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Research Article

Factors Associated with Foodborne Pathogens among Food Handlers: A Case Study of Thika, Kiambu County, Kenya

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Increasing risks of infections with foodborne pathogens may occur as a result of poor food handling practices. The present cross-sectional study employed a mixed-methods approach to determine the factors associated with foodborne pathogens among food handlers working in the food establishments in Thika, Kiambu County, Kenya. Random sampling was used to enroll respondents in the survey. A single stool specimen was collected from each study participant. Laboratory analysis of the specimen was done to test the selected foodborne pathogens. Overall, 44 out of the 285 food handlers who took part in the study had at least one food-transmitted pathogen, putting the prevalence of foodborne infections among the food handlers at 15.4% (95% confidence interval (CI) 11.7%–20.1%). The findings from multivariate logistic regression indicated the following protective factors for foodborne pathogens among the studied food handlers: being female (adjusted odds ratio (AOR) 0.098 (95% CI 0.0304–0.315, $p<0.001$)); having a valid medical examination certificate (AOR 0.141 (95% CI 0.141–1. 0.439, $p = 0.001$)); not boiling or treating water before serving the water to customers was a risk factor for having infections with foodborne pathogens (AOR 3.043 (95% CI 1.2225–7.577, $p = 0.017$)). The presence of foodborne pathogens among the food handlers in the study area potentially highlights the need to address the spread and transmission of foodborne infections in the study area. There is a need to institute appropriate control measures, including regular screening of food handlers for foodborne illnesses in addition to training them on safe food handling practices, hand hygiene practices, and regular monitoring of the food handling practices.

1. Introduction

Food safety is an essential public health matter to prevent foodborne diseases. To respond to the expanding cases of foodborne diseases, the governments from different parts of the world are increasing their strategies for improving food safety [1]. Both food producers, processors, distributors, and customers are interested in having safe food for healthy living. Globally, one person in ten falls ill from foodborne illness, and 420,000 people die yearly, of whom under fives account for one-third of these deaths. [2] In the United States, foodborne infections are responsible for about 9 million incidents of foodborne illness, 56,000 hospitalizations, and 1,300 fatalities every year. This is an indication that the prevalence of foodborne infections is a challenge not only for the underdeveloped, but also for the developed nations [3].

Foodborne illnesses are also rampant in developing nations, including Kenya, due to poor food handling methods, poor regulatory systems, inadequate food safety laws, a lack of education among handlers, and inadequate funds to buy safe equipment [4]. Studies carried out in the northern area of Ethiopia indicate that 30.3% and 52.5% of handlers had effective food handling methods in Dangila and Gondar towns, respectively [5]. The study done on humans in the Metropolis of Ghana found that the majority of the incidents leading to foodborne deaths are linked to poor knowledge and a lack of awareness attributed to a lack of food handlers' training [6]. Between 2017 and 2018, there was an outbreak of listeriosis in South Africa from a company processing meat, infecting 978 people. More appealing was the loss of 183 people, while 15 countries that imported the meat from the processing company were put at risk [7]. This reveals how

the core activities of food safety, such as control, assurance, and regulations have been conducted with less attention. It is the absence of precautionary measures, inadequate oversight systems, poor certification, and a lack of training on proper hygiene measures that contribute to foodborne disease outbreaks [8].

In Kenya, the informal food sector largely accounts for at least 80% of the local markets. Hygiene control in the informal sector is limited since monitoring this sector is difficult. The inadequate hygiene control in these informal sectors promotes higher incidences of foodborne illnesses [9]. Various studies concerning factors associated with food safety practices among food handlers have been conducted in selected areas of Kenya, like hospital settings [10]. In the Kenyan context, guided by Kenyan law (the Food Drugs and Chemical Substances Act, Cap 254), every food handler must be subjected to routine medical examination to reduce the spread of foodborne infections. This entails stool and urine tests for *Salmonella enterica*, Campylobacter spp., *Entamoeba histolytica*, parasitic infections, and urethra infections.

The foodborne pathogens studied in this context included *Salmonella enterica*, Campylobacter spp., and *Entamoeba histolytica*. Hospital data from four health centers in Thika Sub-County revealed that 725 cases of foodborne illnesses were reported between February 2021 and August 2021 as follows: Salmonella (200), Campylobacter (165), *E. histolytica* (156), parasitic infections (100), and UTIs (104), respectively.

Thus, the present research aimed at determining factors associated with foodborne pathogens among food handlers in Thika, Kiambu County, Kenya.

2. Methods

2.1. Study Area. Kiambu County is one of the 47 counties in Kenya. It falls in the larger Nairobi metropolitan area, and it is a fast-growing town. Geographically, the county is found in the central region. The geocoordinates of Kiambu County are 108′ 46.28″ S and 36057′ 59.4″ E. Thika Sub-County is one of the Kiambu County's twelve subcounties, and it is located in the western part of the county with five administrative wards, namely: the hospital ward, the township ward, the Gatuanyaga ward, the Kamenu ward, and the Goliba ward. According to the 2019 national census, Thika has a population of 279,429 with a total area of 217.5 km^2 and an elevation of 5,351 ft above sea level. Thika Sub-County is the commercial hub and industrial town of Kiambu Sub-County. The economy of the Thika Sub-County depends on agriculture and industries like textile industries, bakeries, oil industries, pharmaceutical, and chemical industries, motor vehicle dealers, and cigarette manufacturing industries. Thika Sub-County is home to three universities, tens and hundreds of middle-level colleges, and several secondary and primary schools. The subcounty also has many financial institutions. This makes the subcounty have a large number of food and drinking establishments (~2,000), highlighting the importance of conducting this kind of research in this fast-growing subcounty.

2.2. Study Population. The study population comprised food handlers in licensed food eateries (eating premises) within Thika, Kiambu County, Kenya. Key informants comprised public health officers and hotel managers. The inclusion criteria involved those who had been working in licensed food-eating premises for at least a month and who had consented to take part in the study. Those who did not consent to take part in the study were excluded from the study.

2.3. Study Design and Sample Size. A descriptive cross-sectional study design utilizing mixed methods techniques was employed in the survey. The minimum sample size was calculated using the formula described by Yamane [11] at a confidence interval (CI) of 95%, a 0.05 level of significance, and a desired level of precision of 0.05.

Whereby;

$$n = \frac{N}{1 + N(e)^2}, \tag{1}$$

Whereby;

$$n = \frac{994}{1 + 994(0.05)^2}, \tag{2}$$

N = is the total number of food handlers ($N = 994$, obtained from Kiambu County revenue office and Sub-County Public Health Office).

e = is the degree of precision. (0.05), then n was 285 sample size.

The sample size was distributed among the study sites proportionately.

2.4. Sampling Technique. Simple random sampling was used to select individual food handlers per premise. Two key informants were selected purposively.

2.5. Data Collection Method and Procedures. A questionnaire and observation checklist were used to capture quantitative data. Focus group discussion (FGD) guides and key informant interview (KII) guides were used to obtain qualitative data. The prevalence of foodborne pathogens among the food handlers was determined through laboratory testing of stool samples from consenting food handlers from licensed food premises in the area of study. The foodborne pathogens studied in this research included *Salmonella enterica*, Campylobacter spp., and *Entamoeba histolytica*. Stool specimens were collected among the food handlers and transported to a laboratory for testing the selected foodborne pathogens. Stool processing and examination were conducted at the Thika Level 5 hospital laboratory department by qualified laboratory technicians.

2.6. Data Analysis Techniques. Quantitative data were exported to a Microsoft Excel sheet, then exported to IBM SPSS version 24 for analysis. Frequencies and percentages were used to describe categorical data. For continuous data, the mean and median were used to summarize the data. For the inferential analysis, knowledge of food safety practices was measured as a binary variable based on a set of 21 items. Those who provided the right responses were scored one or zero. After the summation of all the scores, the respondents were dichotomized into those who had a low level of knowledge (scored less than 50%)

and those who had a high level of knowledge (scored 50% or more). A bivariate analysis involving the Chi-square test of independence was used to test the association between independent categorical variables and the dependent variable. Whereas testing for association involved a continuous variable and categorical dependent variables, a *t*-test was utilized. Binary logistic regression analysis was used to test for factors associated with foodborne illnesses while adjusting for confounders. The threshold of significance in hypothesis testing was set at a p-value < 0.05. Qualitative data were transcribed and analyzed thematically using NVIVO version 12 software.

3. Results

3.1. Sociodemographic Characteristics. A total of 285 food handlers took part in the present study. Their sociodemographic characteristics are shown in Table 1.

Table 1 shows that the majority of the study participants were female (52.6%). The age of the study participants ranged from 18 to 58 years with the mean ± standard deviation age being 40.0 ± 11.63 years. Those who were aged twenty years or older were 6.3%, while those who were aged more than fifty years were 22.5%. Participants who were aged between 41 and 50 years were 29.8%; the rest were aged between 21 and 30 years and between 31 and 40 years (17.5% and 23.9%, respectively). Analysis of the highest level of education attained by the study participants indicated that those who had attained primary, secondary, and tertiary education were 24.6%, 45.3%, and 27.7%, respectively. The minority had no formal education (2.5%). Furthermore, the majority were Christians (92.3%) and those who had not undergone training on food safety (74.4%). The study enrolled cooks (15.8%), cashiers (14.0%), service personnel (15.1%), and cleaners (12.3%), among other cadres of staff.

On work experiences, the minority had worked for less than one month (7.0%). Those who had worked for more than one year were 38.2%, while the rest had worked for a period of between 1 and 6 months (26.7%) and between 6 months and 1 year (28.1%).

3.2. Prevalence of the Selected Foodborne Pathogens. Laboratory analysis of stool samples from the enrolled food handlers revealed 8, 12, and 24 cases of *Campylobacter* spp., *S. typhi*, and *E. histolytica* infections, respectively. The corresponding prevalence of infections was as follows: 4.2% (95% CI 2.4%–7.2%), 2.8% (95% CI 1.4%–5.4%), and 8.4% (5.7%–12.2%), respectively. Overall, 44 out of the 285 food handlers who took part in the study had at least one food-transmitted pathogen (prevalence 15.4%, 95% CI 11.7%–20.1%). Figure 1 shows the prevalence of selected foodborne pathogens isolated from the samples collected from the participating food handlers.

3.3. Knowledge of Food Hygiene and Safety Practices. Asked about their main source of information on food hygiene and safety practices, the respondents mentioned mass media (35.4%), health professionals (31.9%), and health centers (32.6%), as shown in Figure 2.

Inquiries on the causes of foodborne illnesses yielded the responses shown in Table 2.

Table 1: Sociodemographic characteristics of study participants.

Variable	Characteristics	Frequency ($n = 285$ (%))
Gender	Male	135 (47.4)
	Female	150 (52.6)
Age (years)	≤20	18 (6.3)
	21–30	50 (17.5)
	31–40	68 (23.9)
	41–50	85 (29.8)
	>50	64 (22.5)
Level of education	Primary	70 (24.6)
	Secondary	129 (45.3)
	Higher education	79 (27.7)
	No formal education	7 (2.5)
Religion	Christians	263 (92.3)
	Muslim	22 (7.7)
Location	Gatuanyaga	26 (9.1)
	Hospital	65 (22.8)
	Kamenu	61 (21.4)
	Ngoliba	31 (10.9)
	Township	102 (35.8)
Work experience	<1 month	20 (7.0)
	1–6 months	76 (26.7)
	>6 months–1 year	80 (28.1)
	>1 year	109 (38.2)
Work responsibility	Cook	45 (15.8)
	Cashier	40 (14.0)
	Service	43 (15.1)
	Cleaner	35 (12.3)
	All	98 (34.4)
	Other	24 (8.4)
Trained in food safety	Yes	73 (25.6)
	No	212 (74.4)

Table 2 shows that the majority of the food handlers interviewed mentioned germs as the causative agent of foodborne illness (64.6%). Those who responded in the affirmative when asked if *Salmonella spp.* and *Campylobacter spp.* were causative agents of foodborne illness were 49.8% and 38.9%, respectively.

Table 3 shows the findings of the assessment of the participant's knowledge of food hygiene practices, routes of transmission of foodborne illnesses, and symptoms of foodborne illnesses.

Table 3 shows that the research participants mentioned the following as the appropriate moments for handwashing: after using the toilet (41.9%), before and after food preparation (42.5%), after touching anything (33.3%), and after counting money (33.7%). The main routes of transmission of foodborne illnesses are contaminated food (42.5%), contaminated water (40.0%), and vectors (60.7%), as stated by the study participants. Symptoms of foodborne illnesses mentioned by the study participants included vomiting (31.9%), fever (36.5%), and diarrhea (32.6%).

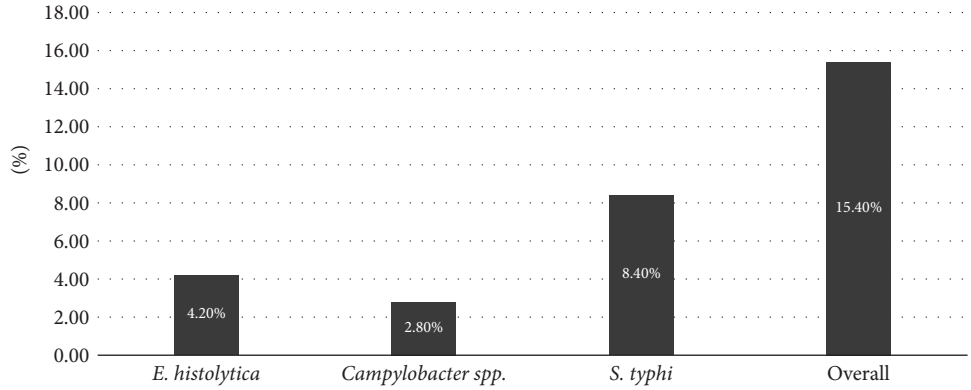

Figure 1: Prevalence of selected foodborne pathogens.

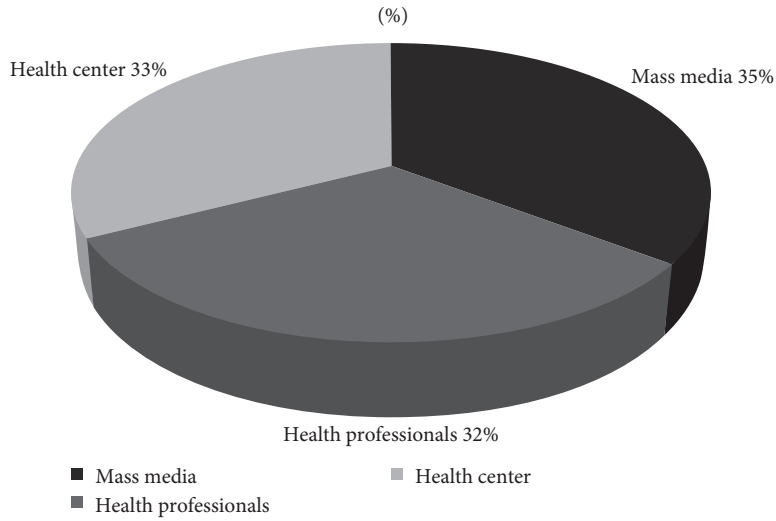

Figure 2: Source of information on food hygiene and safety practices among food handlers.

Table 2: Responses on the causes of infections with foodborne pathogens among food handlers.

Inquiry	Response	Number ($n = 285$ (%))
Salmonella spp.	Agree	142 (49.8)
	Disagree	143 (50.2)
Campylobacter spp.	Agree	111 (38.9)
	Disagree	174 (61.1)
Causes of foodborne illnesses	Germs	184 (64.6)
	Chemicals	75 (26.3)
	Do not know	26 (9.1)

Assessment of knowledge on food hygiene among the research participants entailed asking them to rate their level of agreement with some identified statements. The results are shown in Table 4.

Table 4 shows that the majority of the respondents (52.6%) were in agreement with the statement that "*poor hygiene causes cross contamination*," with those who agreed and strongly agreed being 17.2% and 35.4%, respectively. Those who were in agreement or strong agreement with the statement that good hygiene practices prevent diarrhea were 17.9% and 33.3%, respectively.

Table 5 shows the results of the assessment of knowledge on food contamination among the food handlers.

Those who agreed to the following statements: "When hands are cleansed before beginning work, the risk of food contamination is reduced", "Preparing meals ahead of time lowers the likelihood of infection," and "When people eat and drink at their desks, the risk of food contamination rises," were 49.8%, 46.7%, and 52.3%, respectively. Asked if pregnant women who get a foodborne illness are more likely to have an abortion and that when one has a skin problem, it is vital to take time off from work, 49.1% and 52.3% responded in the affirmative.

A summation of the scores derived from the nineteen knowledge assessment items was shown in Table 6.

Table 6 revealed that the minimum and maximum scores were four and fifteen, respectively. The mean $\pm$ SD score was 9.2 ± 1.77. Further analysis of the knowledge scores

Table 3: Assessment of knowledge on food hygiene practices, routes of transmission and symptoms of foodborne illnesses.

Question	Attribute	Number ($n = 285$ (%))
Best time for handwashing	After using toilet	140 (41.9)
	Before and after food preparation	121 (42.5)
	After touching anything	95 (33.3)
	After counting money	96 (33.7)
Main routes of transmission of foodborne illnesses	Contaminated food	121 (42.5)
	Contaminated water	114 (40.0)
	Vectors	173 (60.7)
	Do not know	35 (12.3)
Symptoms of foodborne illnesses	Vomiting	91 (31.9)
	Fever	104 (36.5)
	Diarrhea	93 (32.6)
	Do not know	30 (10.5)

Table 4: Assessment of knowledge on food hygiene.

Response	Number ($n = 285$ (%))
Poor hygiene causes cross contamination	
Strongly agree	101 (35.4)
Agree	49 (17.2)
Neutral	44 (15.4)
Disagree	46 (16.1)
Strongly disagree	45 (15.8)
Good hygiene practices prevent diarrhea	
Strongly agree	95 (33.3)
Agree	51 (17.9)
Neutral	42 (14.7)
Disagree	55 (19.3)
Strongly disagree	42 (14.7)

Table 5: Assessment of knowledge on food contamination.

Characteristics	Response (n (%))		
	Agree	Uncertain	Disagree
When hands are cleansed before beginning work, the risk of food contamination is reduced.	142 (49.8)	70 (24.6)	73 (25.6)
Preparing meals ahead of time lowers the likelihood of infection.	133 (46.7)	76 (26.7)	76 (26.7)
When people eat and drink at their desks, the risk of food contamination rises.	149 (52.3)	72 (25.3)	64 (22.5)
Pregnant women who get a foodborne illness are more likely to have an abortion.	140 (49.1)	68 (23.9)	77 (27.0)
When you have a skin problem, it is vital to take time off from work.	149 (52.3)	62 (21.8)	74 (26.0)

indicated that the respondents who were deemed to be highly knowledgeable on food hygiene and safety practices were 44.2% (95% CI 38.6%–50.0%). The majority were classified as having low knowledge of food hygiene and safety practices (55.8%, 95% CI 50.0%–61.4%).

Table 6: Level of knowledge on food hygiene and safety practices.

Knowledge level	Frequency ($n = 285$ (%))	95% Confidence interval	
		Lower	Upper
Low (<50%)	159 (55.8)	50.0	61.4
High (≥50%)	126 (44.2)	38.6	50.0

Data from KII indicated a lack of skills and knowledge in handling food safely is a major reason for inadequate food safety measures. One of the respondents noted as follows:

> *I think the reason for improper food handling is that we don't know clearly what is safe and unsafe. In the absence of adequate knowledge and information, you have to rely on common sense and instincts. You sometimes end up doing the wrong things.* (*KII 5*, *male*, *38 years*)

3.4. Food Handling Practices. Table 7 shows the findings on the self-reported assessment of assorted food handling practices among the interviewed food handlers. Those who reported that they had a valid medical examination certificate, washed hands with soap and water before handling food, and always donned gloves and hairnets when handling food were the majority (62.8%, 67.4%, and 63.2%, respectively). The minority refuted undertaking the following: chewing or smoking while working, working when having a cold, and handling food when experiencing diarrhea (34.7%, 34.0%, and 35.1%, respectively). Most of the respondents mentioned that they adhered to the following food handling practices: cleaning food contact surfaces before and after preparing food (70.9%), checking the expiry dates or shelf life of food (65.3%), boiling or treating water before serving the customers (71.9%), and drying hands with a towel after washing them (70.2%).

Participants in FGD mentioned that some food safety measures cannot be implemented due to various constraints, including time pressure and, more critically, a lack of

Table 7: Food handling practices.

Practice	Response (n (%))	
	Yes	No
Valid medical examination certificate	179 (62.8)	106 (37.2)
Washes hands with soap and water before handling food	192 (67.4)	93 (32.6)
Wears gloves and hairnets when handling food	180 (63.2)	105 (36.8)
Chews/smokes while working	186 (65.3)	99 (34.7)
Works when having a cold	188 (66.0)	97 (34.0)
Handles food when having diarrhea	185 (64.9)	100 (35.1)
Cleans food contact surfaces before and after preparing food	202 (70.9)	83 (29.1)
Checks the expiry dates/shelf life of food	186 (65.3)	99 (34.7)
Boils or treats water before serving the customers	205 (71.9)	80 (28.1)
Dries hands after washing them with a towel	200 (70.2)	85 (29.8)

establishments, such as running water, freezers, and refrigerators. Despite having the correct knowledge and awareness of the risks of foodborne illnesses, they are also restricted by time problems. One FGD is posited as follows:

> *The point is that I don't have piped or running water, and that is a common problem in this area; it's not just my problem. I know that having running water would be hygienic and convenient. But there are no such establishments around here, and people here wash in a basin…* (*FGD 1, female, 41 years*).

The qualitative results indicated that pursuing quality of life affected risk perception and the adoption of measures to curb foodborne illnesses. Persons with higher levels of general hygiene and health consciousness and awareness and the pursuit of delicious food were reported to adopt safe food handling practices.

> *Some people pay a lot of attention to hygiene. For example, they wash their hands while cooking. But we don't care about that at times. …* (*FGD 6, male, 28 years*)

> *You must pay attention to hygiene, or you'll get a bad stomach or food poisoning. So, it is not good to not pay attention to hygiene. Must pay attention…* (*KII 7, female, 42 years*)

Analysis of qualitative interview data showed that not adopting recommended food hygiene and safety standards is related to personality, including personal handling habits, laziness, and past experiences.

> *Don't even talk about how to operate safely, hygienically, or cleanly. I don't even think about foodborne illnesses or food safety. Well, we are supposed to make safe behavior a habit. If you think the habit is safe, you may keep it. I am lazy and can't do everything for safety, or I'll be tired.…* (*FGD 8, male, 29 years*).

In the local culture, being sparing or frugal is emphasized and praised. Furthermore, the frugal culture also moderates the paths from food safety knowledge to behaviors and practices.

> *Although I know I should throw away the leftovers, I still save them. I feel it's not prudent to waste the food and the money; you know, that's wasting, and I want to save and make more money ….* (*FGD 6, female, 32 years*)

Additionally, many participants were highly pessimistic about the state of food safety; as a result, they either felt helpless or thought that adopting the recommended standards of food safety and maintaining hygiene and cleanliness would be rather costly and time consuming.

> *If you implement the proper food handling measures, it's going to cost you plenty. You can't feel the monetary benefits, and in some sense, they don't exist. It makes your business less competitive because the food will be too expensive.* (*FGD 3, female, 40 years*).

Association between sociodemographic characteristics and the prevalence of foodborne illnesses.

Through the questionnaires, the study analyzed the association between sociodemographic characteristics and the prevalence of foodborne illnesses. The results are shown in Table 8.

Table 8 shows the outcomes of the evaluation of the sociodemographic characteristics of food handlers associated with foodborne illnesses. The mean ± standard error (SE) age of the group that was found infected with at least one foodborne pathogen was 41.2 ± 1.77 years. The mean ± SE age of the uninfected group was 39.8 ± 0.75 years. There was no significant difference in the ages of the two groups ($p = 0.861$). Similarly, there were no significant differences in the ages of infected and uninfected groups of food handlers when the analysis was stratified by age groups. The proportion of males who were infected was statistically significantly lower than that of females (10.4% and 20.0%,

Table 8: Bivariate analysis of the association between sociodemographic characteristics and prevalence of foodborne pathogens.

Variable	Characteristic	Foodborne pathogen		χ^2	OR (95% CI)	*P*-value
		+ve($n = 44$)	−ve($n = 241$)			
Age (years)	Mean ± SE	41.2 ± 1.77	39.8 ± 0.75			0.861
	≤20	3 (16.7)	15 (83.3)	0.861	0.867 (0.216–3.478)	0.840
	21–30	5 (10.0)	45 (90.0)	0.041	0.481 (0.158–1.471)	0.193
	31–40	12 (17.6)	56 (82.4)	0.027	0.929 (0.383–2.249)	0.870
	41–50	12 (14.1)	73 (85.9)	0.580	0.712 (0.297–1.710)	0.446
	>50	12 (18.8)	52 (81.3)		Ref	
Gender	Male	14 (10.4)	121 (89.6)	5.047	0.463 (0.234–0.916)	0.031
	Female	30 (20.0)	120 (80.0)		Ref	
Level of education	No formal education	1 (14.3)	6 (85.7)	0.001	1.030 (0.113–9.399)	0.665
	Primary	10 (14.3)	60 (85.7)	0.004	1.271 (0.580–2.787)	0.549
	Secondary	22 (17.1)	107 (82.9)	0.360	1.030 (0.409–2.596)	0.950
	Higher education	11 (13.9)	68 (86.1)		Ref	
Religion	Christianity	42 (16.0)	221 (84.0)	0.736	1.900 (0.428–8.437)	0.546
	Muslim	2 (9.1)	20 (90.9)		Ref	
Monthly income (KSh.)	20,000 and above	10 (26.3)	38 (86.4)	0.076	0.842 (0.247–2.868)	0.783
	10,000–2,000	10 (18.5)	44 (81.5)	0.114	0.875 (0.326–2.347)	0.734
	5,000–10,000	21 (14.0)	128 (85.9)	0.070	0.875 (0.326–2.347)	0.791
	Below 5,000	6 (15.8)	32 (84.2)		Ref	
Work experience	Less than one month	1 (5.0)	19 (95.0)	1.580	0.285 (0.036–2.272)	0.304
	1–6 months	9 (11.8)	67 (88.2)	0.522	0.727 (0.305–1.730)	0.470
	6 months–1 year	17 (21.3)	63 (78.8)	1.000	1.460 (0.693–3.075)	0.317
	More than 1 year	17 (15.6)	92 (84.4)		Ref	
Locality	Gatuanyaga	5 (19.2)	21 (80.8)	0.190	1.280 (0.421–3.890)	0.663
	Hospital	10 (15.4)	55 (84.6)	0.003	0.977 (0.414–2.308)	0.958
	Kamenu	8 (13.1)	53 (86.9)	0.201	0.811 (0.325–2.026)	0.654
	Ngoliba	5 (16.1)	26 (83.9)	0.004	1.034 (0.346–3.092)	0.953
	Township	16 (15.7)	86 (84.3)		Ref	
Work responsibility	Cashier	6 (15.0)	34 (85.0)	0.005	0.958 (0.293–3.132)	0.943
	Service	6 (14.0)	37 (86.0)	0.045	0.880 (0.270–2.867)	0.832
	Cleaner	5 (14.3)	30 (85.7)	0.025	0.905 (0.261–3.137)	0.875
	All	16 (16.3)	82 (83.7)	0.014	1.059 (0.402–2.788)	0.907
	Other	4 (16.7)	20 (83.3)	0.013	1.086 (0.284–4.157)	0.904
	Cook	7 (15.6)	38 (84.4)		Ref	
Training on food safety	Yes	5 (6.8)	68 (93.2)	5.546	0.326 (0.123–0.862)	0.023
No	39 (18.4)	173 (81.6)			Ref	

respectively, $p = 0.031$). Male food handlers were 54% less likely to have been found positive for a foodborne infection (odds ratio (OR) 0.463; 95% CI 0.234–0.916, $p = 0.031$). Training on food safety was associated with significantly lower odds of being found positive for foodborne infection (OR 0.326 (95% CI 0.123–0.862), $p = 0.023$). The rest of the sociodemographic attributes, including religion, monthly household income, level of education, work experience, work responsibility, and locality, were not significantly associated with infection with foodborne pathogens.

The findings from the analysis on the association between food handling practices and the prevalence of foodborne pathogens are shown in Table 9. Possession of a valid medical examination certificate was associated with a 61.5% decrement in the odds of being diagnosed with a foodborne pathogen (OR 0.385 (95% CI 0.200–0.740), $p = 0.003$). The proportion of the infected among those who had a valid medical examination certificate was 10.6%, while that of the group that lacked a valid medical examination certificate was 23.6%. Washing hands with soap and water before handling food was associated with 76.3% reduction in the odds of being infected with a foodborne pathogen (OR 0.237 (95% CI 0.122–0.464), $p = 0.001$). The prevalence of foodborne pathogens was significantly lower among those who reported that they always washed their hands with soap and water before handling food when compared to their counterparts who reported on the contrary (8.9% versus 29.0%, respectively). Cleaning food contact surfaces before and after preparing food was associated with lower incidences of foodborne illnesses (OR 0.425 (95% CI 0.220–0.821),

Table 9: Bivariate análysis of the association between food handling practices and the prevalence of foodborne pathogens.

Variable	Foodborne pathogen		OR (95% CI)	χ^2	*P*-value
	+ve($n=44$)	−ve($n=241$)			
Valid medical examination certificate					
Yes	19 (10.6)	160 (89.4)	0.385 (0.200–0.740)	8.579	0.003
No	25 (23.6)	81 (76.4)	Ref		
Washes hands with soap and water before handling food					
Yes	17 (8.9)	175 (91.1)	0.237 (0.122–0.464)	9.540	<0.001
No	27 (29.0)	66 (71.0)	Ref		
Wears gloves and hairnets when handling food					
Yes	29 (16.1)	151 (83.9)	1.152 (0.586–2.265)	0.169	0.681
No	15 (14.3)	90 (85.7)	Ref		
Chews/smokes while working					
Yes	31 (16.7)	155 (83.3)	1.323 (0.658–2.662)	0.619	0.432
No	13 (13.1)	86 (86.9)	Ref		
Works when having a cold					
Yes	27 (14.4)	161 (85.6)	0.789 (0.406–1.532)	0.491	0.482
No	17 (17.5)	80 (82.5)	Ref		
Handles food when having diarrhea					
Yes	31 (16.8)	154 (83.2)	1.347 (0.670–2.710)	0.702	0.402
No	13 (13.0)	87 (87.0)	Ref		
Cleans food contact surfaces before and after preparing food					
Yes	24 (11.9)	178 (88.1)	0.425 (0.220–0.821)	6.046	0.010
No	20 (24.1)	63 (75.9)	Ref		
Checks the expiry dates/shelf life of food					
Yes	29 (15.6)	157 (84.4)	1.034 (0.525–2.036)	0.010	0.922
No	15 (15.2)	84 (84.8)	Ref		
Boils or treats water before serving the customers					
Yes	22 (10.7)	183 (89.3)	0.317 (0.164–0.614)	12.394	<0.001
No	22 (27.5)	58 (72.5)	Ref		
Dries hands after washing them with a towel					
Yes	35 (17.5)	165 (82.5)	1.791 (0.820–3.913)	2.183	0.140
No	9 (10.6)	76 (89.4)			
Level of knowledge					
Low	27 (61.4)	132 (54.8)	1.311 (0.679–2.532)	0.655	0.418
High	17 (38.6)	109 (45.2)	Ref		

$p = 0.010$). Boiling and/or treating water before serving it to the customers was statistically significant as a protective factor against infections with foodborne pathogens (OR 0.317 (95% CI 0.164–0.614), $p = 0.001$). The rest of the assessed food handling practices were not associated with the prevalence of foodborne illnesses among food handlers in the study area. Additionally, the level of knowledge was not associated with the prevalence of foodborne illnesses among food handlers in the study area ($p = 0.418$).

To determine the factors predictive of foodborne pathogens, a multivariate logistic regression model was run, and the outputs are shown in Table 10. Female food handlers had 99.2% lower odds of being found to be infected with foodborne pathogens when compared to male food handlers (adjusted odds ratio (AOR) 0.098 (95% CI 0.0304–0.315, $p<0.001$). Having a valid medical certificate was also significantly predictive of being found positive for a foodborne pathogen, with those who had a valid medical certificate being 86.9% less likely to be diagnosed with a foodborne illness when compared to their counterparts who lacked a valid medical certificate (AOR 0.141 (95% CI 0.141–1. 0.439, $p = 0.001$)). Furthermore, not boiling or treating water before serving it to customers was associated with about a threefold increment in the odds of being diagnosed with a foodborne pathogen (AOR 3.043 (95% CI 1.2225–7.577, $p = 0.017$)). The remaining variables were not statistically significantly associated with being diagnosed with a foodborne illness.

4. Discussion

The present study demonstrated a substantial burden of infections with foodborne pathogens in the study population, with about one in every ten food handlers testing positive for a foodborne pathogen. Additionally, the survey demonstrated suboptimal compliance with the regulations on food safety,

Table 10: Multivariate analysis to determine factors predictive of foodborne pathogens.

Variable	β	Standard error	Adjusted odds ratio	95% Confidence interval		P-value
				Lower	Upper	
Gender (Ref.: Male)	−2.324	0.595	0.098	0.0304	0.315	<0.001
Training on food safety practices (Ref.: Male)	−1.956	0.577	0.141	0.439	0.046	0.001
Valid medical examination certificate (Ref.: No)	−0.363	0.413	0.696	0.3092	1.565	0.379
Washes hands with soap and water before handling food (Ref.: No)	−0.118	0.346	0.889	0.4510	1.751	0.732
Cleans food contact surfaces before and after preparing food (Ref.: No)	−0.008	0.361	0.992	0.4889	2.013	0.982
Boils or treats water before serving it to the customers (Ref.: Yes)	1.113	0.465	3.043	1.2225	7.577	0.017

considering that only three in five food handlers had valid medical examination certificates at the time of the survey.

It is also noteworthy that the level of knowledge on food safety and foodborne illnesses was low, with more than one-half of the participants being classified as having inadequate knowledge of food hygiene and safety practices. The possession of inadequate food safety knowledge by food handlers poses a serious threat to food safety in service establishments. The results from the present study differ from those of a study done in Embu municipality, Kenya, whereby 28.9% of the food handlers were infected with *S. typhi* and 42% of the food handlers had no valid medical certificates [12]. The difference may be attributed to the differences in study settings and disparities in sociocultural environments. The high prevalence of foodborne pathogen infestations in these study areas most probably reflects poor personal hygiene practices, poor environmental sanitation, and inadequacies in the supply of safe drinking water.

Compared to the findings from our study, a similar survey done in southwestern Nigeria showed a much lower prevalence of salmonellosis (7.0%) [13]. Another study conducted in Algeria revealed a higher prevalence of *Entamoeba histolytica* (7.7%), while at the same time reporting a lower proportion of individuals who had salmonellosis (2.6%). The study enrolled only male food handlers, and this may explain the discordance in the findings between the Algerian study and the current research [14]. A study conducted among food handlers working in catering establishments of public institutes found in Dawuro zone, southwestern Ethiopia, documented the prevalence of foodborne pathogens, which was not very different from what the present study recorded; the prevalence of salmonellosis in the Ethiopian study was 6.4%, while that of *E. histolytica* was 4.23% [15]. Still, in Ethiopia, the prevalence of salmonellosis among food handlers was 2% [16]. The most probable explanation for the discrepancy in the findings between the surveys is the study population variance. The Nigerian and Ethiopian research focused on food handlers serving in school food programs and universities, respectively, as opposed to food outlets patronized by the low-income earners in our study. Institutions such as schools are likely to be more stringent in ensuring that their workers observe the statutory requirements and regulations on food safety. Furthermore, institutions are more likely to establish and maintain sanitation and hygiene facilities, thus minimizing the transmission of pathogens. Moreover, people with low socioeconomic status, as is the case for our study participants, have a higher probability of using less sanitary sewage disposal systems (such as pit latrines), which may predispose them to free handling of feces and contamination of water and surface soil with feces and infective microorganisms [13].

Contrary to what was found in the current study, the research conducted in Gondar, Ethiopia, reported no presence of *Salmonella species* in food handlers [17]. Moreover, a study carried out in southeast Ethiopia documented a higher prevalence of *Entamoeba histolytica* (10.8%) [18]. The variations in findings observed between the two studies could be due to the differences in socioeconomic conditions, types of diagnostic sensitivity, epidemiological differences, seasonal variations, and differences in the hygiene of the individuals and the working environments.

The present study showed that only about one-quarter of the respondents were trained in food handling and safety. This statistic is lower than the finding reported in northern Ethiopia (44%), [19]. This might be because there is a difference in the number of institutions working in safety, the tendency of employers to recruit food handlers without considering health certificates as a basic criterion, and the low monthly salary (payment) for food handlers in the other study areas [20].

The present survey documented a higher risk of asymptomatic foodborne pathogen reservoirs in women. The finding reiterates those of past research that has demonstrated that women carry a disproportionally higher burden of foodborne pathogen infections when compared to their male counterparts [21–23]. Gender being a predictor of foodborne pathogen infections could be explained, at least in part, by the tendency of women to keep long nails in the name of fashion. Indeed, recent research done in southwestern Ethiopia indicated that food handlers with untrimmed fingernails were at an increased risk of being infected with intestinal parasites and having *S. typhi* infections (AOR: 0.382; 95% CI 0.229, 0.635) [15]. Compared to other parts of the hand, the area beneath the fingernails harbors the most microorganisms and is the most difficult to clean [24]. Moreover, untrimmed fingernails could serve as a vehicle for the transport of intestinal parasites or enteric bacteria from source to food due to the difficulty of cleaning [16]. In concordance with the findings in

the current study, a study done in Ethiopia reported that males were more likely to have good food hygiene practices as compared to their female counterparts [25].

The present study showed a lack of a statistically significant association between the level of education of the food handlers and infection with foodborne pathogens. The lack of association may be explained by the fact that some of the respondents may not have had any training on food handling-related issues as they pursued education. This finding may justify the notion that adequate food safety knowledge can mostly be attained through effective food safety training for food handlers. Indeed, studies conducted in Saudi Arabia, Ethiopia, and Ghana have identified the importance of knowledge of food safety to street-cooked food handlers and recommended training programs on food safety to cultivate knowledge of hygiene practices [26–29]. On the other hand, studies have reported an association between education and infection with foodborne pathogens. For instance, in a study done in Ethiopia, food handlers who had no education were 2.142 times more likely to have increased intestinal parasitic and *S. typhi* infections when compared to respondents who had secondary and above education (AOR: 2.142; 95% CI 1.048, 4.378) [15]. Earlier studies conducted elsewhere in Ethiopia also reported similar findings [16, 19]. This showed that because they were less knowledgeable about food safety and the spread of parasitic and enteric illnesses, food handlers were more susceptible to parasitic and enteric infections due to a lack of education. The differences in findings observed in these studies are probably a reflection of the differences in the study settings.

The following practices were significantly predictive of a lower prevalence of infections with foodborne pathogens: attending a food handling or safety course, having a valid medical certificate, treating drinking water, and using appropriate handwashing practices. Furthermore, the present study showed that washing hands with soap and water before handling food was associated with a reduction in the odds of being infected with a foodborne pathogen. Similarly, a survey done by a team led by Lette found that food handlers who did not wash their hands with water and soap before handling food were 3.06 times (AOR: 3.06, 95% CI 1.16, 7.26) more likely to be infected with intestinal parasites when compared to those who did [17]. Similarly, in southwest Ethiopia, food handlers who did not follow regular handwashing before a meal were an independent predictor of intestinal parasite infection, including *E. histolytica* [30].

Less than one-half of the participants were found to have satisfactory knowledge of food handling and food safety practices. The finding is possibly a reflection of the fact that most of the respondents admitted that they had not attended the requisite training on food handling and/or food safety. Similar observations were made in a study conducted in the Republic of Ireland [31]. In discordance with the findings in the current study, research on knowledge of foodborne infections and food safety practices among food handlers in Nigeria found that 41.6% of food handlers had poor knowledge and only 7.6% of respondents had adequate knowledge [32]. A study carried out in Limpopo Province, South Africa, reported that 51% of the hospital food handlers possessed satisfactory food safety knowledge, 10% possessed good food safety knowledge, and 39% possessed inadequate food safety knowledge, which is different from what the current study documented [33].

About half of the respondents in the present study affirmed that *Salmonella spp*. is a cause of foodborne illness. The finding is not very different from that of Machado and Cutter, who in their study found that only a minority of food handlers (49.1%) knew that Salmonella is a foodborne bacteria pathogen [34]. Similarly, in South Africa, only a few of the hospital food handlers (47.1%) correctly indicated *Salmonella spp*. as the main foodborne bacterial pathogen associated with poultry products [33]. The findings may be attributed to the lack of microbial hazard knowledge among food handlers, which may be caused by the absence of food safety education and training on microbial hazards in foods. Additionally, in the current study, knowledge of food safety was not associated with infections with foodborne pathogens. This may be an indication of our scenario, whereby there are bottlenecks in translating knowledge into practice in the study population. In line with this argument, a recent review demonstrated an unsatisfactory translation of knowledge into attitudes or practices, or attitudes into practices, following the training of food handlers [34]. This finding adds to the growing body of evidence that training and knowledge alone are not sufficient to improve practices [35, 36]. Considering that our study found that practices were significant determinants of infection with foodborne pathogens, the challenges associated with the poor translation of knowledge into practices must be identified and addressed. From the current study and other studies, it is clear that knowledge of food safety and foodborne pathogens alone may not be used to predict good safety practices. Other explanatory variables, such as training of food handlers, environmental hygiene of food outlets, food control monitoring, and foodborne disease surveillance not assessed in this study, may also contribute to good safety practices. In agreement with the current study findings, research done in Algeria demonstrated that handwashing with soap and water had a protective effect against infections with foodborne pathogens [14].

During data collection and interviews with respondents, it was observed that the water used in washing and rinsing plates often got very dirty before it was changed, while some did not allow the water used in rinsing the plates to dry before the plates were used in serving the food. A similar observation was made in Ogun State, Nigeria [32]. About one-third of the respondents had poor food safety practices. This study's finding is similar to the report by Gizaw, where 22.1% of food handlers had poor food safety practices [5]. It has been reported that food handlers do observe food safety practices like personal hygiene and handwashing, food separation, sickness leave from work, vaccination or deworming, and the use of gloves, masks, and caps [32, 37].

The present study is not without limitations. Only one stool specimen was collected from each participant. However, it is known that the studied foodborne pathogens are

transmitted intermittently in the stools of chronic carriers [38]. Thus, our study may have underestimated the prevalence of foodborne pathogen infections among food handlers.

5. Conclusions

The relatively high prevalence of asymptomatic foodborne pathogen carriers among the food handlers in the study area highlights a significant public health concern in this setting. Besides addressing the risk factors, the study recommends intensification of surveillance of foodborne diseases in the study area. The high prevalence maybe as a result of antimicrobial résistance of foodborne pathogens which pose a greater health risk as a result of potential treatment failure.

The study also identified a set of modifiable risk factors associated with foodborne pathogen infections that should be addressed. The factors that were found to be associated with the prevalence of foodborne illnesses among food handlers in the study area included gender, undergoing training on food safety, possession of a valid medical examination certificate, washing hands with soap and water before handling food, cleaning food contact surfaces before and after preparing food, washing hands with soap and water before handling food, and boiling or treating water before serving the customers.

Data Availability

The data are accessible on request from the corresponding author.

Ethical Approval

Ethical clearance was sought from the Institutional Research Ethics and Review Committee (IREC) of Mount Kenya University. Further approval was sought from the National Commission for Science, Technology, and Innovation (NACOSTI), Kenya. The local authorities in charge were informed by the study. Informed consent was sought from the respondents before the administration of the questionnaires and sample collection. Participants who tested positive for foodborne pathogens were provided with treatment according to Ministry of Health guidelines.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

Joseph Kimemia designed the study, collected, organized, and analyzed the data, and drafted the manuscript. John Kariuki, Alfred Owino, and Murima Ng'ang'a designed the study, conducted data analysis, and assisted in organizing the manuscript. All the authors read and approved the manuscript.

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