Baş et al., 2006 and Giritlioglu et al., 2011. Information on food safety practices was collected through a semi-structured questionnaires through in-person interviews by trained study personnel at two levels: the institution level (from the 16 facilities), and the individual level (from food service workers). The institution and individual-level information on food safety practices was collected by questionnaires administered to kitchen supervisors, and individual food service workers. All responses were validated by interviewers' observations of the facilities and respondents, and responses were corrected in situations where observations did not agree with the responses (e.g., there was no soap at hand washing basins but the respondent indicated that soap was provided). Individual respondents were assigned food safety attitude and hygiene practice scores:

$$Attitude_{ij} = \frac{\sum_{j=1}^{16} Response_{ij}}{\sum_{j=1}^{16} MaxResponse_j} \times 100 \qquad Practice_{ik} = \frac{\sum_{k=1}^{12} Response_{ik}}{\sum_{k}^{12} MaxResponse_k} \times 100$$

Where, $Attitude_{ij}$ = attitude score for respondent *i*; $Response_{ij}$ = response of respondent *i* to attitude question *j*; $MaxResponse_j$ = the maximum value of possible responses to attitude question *j* (2 for yes/no responses); $Practice_{ik}$ = hygiene practice score for respondent i, $Response_{ik}$ = response of respondent *i* to hygiene practice question *k*; and $MaxResponse_k$ = the maximum value of possible responses to practice question *k* (6 for Likert scale questions regarding the frequency of personal hygiene practices; 2 for yes/no responses). The attitude and practice scores could range in value from 0 to 100.

Food sample collection

Food samples were collected from the study kitchens at serving point. Approximately 250-500 g of food were collected and sealed in sterile stomacher bags, placed in cool boxes, and transported to the food safety laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University, within 30 minutes after collection. Samples were processed within 6 hours of collection.

Microbiological analyses

Food contamination was measured by total aerobic mesophilic bacteria plate counts (APC), enumeration of *Escherichia coli (E. coli)* and total coliforms, and presence of *Salmonella.* A 25 g sample was collected from each food sample, and prepared using sterile surgical blades and adding 225 ml of sterile buffered peptone water. Each sample was divided into two, and each sub-sample was placed in sterile stomacher bags and homogenized using a pulsifier. After homogenization, each sub-sample was divided into two, and serial 10-fold dilutions were made, up to 10^{-7} dilution (Harrigan, 1998). Selected dilutions of the food samples were mixed by vortexing, and inoculations were made within 25 min of processing, using methods adapted from Downes and Ito (2001).

For total aerobic mesophilic bacteria (APC) counts, 0.1 ml of the processed food samples of specified dilutions were inoculated onto sterile Plate Count Agar (HiMedia Laboratories, India), using the surface spread method, and incubated for 24 h at 37°C (Refai, 1979; Harrigan, 1998). After incubation, plates containing 25-250 colonies were selected for counting. Counts obtained were characterized by the reciprocal of the dilution factors used, and additionally by 10^1. The bacteria population was expressed as a number of colony forming units per gram (CFU/g).

In processing for total coliforms and *E. coli*, 0.1 ml of the processed food samples of specified dilutions were inoculated onto Chromocult coliform agar (Merck, Germany), a selective indicator media for the enumeration of *E. coli* and other coliforms. After incubation for 24 h at 37°C, dark blue colonies were classified as *E. coli*, while pink colonies were classified as other coliforms (Merck, 1996). Gram staining was carried out on suspected *E. coli* colonies, and all cultures with Gram negative short rods were biochemically confirmed as *E. coli* using the IMVIC tests (Downes and Ito, 2001). Indole production was regarded as positive for *E. coli* if there was an appearance of a distinct red color in the upper layer; the Voges-Proskauer (VP) test was considered positive if the eosin pink color developed; the methyl red test was considered positive if a distinct red color developed; and the citrate utilization test was considered positive if Simmon's citrate media changed from green to blue.

To enhance the recovery of *Salmonella*, samples underwent pre-enrichment for 24 h at 37°C (Refai, 1979). Enrichment in selective media [Tetrathionate Brilliant green broth (Merck, Germany)] was conducted in triplicate for each sample, for 24 h at 37°C (Downes and Ito, 2001). After enrichment, enriched samples were streaked on plates of Xylose Lysine Desoxycholate (XLD) (Oxoid, UK) selective medium, incubated at 37°C for 24 – 48 h, and examined for *Salmonella* colonies which exhibited the typical appearance "i.e. pink with large black centers which made them appear black" (FDA, 2011). Suspect colonies were subcultured to get a pure culture, and were subjected to confirmatory tests (Harrigan, 1998). Confirmation of *Salmonella* was based on results of Gram staining, urease, indole, citrate, and TSI tests (Oxoid, UK).

Statistical analyses

The primary outcomes of interest were the safety status of food in each facility, and the use of unsafe food handling practices at the individual and institutional level. Each employee and institution was classified as having safe food handling practices if they had food hygiene practices and attitude scores of 75% or more. For each facility, foods were classified as safe if the mean APC of the three samples was less than 100,000 CFU/g, and the mean counts for coliforms and *E. coli* were less than 100 CFU/g, using cutpoints for microbiological food safety (Gilbert et al., 2000). There were only two food samples where *Salmonella* was detected, so statistical analyses regarding *Salmonella* were not conducted.

Descriptive statistics were generated to characterize the study respondents, responses to questionnaires, attitude and practice scores, and laboratory testing results. Associations between food service worker characteristics (age, gender, level of education and working experience measured by years in employment) and their attitudes on hygiene were assessed using the chi-square test for associations. Associations between safe food handling status and categorical risk factors were evaluated through odds ratios (OR), with 95% confidence intervals and p-values. Associations between mean APC, coliforms and *E. coli* with different types of food were assessed using the non-parametric Kruskall-Wallis X^2 of the Wilcoxon Rank-Sum test, and associations between unacceptable levels of bacteria with different types of food were assessed using Fisher's Exact 2-tailed test, and the strength of association reported through odds ratios with 95% confidence intervals.

Multivariable logistic regression was used to identify risk factors associated with the safety of foods. Risk factors significantly associated with food safety from the univariable analyses ($p \leq 0.05$) were considered for inclusion in multivariable analysis. Binary logistic regression was used to screen these risk factors – those that were statistically significant ($p \leq 0.05$) were used in the multivariable analysis. Stepwise logistic regression was used to develop the final model for food safety, with adjustment for confounders (Kleinbaum and Klein, 2010).

RESULTS

A total of 94 interviews were conducted, including 54 individual respondents (41 from Group A, 13 from Group B) and 40 institutional respondents (Table 1). The majority of individual respondents were females from 26 to 60 years in age, received secondary level educations, and had worked with food service facilities for more than twelve years. The majority of the individual respondents were food servers and cooks, and only 40.7% of respondents had attended on-the-job training since they joined employment. The 40 institutional respondents (33 from Group A, 7 from Group B) were males from 26 to 60 years in age, received secondary and tertiary educations, and had over 5 years of experience in food service. Chiefs and cooks made up the majority of institutional respondents, and only 35% had attended any on-the-job training.

Safe food handling attitudes and practices

When asked about attitudes regarding food safety, the

Table 1. Characteristics of study respondents.

Factor	Level	Individual (n = 54)		Institutional (n = 40)	
		N	%	N	%
Facility type	A	41	75.9	33	82.5
	B	13	24.1	7	17.5
Gender	Male	19	35.2	24	60.0
	Female	35	64.8	16	40.0
Age	18 – 25	6	11.1	2	5.0
	26 – 35	11	20.4	13	32.5
	36 – 45	17	31.5	8	20.0
	46 – 60	19	35.2	17	42.5
	> 60	1	1.9	0	0
Highest Level of Education	None	1	1.9	0	0
	Primary	19	35.2	2	5.0
	Secondary	32	59.3	19	47.5
	Tertiary	1	1.9	14	35.0
	Other	1	1.9	5	12.5
Food Service Industry Experience	1 – 5 years	12	22.2	8	20.0
	6 – 12 years	5	9.3	10	25.0
	13 – 20 years	17	31.5	5	12.5
	21 – 30 years	18	33.3	11	27.5
	> 30 years	2	3.7	6	15.0
On-the-job training		22	40.7	14	35.0
Role	Cook	24	44.4	9	22.5
	Server	25	46.3	8	20.0
	Caterer	1	1.9	-	-
	Kitchen Supervisor	4	7.4	-	-
	Chief	-	-	12	30.0
	Bursar	-	-	7	17.5
	Warden	-	-	4	10.0

majority of individual respondents indicated they understood the importance of safe food handling and their personal responsibility for food safety, but respondent attitudes about proper food storage and holding temperatures and food safety were mixed (Table 2). The majority of institutional respondents reported employees washed hands properly and frequently, appeared in good health, kept fingernails short, unpolished and clean, and wore little jewelry (Table 3).

Microbiological testing of foods

A total of 48 food samples (27 from the University, 21 from restaurants outside the University) were collected (Table 4). The most commonly served foods were posho, rice, beans, and beef, and there was a larger variety of foods served in Group B facilities.

The mean APC for all food samples was 937,165 (Figure 1). There were no statistically significant differences in the mean APC for Group A (925,626 CFU/g), versus Group B samples (952,000 CFU/g). Using the APC cutpoint of 100,000 CFU/g, 66.7% of Group A facilities and 71.4% of Group B facilities served meals in violation of food safety standards. Of facilities with violations, all three samples from one facility in Group A (A3) and two facilities in Group B (B3, B4) had APCs higher than 100,000 CFU/g; and three in Group A (A5, A6, A7) and two in Group B (B1, B7) had two samples with unacceptably high APCs.

Total coliforms were found in samples from all facilities, and total coliform plate counts were significantly higher (Kruskall-Wallis $X^2 = 3.88$, 1 d.f., $p = 0.0489$) in samples from Group B (7,965.2 CFU/g) than Group A (5,271.1 CFU/g) (Figure 2). Six Group A facilities and one Group B facility had at least one sample with no total coliforms. The highest mean total coliform CFU/g was 40,490 CFU/g, from one Group A facility (A4). Using a cutpoint of 100 CFU/g, there were no statistically significant differences in the numbers of samples with unacceptable

Table 2. Individual respondent hygiene practices and attitudes (n = 54).

Parameter	Response	#	%
Employee practices			
Meat can be chopped with vegetables	Yes	14	25.9
Raw and cooked foods should be kept separate	Yes	43	79.6
	Yes	7	13.0
Defrosted foods may be frozen only once	No	33	61.0
	Not sure	14	25.9
PPE use reduces food contamination risk	Yes	50	92.6
Knowing fridge temperature reduces food contamination risk	Yes	24	44.4
	Yes	24	44.2
Checking fridge thermometer settings once a day is important	No	26	48.4
	Not sure	4	7.4
Improper heating of food causes foodborne diseases	Yes	52	96.3
Improper food storage may be hazardous to health	Yes	52	96.3
Employee attitudes			
Safe food handling is important	Yes	50	92.6
Learning more about food safety is important	Yes	51	94.4
Food preparation without hygiene rules causes foodborne diseases	Yes	50	92.6
Employee personal hygiene			
How I handle food relates to food safety	Yes	45	83.3
Do not come to work if I have flu or diarrhea	Yes	29	53.7
Do not wear jewelry during food preparation	Yes	29	53.7
Food service staff with cuts on fingers or hands shouldn't touch cooked or unwrapped foods	Yes	30	55.6

Table 3. Institutional respondent hygiene practices and attitudes (n = 40).

Parameter	# Yes	%
Employee practices		
Employees use effective hair restraints	10	25.0
Hands are washed properly and frequently	34	85.0
Employees cover wounds completely	15	37.5
Food preparation activities only in designated zones	15	37.5
Employees wear clean and proper uniforms	10	25.0
Fingernails are short, unpolished, and clean	27	67.5
Jewelry is limited to a plain ring	34	57.5
Employees use disposable tissues	4	10.0
Facilities		
Employees appear in good health	32	80.0
Sinks are unobstructed	22	55.0
Sinks are stocked with soap	10	25.0
Hand washing reminder signs are posted	6	15.0
Employee toilets are operational and clean	35	87.5

coliform levels between the two groups. Only three Group A facilities and one Group B facility had acceptable mean total coliform levels.

Isolation of *E. coli* was not common: it was detected in 6 samples from five facilities from Group A, and 7 samples from three facilities from Group B (Figure 3). The highest mean *E. coli* CFU/g (7,530 CFU/g) was found in the same Group A facility with the highest mean

Table 4. Types of foods in samples collected from study facilities

Food	Group A (n=9)		Group B (n=7)	
	# Facilities serving	# Samples	# Facilities serving	# Samples
Posho	9	26	7	15
Rice	9	25	6	13
Beans	9	13	5	8
Beef	8	8	7	10
Matooke	0	0	7	17
Cabbage	2	2	5	8
Sweet Potato	1	1	6	9
Irish Potato	1	1	3	7
Chicken	4	4	2	2
Fried Chicken	4	4	2	2
Soup	4	4	1	1
Other Foods*	0	0	7	25

*Fried rice (5 samples from 4 sites); groundnut stew (4 samples from 4 sites); greens (4 samples from 3 sites); cassava, millet (3 samples from 2 sites); pumpkin (2 samples from 2 sites); and avocado, fish, goat, spaghetti (1 sample from 1 site).

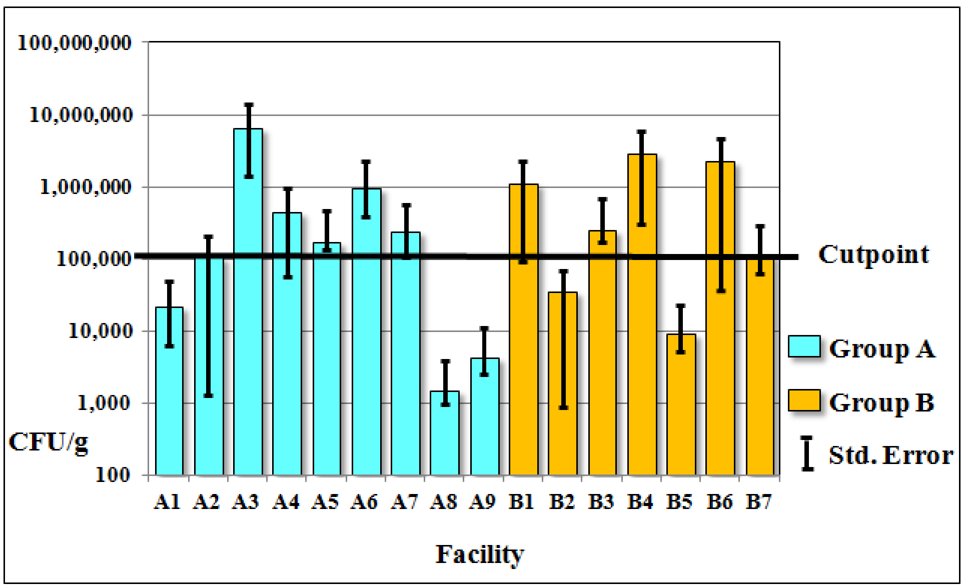

Figure 1. Mean Aerobic Plate Counts for food samples from university residence halls (n=9) and local restaurants (n=7), with cutpoints for microbiological food safety.

total coliforms (A4). Again, using the 100 CFU/g cutpoint for food safety, only one Group A and two Group B facilities had unacceptable levels of *E. coli.* There were no statistically significant differences in *E. coli* levels between the two sites.

Two food samples from two Group A facilities (A2, A9), collected on the second sampling visits, were positive for *Salmonella*. Both halls served the same food items (boiled rice, posho and beans) on that date. Facility A2 had APC (104,433 CFU/g) and total coliforms (107 CFU/g) slightly above the food safety cutpoints, while facility A9 had an acceptable APC (4,200 CFU/g) but unacceptably high total coliforms (1,007 CFU/g). Both facilities had no *E. coli*.

When examining specific foods, there were several foods that were associated with increasing or decreasing the risk of unacceptable levels of bacteria (Table 5). Food samples from both groups that contained beef were at

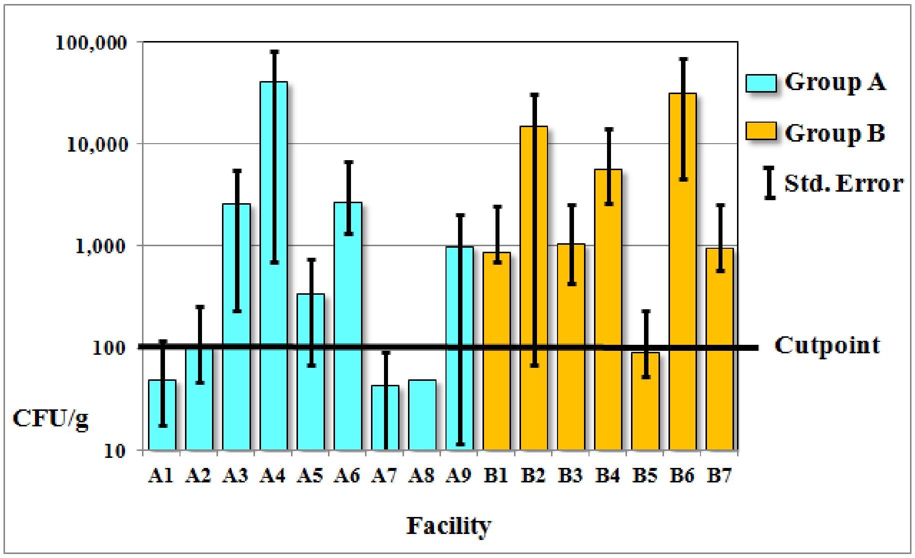

Figure 2. Mean total coliform counts for food samples from university residence halls (n=9) and local restaurants (n=7), with cutpoints for microbiological food safety.

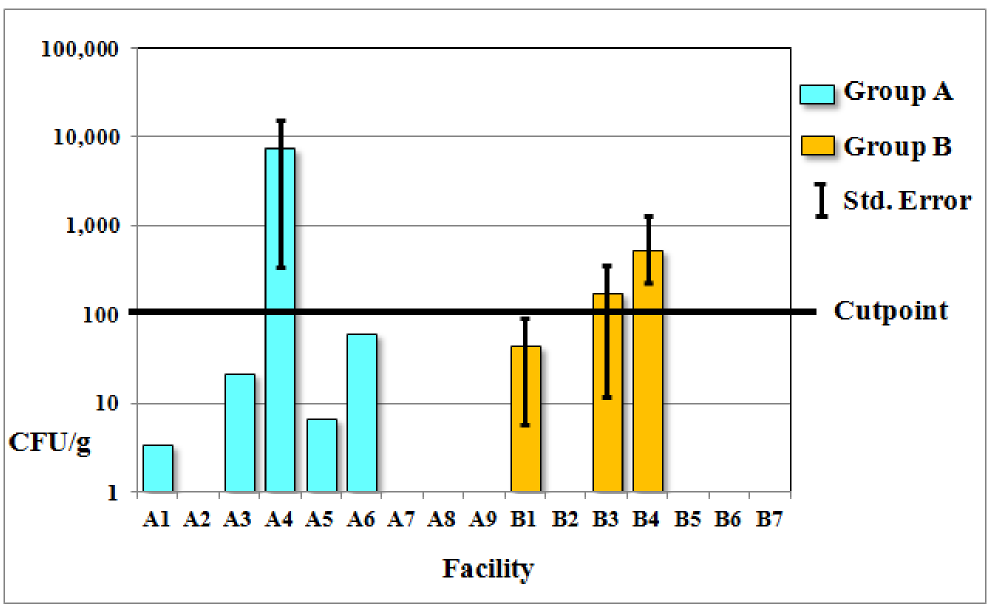

Figure 3. Mean *E. coli* counts for food samples from university residence halls (n=9) and local restaurants (n=7), with cutpoints for microbiological food safety.

higher risk for unacceptable coliform levels, and mean coliform counts for samples with beef (13,117 CFU/g) were significantly higher (Kruskall-Wallis X^2 – 4.5, 1 d.f., p = 0.0345) than samples that did not contain beef (2,449 CFU/g). Samples from Group B facilities that contained beans were at higher risk for unacceptable levels of *E. coli*, and had significantly higher mean *E. coli* (217.5 CFU/g) than meals that did not contain beans (29.2 CFU/g) (Kruskall-Wallis X^2 = 4.8, 1.d.f., p = 0.0278). Meals that contained sweet potato were at lower risk for unacceptable APC levels for both groups combined, and this association was statistically significant when considering samples from Group B alone (89,056 CFU/g with sweet potato versus 1,605,968 CFU/g without; Kruskall-Wallis X^2 = 5.9, 1.d.f., p = 0.0156). Samples from Group B that contained matooke had statistically lower mean levels of *E. coli* than samples without matooke (37.1 CFU/g and 405.0 CFU/g, respectively;

Table 5. Associations ($p < 0.1$) between food type and unsafe levels of aerobic mesophilic bacteria, coliforms, and *E.coli*

Group	Food	# Tested	Bacteria	% Unsafe	Odds Ratio	95% C.I.
Both Groups	Posho	41	*E. coli*	12.2	0.24	0.04 – 1.46
	Beef	18	Coliforms	37.5	3.91	0.91 – 16.82
	Sweet potato	10	APC	20.0	0.10	0.02 – 0.63
	Chicken	12	Coliforms	41.7	0.29	0.07 – 1.17
Group B	Beans*	8	*E. coli*	50.0	12.00	1.02 – 14.34
	Beef	10	APC	80.0	7.00	0.97 – 50.57
	Matooke*	17	*E. coli*	11.8	0.04	0.003 – 0.66
	Sweet potato*	9	APC	22.2	0.06	0.01 – 0.51

* Association significant at $p \leq 0.05$

Kruskall-Wallis $X^2 = 5.3$, 1.d.f., $p = 0.0218$), and were significantly less likely to have unacceptable levels of *E. coli*.

Institutional and individual-level food safety attitudes and practices

A minority of institutional respondents were classified as using safe food hygiene practices (26.9% from Group A; 42.9% from Group B). There were no significant differences in age and work experience, but respondents with secondary and higher level educations were more likely to use safe food hygiene practices (O.R. = 4.75; 95% C.I. = 2.57 – 8.79). For specific practices, the use of effective hair restraints (O.R. = 56.0; 95% C.I. = 6.78 – 462.64) and posting hand washing reminder signs (O.R. = 9.33; 95% C.I. = 1.38 – 63.20) were positively associated with safe hygiene practices.

Over 90% of the 54 individual respondents (95.1% in Group A; 84.6% in Group B) were classified as using safe food handling practices. There were no significant differences in age, education, work experience, position in kitchen, or facility between safe and unsafe food handling respondents. For specific hygiene practices and attitudes, there were significant differences between safe and unsafe handling groups for wearing jewelry during food preparation (OR = 0.84, 95% C.I. = 0.71 – 1.0), and believing that food preparation without hygiene rules causes foodborne diseases (OR = 24.0, 95% C.I. = 2.14 – 269.12).

The association between individual worker risk factors and food classified as safe through microbiological analyses were tested, and odds ratios computed for nine variables were considered for inclusion in multivariable analyses (Table 6). After multivariable model building was completed, the final model for safe food (based on microbiological testing) contained only one variable: not wearing jewelry was associated with decreasing risk for unsafe foods (adjusted OR = 0.05, 95% CI: 0.00 – 1.05). Overall, 48.6% of the variation in safety of food served in Makerere University halls of residence and neighborhood restaurants was correctly explained by the model (Hosmer and Lemeshow goodness-of-fit $X^2 = 4.45$, 5 d.f., $p = 0.49$).

DISCUSSION

Food service employees

The majority of individual respondents in this study were female. Although this study found no associations between gender and safe food handling, female workers had better hygiene scores and practices than males (Çakiroğlu and Uçar, 2008; Kibret and Abera, 2012), and female clients in a study of food service outlets in Nigeria were more likely to patronize outlets with better hygiene levels (Olumakaiye and Bakare, 2013). Most respondents were from 18 to 45 years of age, and had worked in food service facilities for more than five years. Other studies have found that older workers had better hygiene scores than younger workers (Çakiroğlu and Uçar, 2008; Olumakaiye and Bakare, 2013), and workers with more than seven years of food service work experience had better hygiene scores than younger and newer workers(Çakiroğlu and Uçar, 2008).

There were differences in level of education between individual food service workers and institutional respondents. The majority (59.3%) of individual workers possessed secondary level educations, which is higher than reported in studies of food handlers (Baş et al., 2006) The majority of institutional respondents had attained higher education levels than the individual respondents. Higher levels of education have been associated with better food safety knowledge awareness, and better sanitary conditions in other studies (Zeru and Kumie, 2007; Olumakaiye and Bakare, 2013; Onyeneho and Hedberg, 2013), and a study of the environmental hygiene of food service outlets were significantly

Table 6. Association between risk factors and food safety determined by microbiological testing, from 41 workers in 9 kitchens from Makerere University, and 13 workers in 7 kitchens from local restaurants.

Variable	Level	Odds Ratio	95% C.I.
Education Level	Primary and Below	4.75*	2.57 – 8.79
	Secondary and above	(baseline)	
Use effective hair restraints	No	56.0**	6.78 – 462.64
	Yes	(baseline)	
Clean, short, unpolished fingernails	No	6.0	0.67 – 53.68
	Yes	(baseline)	
Wear jewelry during food preparation	No	0.84*	0.71 – 1.00
	Yes	(baseline)	
Cuts and abrasions covered	No	0.86	0.18 – 4.04
	Yes	(baseline)	
Hand washing reminders	No	9.33	1.38 – 63.20
	Yes	(baseline)	
Personal protective equipment reduces food contamination risk	No	1.08	1.00 – 1.18
	Yes	(baseline)	
Prepare food when sick	No	3.82	0.37 – 39.28
	Yes	(baseline)	
Prepare food disregarding hygiene rules	No	24.0**	2.14 – 269.11
	Yes	(baseline)	

*p < 0.05; **p < 0.01

associated with the age, education level and income of operators (Olumankaiye and Bakare, 2013). The requirements for employee education and training by food service facilities has been shown to have positive influences on food hygiene. Studies have reported that food service workers from hospitals and schools had better food safety knowledge, attitudes and practice scores than workers from smaller food service establishments, fast-food outlets, and vending stalls or street food vendors (Baş et al., 2006; Onyeneho and Hedberg, 2013).

Specific training for food service workers was not common in this study. Only 40.7% of individual respondents and 35% of institutional respondents had attended any on-the-job training since they joined employment, which is lower but comparable to other studies (47.8%, Baş et al., 2006). In several studies, food service workers that received training had better hygiene scores and safe food handling practices than those that did not receive training (Baş et al., 2006; Kibret and Abera, 2012; Onyeneho and Hedberg, 2013; Ababio and Lovatt, 2014). This indicates that on-the-job and short term training sessions for food service workers would be beneficial to facilities in this study. A study of 277 food handlers in Ethiopia found the most common sources of information about food safety were mass media (50%) and health centers (42.7%) (Zeru and Kumie, 2007), which also suggests that using less traditional venues for education, such as radio or newspaper campaigns, can also provide useful information to food service workers and the population in general.

Food service employee knowledge, attitudes, and practices

The majority of individual respondents indicated they understood the importance of safe food handling and their personal responsibility for food safety, but knowledge and attitudes about some aspects of food safety were mixed. The majority of individual respondents acknowledge the importance of separating raw and cooked food, using personal protective equipment (PPE) to reduce food contamination, and the hazards of improper food heating and food storage, which has been seen in other studies of food service workers (Baş et al., 2006). However, less than 45% of respondents indicated that knowing refrigerator temperatures was important, and that checking refrigerator thermometer settings was important, which was seen in 35% of head chefs and managers of restaurants in Nigeria (Onyeneho and Hedberg, 2013).

Over 80% of individual respondents reported that food handling affected food safety, but only 54% of respondents understood that working when sick or wearing jewelry during food preparation were practices to be avoided for food safety. Approximately 44% of respondents did not acknowledge that food service workers with cuts on their fingers or hands should avoid handling cooked or unwrapped foods, which is similar to findings from other studies in Turkey and Nigeria (Baş et al., 2006; Onyeneho and Hedberg, 2013). One study reported that 47% of food service chefs and managers had a lack of awareness that sick persons can spread foodborne illness (Onyeneho and Hedberg, 2013), and surveys of food vendors found that only 42% of workers in Nigeria (Olowogbon et al., 2012) and 23% in Ethiopia (Zeru and Kumie, 2007) had at least one medical examination per year. The health status of these workers could have serious implications for food safety.

Environmental hygiene is important for food safety, and necessary to support safe food handling and hygiene by employees. It was the duty of the employer to provide and enforce use of facilities and tools for the safe handling of food, including PPE. The majority of institutional respondents reported employees washed hands properly and frequently, appeared in good health, kept fingernails short, unpolished and clean, and wore little jewelry, but this study revealed inadequate provision of uniforms, hygiene and food handling equipment. Most facilities had sinks with no soap, hand washing reminder signs were not posted, and kitchen staff did not wear proper or full uniforms (including hair restraints or a cap). In sites with poor access to clean running water, hand washing water (Taulo et al., 2009) and dish washing water (Nkere et al., 2011) can harbor fecal bacteria and serve as a source of bacterial contaminants for both food and workers. Other studies have found that foods that have been properly prepared can become contaminated by serving utensils washed in contaminated water, or handled by unwashed hands (Taulo et al., 2009; Nkere et al., 2011).

From the results of the multivariable analysis, food service employees who wore jewelry (36% of employees) during food preparation were more likely to be associated with the serving of unsafe food. It is possible that, when jewelry becomes contaminated, the lack of soap at sinks and absence of hand washing reminder signs allows jewelry to stay contaminated for longer periods of time, and increase the opportunities for cross- contamination during food handling. It is also likely that the insistence on wearing large amounts of jewelry during food preparation is reflective of a lack of awareness of potential hazards: workers may not realize that this can be a source of contamination, or may not be aware of the hazards that avoiding hand washing to avoid damaging jewelry can pose.

Although the majority of individual respondents indicated they understood the importance of safe food handling and their personal responsibility for food safety, they performed poorly in important food safety and hygiene practices, which has been widely reported in food hygiene practice studies in Ghana (Ababio and Lovatt, 2014), Nigeria (Ondyeneho and Hedberg, 2013), and other countries (Fulham and Mullan, 2011). In one study of the “intention-behavior gap” in hygienic food handling (Fulham and Mullan, 2011), researchers found that subjective norms (food handling practices by co-workers, “peer pressure”) and perceived behavioral control (the worker’s perception of the ease or difficulty of performing the behavior) predicted their intentions to follow good food handling practices and these intentions predicted behavior. However, the study found that behavioral prepotency (old habits, past behaviors) was the best predictor of intention and behavior, regardless of worker knowledge or attitude (Fulham and Mullan, 2011). Hygienic food handling has immediate negative perceived behavioral control (takes more time, costs more, inconvenient to use, uncomfortable to wear), and the benefits of hygienic food handling are not immediate and personal, but are more long-term and general, which contributes to why workers often fail to use best practices even when they are aware of their importance. Some possible solutions to overcome the “intention-behavior” gap are to change the working atmosphere of food service workers (subjective norms) or to change the perceptions of the ease or difficulty of using safe food handling practices (perceived behavioral controls). Individual respondents in this study indicated their willingness to wear proper uniforms and use hair restraints if the employer provided them.

Safety of food served in residence halls and neighborhood restaurants

The majority of food samples tested in this study had APC and total coliform CFU/g counts higher than acceptable, which indicates that there are ample areas for improvement in safe food handling. In the case of the samples that tested positive for *Salmonella*, both came from two halls that served the same food items on that sampling date, and were collected by different individuals. This suggests a common source of *Salmonella* for these two food service facilities, but identifying the common source is difficult, given that the two halls are far apart and unlikely to share personnel or facilities.

The findings that there were significantly higher levels of coliforms in samples from neighborhood restaurants (Group B) than in samples from University food service facilities (Group A) were expected, given that the residence halls have better facilities than the restaurants, of which some operate in improvised structures. However, the lack of significant differences in APC or *E. coli* CFU/g in food samples from Makerere University food service facilities (A1-A9) than in food samples from neighborhood restaurants (B1-B7) was unexpected. This may be explained by laxity in supervision in the halls as compared to the restaurants, where the owners seem to supervise their staff more keenly. However, given the generally low levels of good hygiene practices and problems in environmental hygiene, there are likely other factors beyond the scope of this study which influenced the levels of bacteria found in food samples from food service facilities in this study.

Conclusions

In general, this study has found that there is a critical need for improving food safety at restaurants and dining halls at Makerere University. The APC levels in samples of all facilities were higher than desired. The finding that the majority of respondents did not follow good hygiene practices (e.g., use of hair restraints), indicates laxity or lack of supervision, and a need to overcome the problems of the “intention-behavior gap” in hygienic food handling. Employees in food service facilities are aware of proper food handling hygiene practices and have positive attitudes towards food safety, but inadequate facilitation (e.g., lack of soap at sinks) prevents them from observing good hygiene practices when handling food.

Based on results from this study, there are specific areas for improvement in both university dining halls and local restaurants. For individual kitchen workers, providing training on personal hygiene and proper food handling techniques will be helpful, particularly in raising awareness of some specific practices (for example working while sick, handling food when there are cuts or wounds on the hand).

At the institutional level, food service facility managers should improve environmental hygiene, including steps such as ensuring that sinks or hand washing basins in kitchens and toilets have running water, and are stocked with soap at all times, and hand washing reminder signs should be posted. To improve the workforce itself, food service facility managers should establish and maintain minimum qualifications for employees above primary education, as better-educated staff are more likely to adhere to good hygienic practices. Managers can support safe food handling by their employees by providing and enforcing wearing of uniforms, including clothing, hair restraints, aprons and gum boots, by all food service workers.

There is a need for governmental support to improve food safety management systems, and education and awareness programs (Onyeneho and Hedberg, 2013; Ababio and Lovatt, 2014). Regular inspection of food service facilities is critical: facilities subject to regular inspection had better sanitary conditions than uninspected facilities (Zeru and Kumie, 2007). Finally, government and leaders in the food service industry should strive to institute a thorough assessment of the food processing chain to identify and address areas that are responsible for food contamination.

Conflict of interests

The authors did not declare any conflict of interest.

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