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Meat safety knowledge, attitude and practices of slaughterhouse workers in Kajiado, Kenya

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Abstract

Background: A major contributor to the poor meat safety status in Kenya is low level of slaughter hygiene knowledge and practices among slaughterhouse workers.

Introduction: The study determined knowledge, attitude and practices (KAPs) of workers from 7 small and medium slaughterhouses in Kajiado County on slaughter hygiene and meat safety.

Methodology: Semi-structured questionnaires were administered to 78 workers, managers and meat inspectors.

Results: Majority (92.3%) of workers lacked slaughter hygiene and meat safety training. Workers had high knowledge with an overall mean score of 19.2 ± 2 out of 24, high personal hygiene scores (9.9 ± 0.8 out of 11), moderate carcass contamination scores (4.2 ± 0.8 out of 6), meat-borne illness score (3.1 ± 1 out of 4) and temperature intervention scores (2.1 ± 0.6 out of 3). Moderate and high scores were recorded in attitude and practices and differed significantly across slaughterhouses ($p < 0.05$) with a mean of 33 ± 5 out of 40 and 59.3 ± 3.5 out of 65, respectively. There was no significant difference in KAP scores between trained and untrained workers. Carcass decontamination practices by workers differed from that of the meat inspector. Surface and handheld equipment sanitization practices were observed as poor. Medical testing practice was poor and significantly different across slaughterhouses ($p < 0.001$) with infection rates of zoonoses and occupational hazards as high as 33% in some slaughterhouses.

Conclusion: The study concluded that although high knowledge and neutral attitude were scored by slightly more than half of the workers, poor practices were reported and observed in carcass decontamination, equipment and facility sanitization and worker medical examination. Slaughter facilities in Kajiado County have an opportunity to offer their workers role-specific training, the provision of personal protective equipment, hygiene and sanitation facilities and strict oversight of worker medical testing.

KEYWORDS
knowledge, meat contamination, carcass washing, meat safety, slaughterhouses, zoonoses

1 | INTRODUCTION

Foodborne hazards in Kenya have accounted for a significant proportion of morbidities and fatalities. Within a period of 23 years (1970–1993), Kenya had suffered 37 foodborne disease outbreaks. The bacterial agents largely attributed to foodborne illnesses included *Staphylococcus aureus*, *Escherichia coli*, *Clostridium perfringens* and *Clostridium botulinum* in addition to fungal toxins and chemical poisoning (Ombui et al., 2001). Although since then fewer national studies have been done on foodborne illnesses, many authors agree that poor food handling is a key factor to foodborne illnesses (Jones and Angulo, 2006; Githiri et al., 2009; Kago, 2015; Kunyanga et al., 2021).

Meat production in Kenya is governed by several policies and legislative frameworks that span along the entire value chain. The Meat Control Act (Cap 356) (2012) exerts control over slaughterhouses and meat intended for human consumption. The Animal Disease Act (Cap 364) makes provisions for matters relating to animal diseases and zoonoses, whereas the Prevention of Cruelty to Animals' Act (Cap 360) provides for the prevention of cruelty to animals, including during the slaughter of food animals. The Public Health Act (Cap 242) enables provision for the security and health of the citizens, whereas the Food, Drugs and Chemical Substances Act controls the adulteration of food. Other acts include the Kenya Meat Commission Act, the Rabies Act, the Cattle Cleansing Act, the Veterinary Surgeons and Veterinary Para-professionals Act, the National Biosafety Authority Act and the Uplands Bacon Factory Act. The National Food Safety Policy acknowledges the need for an integrated food safety and control management system (GoK, 2021) that will erase some of the abovementioned frameworks, some of which are deemed obsolete, have overlapping roles and foster conflict of interest.

Notwithstanding the adequate legislation governing meat safety and slaughter operations in Kenya, previous studies indicate that meat originating from small and medium slaughter (SMS) facilities in Kenya barely meets the minimum hygiene and sanitary standards of the country with regard to parasites and bacterial diseases (Wambui, 2016). Out of about 2000 licenced slaughterhouses in Kenya, only about 15 are export-oriented (KEPSA, 2019), thus making SMS the majority of slaughterhouses in the country. The dismal hygiene and sanitation status has been previously attributed to low levels of slaughter hygiene and meat safety knowledge (Aklilu, 2008), insufficient antemortem inspection (Muthee, 2006) and non-compliance to regulations by slaughterhouses and their workers (Cook et al., 2017). Therefore, scenarios of meat-borne illnesses following consumption of contaminated meat pose public health concern in Kenya. For instance, cases of human anthrax have been reported following the hyperconsumption of uninspected meat (Ombui et al., 2001), whereas Shiga-toxin producing *E. coli* has been detected in raw meat (Kago, 2015; Hoffmann & Baral, 2019). Similarly, poor slaughter hygiene and meat safety practices may lead to the dispatch of meat products of low sanitary standard negatively influencing the keeping quality of the product. It is therefore paramount to better understand the relationship between slaughterhouse workers knowledge and attitudes towards slaughter hygiene and meat safety and their practices during slaughter operations in reducing meat-borne diseases. Moreover, there was limited literature addressing the level of meat safety knowledge, attitude and practices (KAPs) among slaughterhouse workers of Kajiado County. Such a gap could deter the development and strengthening of meat-borne disease prevention and public health intervention strategies. Therefore, the study objective was to assess workers' KAPs on slaughter hygiene and meat safety, knowledge of sources of carcass contamination, carcass decontamination interventions practiced and medical testing practices of slaughterhouse workers.

As Kenya's human population is projected to reach 96 million in the year 2050 compared to 47 million in 2019, the demand for animal-derived foods is expected to increase, becoming a key agricultural sector (FAO, 2019; KNBS, 2019). Therefore, meat harvesting systems must adapt to handle accelerated growth in demand, failure to which could lead to public health uncertainties, food and nutritional insecurity, food and slaughter by-products wastes and inaccessibility to markets (Alarcon et al., 2017).

2 | MATERIALS AND METHODS

The study was conducted between February and March 2021, across four sub-counties of Kajiado County in Kenya, namely Kajiado Central (M1), Kajiado East (M2), Kajiado West (M3) and Kajiado North (M4). The map of Kajiado County and study sites is captured in Figure 1. The county lies at latitude 2°09′S and longitude 36°78′E covering an area of 21,900 km^2. This study was authorized by the Department of Veterinary Services, Kajiado County, together with the National Commission for Science, Technology and Innovation, licence number 738580.

2.1 | Slaughterhouse selection

Facilities slaughtering cattle were purposefully selected based on proximity to the Namanga–Bissil–Kajiado–Isinya–Kiserian trade route, where five small slaughterhouses were identified at each of these towns (M1A, M1B, M1C, M2A and M3, respectively). The sixth located in Kitengela (M2B) was chosen as a medium-capacity facility, whereas the seventh located in Ongata Rongai (M4) was included because it predominantly sources its livestock from Kiserian livestock market. All the facilities declared to be Category B slaughterhouses, authorized by the Meat Control Act to slaughter between 6 and 39 cattle per day. They were mixed-species facilities, slaughtering cattle, sheep and

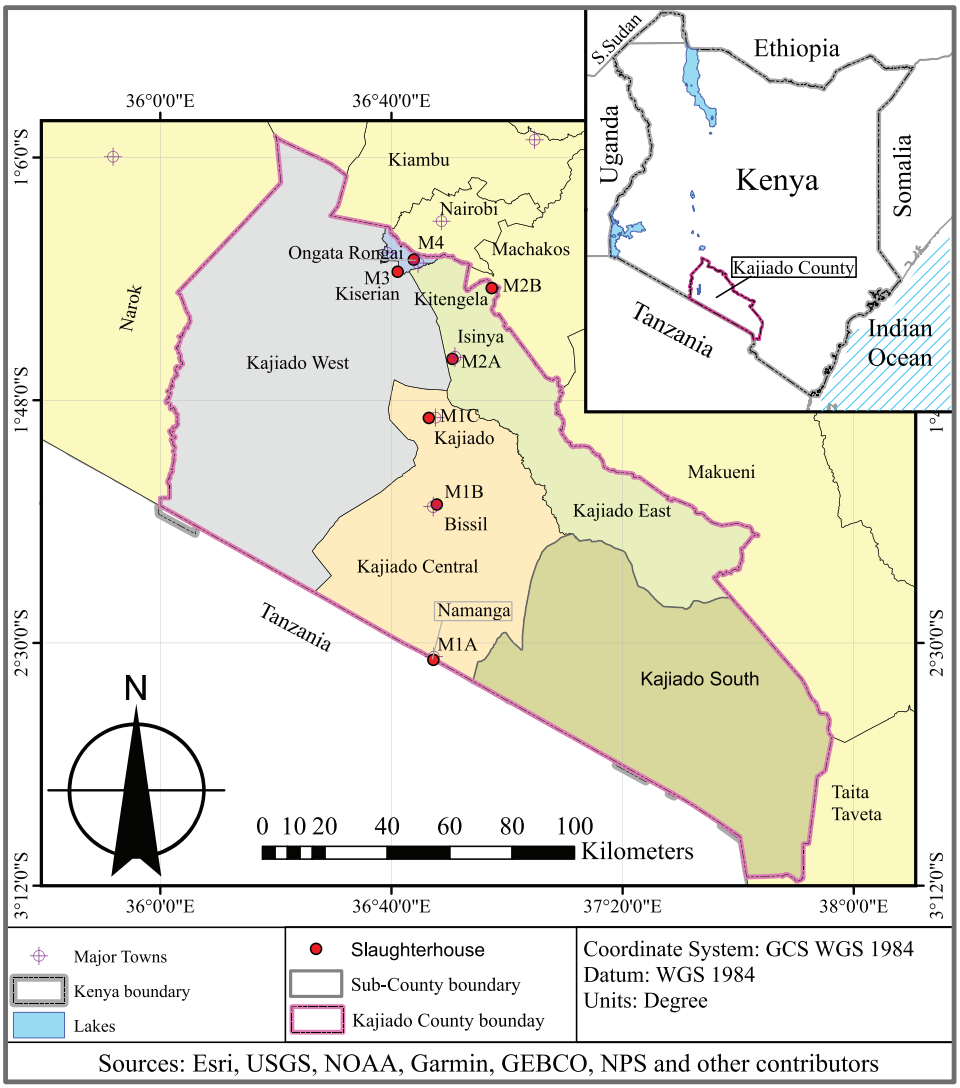

FIGURE 1 Map of Kajiado County and study sites.

goats, whereas M1A additionally slaughtering camels. The slaughterhouses were privately owned, government-licenced and managed by a county government meat inspector. The meat inspectors are veterinary officers assigned to a slaughterhouse to carry out meat inspection and observe hygiene, as well as perform administrative roles (Ameso et al., 2017).

2.2 | Workers' sampling criteria

Workers' sample size was determined following a telephone survey of the meat inspectors across the seven slaughterhouses, and population size was determined to be 96. Using the following formula by Yamane (Anokye, 2020), where *n* is sample size, *N* is population size and e is level of precision at 95% confidence interval, a sample size of 77 was derived:

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

Out of 96 workers, only 78 accepted to participate, yielding a response rate of 81.25%.

2.3 | Workers' questionnaire

The data was collected by interviewing the respondents in the local language of Kiswahili. Each questionnaire was divided into five sections. The first collected workers' personal information, such as age, sex, religion, household size, education level, slaughterhouse role and work-related training.

The second section surveyed workers knowledge using 24 statements on personal hygiene (11), carcass contamination (6), meat-borne illnesses (4) and intervention by temperature control (3), with each having 3 choices, *Yes*, *No* or *I don't know*, and the correct and wrong answer received a score of 1 and 0, respectively. The possible scores varying from 0 to 24 points were classified into three levels of Bloom's cut-off points, 80.0%–100.0% (19.2–24.0) is a high level of knowledge, 60.0%–79.0% (14.4–19.1) moderate knowledge and 0.0%–59.0% (0–14.3) as

a low level of knowledge. Each participant's score was tallied up to generate a total score and mean.

The third section surveyed workers attitudes using eight positive and negative statements that participants were to agree or disagree with, guided by a five-point hedonic scale comprising the following terms: *strongly disagree*, *disagree*, *neither agree or disagree*, *agree* or *strongly agree*. Scores of 5–1 were assigned according to each statement, with 5 being the most agreeable answer. Total scores ranged from 1 to 40, with positive attitude marked with a score range of 32–40, neutral attitude score ranging from 24 to 31 and negative attitude scoring 1–23.

The fourth section surveyed workers practices using 13 statements and participants' responses guided by a 5-point Likert scale with the following terms: *always*, *often*, *sometimes*, *rarely*, or *never*. Good practice was assigned 5 and poor practice 1 according to the statements. Total scores expected to range from 1 to 65, with good practice marked with a score range of 52–65, fair practice score ranging from 39 to 51 and poor practice scoring 1–38. Each participant's score was tallied up to generate total scores and mean.

Lastly, workers were asked about their medical testing history, date of last testing and diagnosis disclosed. A pre-test was carried out at a slaughterhouse in Ildamat ward of Kajiado town to validate the questionnaire. Due to the small number of workers, no exclusion criteria were set. All workers were informed about the particulars of the study and the voluntary nature of the activity before being asked to sign a consent form ahead of the interview.

Workers' average household size was derived by dividing the total number of persons in households by the number of householders ($n = 78$). Some submissions from the meat inspectors and managers' questionnaires were included to support the workers responses.

2.4 | Data handling and statistical analysis

Data entry was first done with Excel and followed up analysis using R Statistics. The precision of the data entry from questionnaires was assessed by data cleaning and exploration in R. Frequency in percentage (%), mean and standard deviation were the main descriptive statistics used to summarize the data. A Kruskal–Wallis test was used to test differences in means at 95% confidence interval ($p < 0.05$). Following a significant Kruskal–Wallis test, a post hoc Dunn test would be conducted. An independent chi-square test of association was used to test the relatedness of two categorical variables. Where counts were less than 5, Fisher's exact test was used instead.

3 | RESULTS

3.1 | Socio-demographic profiles

Seventy-eight workers responded, and the survey statistics are summarized in Table 1. Male workers made up 96.2% of the participants. The mean age was 41.51 ± 10.95 years, with two youth aged 24 years, and three elderly workers aged 68, 70 and 80 years. The average household size was 4.05 persons per household with almost 18% of the workers having household size ranges from 6 to 10 persons per household. Majority of workers (62.8%) had primary school education, whereas 28.2%, 2.6% and 6.4% had secondary, tertiary and no formal education, respectively. Half of the workers (51.3%) performed flaying, splitting and eviscerating roles. Women workers were present at one slaughterhouse and had offal washing ($n = 1$) and meat selling ($n = 2$) roles. Only 7.7%, 5.1% and 6.4% of the workers had been trained on slaughter hygiene and meat safety, halal slaughtering and good flaying practices, respectively, leaving 80.8% of the workers untrained. Majority of the workers (91.02%) provided their own personal protective equipment (PPEs), which included aprons, caps, masks and gumboots. All the workers were Kenyan, 88.5% and 11.5% being Christian and Muslim, respectively.

3.2 | Knowledge of slaughter hygiene and meat safety

Knowledge questions are presented in Table 2. The overall mean knowledge score attained by the workers was 19.2 ± 2 out of 24 (80.0%) indicating high knowledge. Slightly more than half of the workers (51.3%) scored highly, whereas 43.6% and 5.1% had moderate and low scores, respectively, as indicated in Table 3. The mean score on personal hygiene knowledge was 9.9 ± 0.8 out of 11 (90%), with the majority of the workers (93.6%) scoring highly and 6.4% of the workers scoring moderately. No poor scores were recorded. The mean score on carcass contamination indicated moderate knowledge at 4.2 ± 0.8 out of 6 (70%), with 41%, 38.5% and 20.5% of the workers attaining high, moderate and low scores, respectively. Meat-borne illness knowledge had a mean score of 3.1 ± 1 out of 4 (77.5%), a moderate level of knowledge, with 44.2%, 35.1% and 20.8% of workers getting high, moderate and low scores, respectively. Knowledge in intervention by temperature control was moderately scored with a mean of 2.1 ± 0.6 out of 3 (70%) with 23.1%, 66.7% and 10.3% of the workers attaining high, moderate and low scores, respectively.

As summarized in Table 4, middle-aged workers, 35–44 years attained higher ($p < 0.05$) scores (20.0 ± 1.8) in overall knowledge than elderly workers (18 ± 1.8). Similarly, in carcass contamination statements, middle-aged workers attained higher ($p < 0.05$) scores (4.6 ± 0.7) compared to the youth (4 ± 0.9) and the elderly (3.7 ± 0.9). There were no significant differences observed in knowledge score across the other socio-demographic variables.

3.2.1 | Workers' knowledge of sources of contamination

Workers' knowledge of sources of carcass contamination varied as summarized in Table 5. Worker hands, cutting tools, water for cleaning carcasses and cattle faeces were mentioned as the primary sources of

TABLE 1 Socio-demographic profiles of slaughterhouse workers.

Worker characteristics		*n*	%	M1A	M1B	M1C	M2A	M2B	M3	M4
Gender	Male	75	96.2	7	6	10	9	20	16	7
	Female	3	3.8	-	-	-	-	-	3	-
Age category	24–34 years	26	33.3	1	-	5	2	8	8	2
	35–44 years	25	32.1	1	1	5	4	6	6	2
	45–54 years	16	20.5	2	5	-	3	2	4	-
	55 years and above	11	14.1	3	-	-	-	4	1	3
Household size	1	8	10.3	-	-	1	2	3	-	2
	2–3	20	25.6	3	1	-	1	6	7	2
	4–5	36	46.2	2	2	6	5	8	11	2
	6+	14	17.9	2	3	3	1	3	1	1
Education	No school	5	6.4	-	-	-	1	3	1	-
	Primary	49	62.8	5	5	8	5	10	10	6
	Secondary	22	28.2	2	1	2	3	6	7	1
	Tertiary	2	2.6	-	-	-	-	1	1	-
Roles	Cleaner	6	7.7	-	-	1	-	3	1	1
	FSE	40	51.3	5	5	6	6	9	4	5
	Halal slaughter	7	9	1	1	-	1	1	2	1
	Selling and transportation	14	17.9	-	-	-	-	5	9	-
	Stunning	1	1.3	-	-	-	-	1	-	-
	Washing offal	10	12.8	1	-	3	2	1	3	-
Training	Meat safety	6	7.7	-	-	1	-	4	-	1
	Halal slaughtering	4	5.1	-	-	-	-	1	2	1
	Flaying	5	6.4	-	-	3	-	-	2	-
	None	63	80.8	7	6	6	9	15	15	5
Training authority	In-house meat inspector	12	80	-	-	3	-	4	3	2
	KBHC	2	13.3	-	-	-	-	1	1[a]	-
	Meat school	1	6.7	-	-	1	-	-	-	-
PPE provision	By worker	71	91	7	6	10	9	18	14	7
	By management	7	9	-	-	-	-	2	5	-
Religion	Christianity	69	88.5	6	5	10	7	18	17	6
	Islam	9	11.5	1	1	-	2	2	2	1

Abbreviations: FSE, flaying, splitting and evisceration; KBHC, Kenya Bureau of Halal Certification; PPE, personal protective equipment.
[a]Implies one worker got trained by both KBHC and in-house meat inspector.

carcass contamination by 97%, 92%, 92% and 87% of the participants, respectively. Blood was mentioned by 10% of the workers, whereas PPEs, meat transport containers and the environment were mentioned by 1%. Flayers failed to identify hide as a carcass contaminant. Similarly, workers in meat selling and transportation and cleaners failed to identify the meat transporting containers, the environment or blood as possible carcass contaminants, respectively. PPEs were not identified to be sources of carcass contamination across the roles except by one stunner. All workers from Kajiado Central (M1A, M1B and M1C) mentioned cattle faeces, worker hands, cutting tools and wash water as sources of carcass contamination, suggesting that they received similar instructions.

3.2.2 | Meat-borne illnesses

Majority of the workers (82.1%) knew that carcass washing before dispatch could reduce the risk of passing contamination and possibly infection to meat consumers. A similar proportion (83.3%) responded that consumption of contaminated meat could lead to diarrhoea. However, only 64.1% asserted that diarrhoea could be infectious. More than three quarters (79.5%) of the participants responded that those working in direct contact with blood had a higher chance of getting zoonoses. This response was recorded by all halal slaughter workers, 83.3% of cleaners, 80.0% of flayers and offal washers and 64.3% of meat sellers and transporters.

TABLE 2 Number and frequency of correctly answered knowledge statements by slaughterhouse workers ($n = 78$).

#	Knowledge questions	*n*	%
Personal hygiene			
1	Putting on gloves is part of personal hygiene	25	32.1
2	Putting on a clean apron is part of personal hygiene	77	98.7
3	Putting on cap/hair net is part of personal hygiene	78	100
4	Putting on mask is part of personal hygiene	78	100
5	Regular handwashing before starting work is part of personal hygiene	78	100
6	Regular handwashing after finishing work is part of personal hygiene	78	100
7	Proper handwashing reduces risk of contamination	78	100
8	Hands washed with water alone are not clean enough	61	78.2
9	Protective clothing should not be taken out of the slaughterhouse for cleaning	68	87.2
10	Workers should not wear accessories (e.g. watches and rings) when handling meat	74	94.9
11	If workers have wounds on their hands, they should bandage the wounds and not directly touch the meat	74	94.9
Carcass contamination			
12	It is important to separate the clean area from the dirty area	76	97.4
13	Can a worker who looks healthy contaminate meat?	57	73.1
14	Using gloves will reduce the risk of carcass contamination	52	66.7
15	Cleaning of equipment after slaughter operations can reduce cross-contamination	77	98.7
16	Using hot water to clean equipment will reduce risk of contamination	63	80.8
17	Do you think carcass contamination poses a health risk to meat consumers?	27	34.6
Meat-borne illnesses			
18	People can get diarrhoea when they eat unclean meat	65	83.3
19	Diarrhoea can pass from one person to another	50	64.1
20	Workers that get in direct contact with blood have a higher chance of getting disease	62	79.5
21	Washing of carcass before dispatch will reduce risk of passing infection to meat consumers	64	82.1
Intervention by temperature control			
22	Using hot water to clean equipment can kill bacteria more than cold water	71	91
23	Bacteria in meat will not grow in refrigeration temperature	18	23.1
24	Cooking will destroy bacteria in meat	77	98.7

TABLE 3 Overall knowledge scores of workers ($n = 78$).

Variable: Knowledge statements	Low *n* (%)	Moderate *n* (%)	High *n* (%)	Min score	Mean (SD)	Max score
Knowledge statements ($n = 24$)	4 (5.1)	34 (43.6)	40 (51.3)	14	19.2 (2.1)	23
Personal hygiene ($n = 11$)	-	5 (6.4)	73 (93.6)	7	9.9 (0.8)	11
Carcass contamination ($n = 6$)	16 (20.5)	30 (38.5)	32 (41)	2	4.2 (0.8)	5
Meat-borne illnesses ($n = 4$)	16 (20.8)	27 (35.1)	34 (44.2)	0	3.1 (1)	4
Intervention by temperature control ($n = 3$)	8 (10.3)	52 (66.7)	18 (23.1)	1	2.1 (0.6)	3

Abbreviation: SD, standard deviation.

Over 73% of respondents knew that workers who seemingly looked healthy could be sources of contamination to carcasses and elaborated that some ailments or conditions could be asymptomatic. However, 65.4% did not know that a contaminated carcass could pose a health risk to meat consumers. When asked whether a cattle carcass contaminated with faeces or rumen content during evisceration poses a health risk to meat consumers, 34.6%, 60.3% and 5.1% responded *Yes*, *No* and *I don't know*, respectively. The *Yes* respondents explained that contami-

TABLE 4 Association between age of workers and knowledge scores mean (standard deviation [SD]).

Worker characteristics		N	Knowledge score	Carcass contamination score	Temperature control score	Meat-borne illnesses score	Personal hygiene score
Age category	24–34 years	26	18.8 (2.2)[ab]	4 (0.9)[b]	2.2 (0.5)	2.9 (1.3)	9.8 (1)
	35–44 years	25	20 (1.8)[a]	4.6 (0.7)[a]	2.2 (0.6)	3.3 (0.9)	10 (0.8)
	45–54 years	16	19.6 (2.2)[ab]	4.2 (0.8)[ab]	2.1 (0.6)	3.3 (0.9)	10 (0.8)
	55+ years	11	18.1 (1.8)[b]	3.7 (0.9)[b]	2 (0.6)	2.7 (0.9)	9.6 (0.5)
	***p*-Value**		**0.019**	**0.016**	0.889	0.223	0.468

Note: NB: Means along columns with similar superscripts are not significantly different. $p < 0.05$.

TABLE 5 Knowledge of sources of carcass contamination across slaughterhouses and roles.

Worker characteristics		N	Faeces	Blood	Hands	Cutting tools	PPEs	Wash water	Environment	Container	Hide
Slaughterhouse	M1A	7	7	-	7	7	-	7	-	-	-
	M1B	6	6	-	6	6	-	6	-	-	-
	M1C	10	10	1	10	10	-	10	-	-	-
	M2A	9	8	-	9	8	-	9	-	-	-
	M2B	20	17	4	20	17	1	18	1	1	-
	M3	19	13	2	17	17	-	16	-	-	-
	M4	7	7	1	7	7	-	6	-	-	-
	Total	**78**	**68**	**8**	**76**	**72**	**1**	**72**	**1**	**1**	-
Roles	Cleaner	6	6	-	6	6	-	6	-	1	-
	FSE	40	35	4	39	38	-	37	1	-	-
	Halal slaughter	7	6	2	7	5	-	6	-	-	-
	Selling and transportation	14	14	2	14	14	-	14	-	-	-
	Stunning	1	-	-	1	-	1	1	-	-	-
	Washing offal	10	7	-	9	9	-	8	-	-	-

Abbreviations: FSE, flaying, splitting and evisceration; PPE, personal protective equipment.

nation could cause food poisoning (92.3%; $n = 24$) or pass a zoonoses (7.7%; $n = 2$). One respondent was unable to qualify his response. However, the *No* respondents explained that meat washed in the slaughterhouse or ahead of cooking is safe (85.1%), cooked meat is safe (8.5%), faeces or ruminal content have no health-threatening hazard (1.3%), slaughterhouse carcass decontamination method is sufficient (1.3%) and that such health risk incidences are unheard of (1.3%).

3.2.3 | Intervention by temperature control

Workers had a good level of knowledge on the use of high-temperature intervention for meat hygiene as 91% knew that hot water would have a greater sanitizing effect on equipment than cold water would. All workers except for 1 (98.7%) knew that cooking meat could reduce bacterial risk in meat. However, low-temperature intervention was poorly understood as 76.9% responded that bacteria will not grow under refrigeration temperatures.

Knowledge results reveal that slaughter hygiene sensitization prioritized on the personal hygiene of workers and paid little attention to sources of carcass contamination, meat-borne illnesses and intervention by temperature control.

3.3 | Attitude

The workers had positive attitude towards slaughter hygiene and meat safety, attaining a mean attitude score of 33 ± 5 out of 40 (82.5%). Majority of the workers (73.1%) had a positive attitude, 24.4% and 2.6% had a neutral and negative attitude, respectively. Attitude results are summarized in Table 6. Mean attitude scores differed significantly ($p < 0.05$) across slaughterhouses as summarized in Table 7. Five slaughterhouses, M1A, M1B, M1C, M2B and M3, attained positive attitude scores of 35.6 ± 2.5, 36 ± 2, 32.7, 34.9 ± 2.8 and 34.4 ± 3.1, respectively, which were significantly higher ($p < 0.05$) than scores in M4 and M2A. However, M1A and M1B scores were significantly higher

TABLE 6 Distribution of attitude levels of slaughterhouse workers ($n = 78$).

Attitude category distribution	
Score levels	*n* (%)
Negative (1–23)	2 (2.6)
Neutral (24–31)	19 (24.4)
Positive (32–40)	57 (73.1)
Attitude score distribution	
Minimum	14
Mean ± SD	33 ± 5
Maximum	40

Abbreviation: SD, standard deviation.

than the others. M4 attained neutral scores of 30 ± 3.8, which were significantly higher than the neutral scores in M2A (28.8 ± 8.5). There were no significant differences across the other socio-demographic variables. The attitude statements are shown in Table 8.

3.4 | Practices

3.4.1 | Personal hygiene and carcass hygiene

The summary statistics of worker practices is in Table 9. The mean practice score was 59.3 ± 3.5, out of 65 (91.2%), indicating good practices in personal hygiene and carcass hygiene. Majority of the workers (97.4%) scored highly indicating good practices, with only two workers scoring fair.

Practice scores across workers' profiles were evaluated and summarized in Table 10. Scores differed significantly across slaughterhouses ($p < 0.05$). All slaughterhouses attained good practice scores above 57. However, M2A had significantly higher score (62.6 ± 2.4) than the others. Score differences across the other socio-demographic variables were not significant. Practice statements and responses are summarized in Table 11.

3.4.2 | Carcass decontamination practice

Workers were asked the methods of carcass decontamination practiced in their slaughterhouses following carcass contamination by either faecal matter or ruminal content, and their responses are in Table 12. Almost half of the workers (47.4%) identified carcass washing with water as the main method of decontamination, whereas the rest identified water washing with knife scrapping (23.1%), washing carcass with a brush (14.1%), cutting out the contaminated part (12.8%) and wiping the contaminated area with a cloth (6.4%). Some workers (3.8%) did not know the applied decontamination method. Workers in M1B, M2A and M3 employed up to four different carcass decontamination methods, those in M1C, M2B and M4 employed three, whereas M1A utilized two practices, contradicting the standard operating procedure instructed by the meat inspector in the respective slaughterhouses. Worker compliance to the prescribed carcass decontamination method ranged from 31.6% (M2A) to 71.4% (M4). Across roles, flayers utilized the most decontamination methods (5) and were the only group that used a cloth for washing carcasses.

There was significant association ($p < 0.05$) between knowledge of sources of carcass contamination with worker roles and slaughterhouses, as summarized in Table 13. Overall, 90% of offal washers, 95% of flayers and 100% of cleaners and transporters knew that dirty knives could contaminate carcasses ($p < 0.05$) compared to only 71.4% of those who conduct Halal slaughter. Similarly, 10%, 14.3%, 16.7% and 22.2% of workers at M1C, M4, M1B and M2A, respectively, could identify cattle faeces compared to workers from M1A, M2B and M3 who could not. Although 31.6% of workers from M3 and 33.3% of those from M1B and M2A could identify dirty worker hands as contaminants ($p < 0.05$), none from M1A, M1C, M2B and M4 could. Similarly, workers from M1A, M2B and M3 could not identify meat-carrying containers as likely contaminants ($p < 0.05$) compared to 10%, 14.3%, 16.7% and 22.2% of workers in M1C, M4, M1B and M2A, respectively. Half the workers at M1C and 57.1% of those at M1A could identify dirty cutting tools as carcass contaminants ($p < 0.05$) unlike 28.6%, 22.2%, 16.7%, 15% and 5% of workers in M4, M2A, M1B, M2B and M3, respectively.

3.4.3 | Medical testing practice

All (100%) the workers from four slaughterhouses (M1A, M1B, M2A and M2B) declared to have received medical certification before engaging in slaughterhouse activities compared to 80%, 89.5% and 85.7% of workers at M1C, M3 and M4, respectively. Slightly over half (52.6%) of all the workers declared to have been tested within the stipulated period of 6 months (biannually), compared to 41% that had been working unexamined beyond 6 months, and 6.7% that declared to have never been tested. There was a significant association between medical testing practice and slaughterhouses ($p < 0.001$), as summarized in Table 14. Good medical testing practice was reported by fewer than 30% of workers in some slaughterhouses (M1A, M1B and M1C) and 42.1% of workers in M3, and by 75%, 77.7% and 85.7% of workers in M2B, M2A and M4, respectively. A majority (60%) of M1C respondents last testing was done more than a year from the date of the interview. Other socio-demographic variables, such as age, education and roles, did not have an association with medical testing practice. Following medical testing, 12 out of 78 (15.4%) workers reported being diagnosed with various diseases ranging from skin infections, typhoid, malaria, tetanus, helminths, bacteraemia and tuberculosis (Table 15). Although workers in some slaughterhouses reported no diseases (M1A and M2A), 33.3%, 26.3%, 20%, 14.4% and 10% of workers in M1B, M3, M1C, M4 and M2B, respectively, reported to have received treatment for ailments. There were no significant differences in mean knowledge ($p = 0.189$), attitude ($p = 0.777$) and practices ($p = 0.65$) scores between the trained and untrained workers.

TABLE 7 Mean attitude scores across slaughterhouse workers (Mean/STD).

Worker characteristics		N	Attitude score	*p*-Value
Slaughterhouse	M1A	7	35.6 (2.5)[a]	**0.012**
	M1B	6	36 (2)[a]	
	M1C	10	32.7 (4.1)[b]	
	M2A	9	28.8 (8.5)[d]	
	M2B	20	34.9 (2.8)[b]	
	M3	19	34.4 (3.1)[b]	
	M4	7	30 (3.8)[c]	
Age category	24–34 years	26	33.5 (5)	0.402
	35–44 years	25	32.8 (4.9)	
	45–54 years	16	35 (3.1)	
	55 years and above	11	32.6 (4.7)	
Education	No school	5	34.8 (2.2)	0.411
	Primary	49	33.7 (3.6)	
	Secondary	22	33 (6.7)	
	Tertiary	2	30.5 (0.7)	
Roles	Cleaner	6	34 (4.5)	0.703
	FSE	40	32.5 (5.6)	
	Halal slaughter	7	34.7 (2.7)	
	Selling and transportation	14	34.4 (2.5)	
	Stunning	1	35 (NA)	
	Washing offal	10	35 (2.4)	
Work experience (years)	≤3 years	16	32.5 (6)	0.427
	4–10 years	29	33.4 (4.5)	
	11–20 years	19	34.9 (3.3)	
	>20 years	14	32.8 (4.4)	

Key: Means along columns with similar superscripts are not significantly different.
Abbreviation: FSE, flaying, splitting and evisceration.

TABLE 8 Number and frequency of slaughterhouse workers' attitudes towards meat safety ($n = 78$).

Attitude statements	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Clean and proper meat handling is your responsibility	3 (3.8)	-	-	17 (21.8)	58 (74.4)
In the slaughterhouse, it is more important to work quickly than to keep carcasses clean	28 (35.9)	31 (39.7)	3 (3.8)	11 (14.1)	5 (6.4)
It is important to learn about meat safety through training	2 (2.6)	1 (1.3)	2 (2.6)	21 (26.9)	52 (66.7)
Long fingernails can contaminate meat	2 (2.6)	-	1 (1.3)	28 (35.9)	47 (60.3)
Slaughterhouse workers are more likely to get sick than outsiders	11 (14.3)	15 (19.5)	7 (9.1)	17 (22.1)	27 (35.1)
When meat is cooked, it is always safe to eat	2 (2.6)	3 (3.8)	6 (7.7)	32 (41)	35 (44.9)
Dirt on clothing or utensils will not pause any risk	7 (9)	7 (9)	3 (3.8)	23 (29.5)	38 (48.7)
In the slaughterhouse, keeping clean is easy	53 (67.9)	10 (12.8)	2 (2.6)	9 (11.5)	4 (5.1)

TABLE 9 Distribution of practice scores of slaughterhouse workers ($n = 78$).

Practice category distribution	
Score levels	*n* (%)
Poor (1–38)	-
Fair (39–51)	2 (2.6)
Good (52–65)	76 (97.4)
Practice Score Distribution	
Minimum	50
Mean + SD	59.3 (3.5)
Maximum	65

4 | DISCUSSION

This is the first study across four sub-counties of Kajiado Kenya to assess the level of KAPs of slaughterhouse workers on slaughter hygiene and meat safety. The dominance of males in slaughter operations in this study (96.2%) was similar to other parts of Kenya, such as Tana River County (100%; $n = 10$) (Nyokabi, 2015), Western Kenya (97%; $n = 738$) (Cook et al., 2017), and in Nairobi County (96.1%; $n = 279$) (Mogute, 2021). The workers' mean age of 41.51 years was comparable to ages in previous studies of 39 years (Cook et al., 2017) and 38 years (Nyokabi, 2015). In this study, roles were associated with age and gender. Younger workers were preferentially assigned cleaning duties, whereas female workers had hygiene roles in offal washing (1.3%) and meat selling (2.6%). One study (Kago, 2015) reported female workers (2.3%; $n = 87$) took roles as butchery attendants, whereas another (Wambui, 2016) reported female workers performing hygiene roles in laundering of worker's PPEs.

The wearing of a white coat, a cap and gum boots is a pre-requisite to entering Kajiado slaughterhouses. The wearing of masks by workers and visitors was observed following the Covid-19 pandemic and was made mandatory as part of the preventive protocol at places of work, in addition to the establishment's requirement to provide handwashing soap, sanitizers and handwashing facilities. The self-provision of PPEs by the majority of workers (91%) in this study echoes with an earlier study where 78% and 84% of workers provided their own coats and boots, respectively (Cook et al., 2017). Another study (Makori et al., 2018) revealed that the provision of PPEs by the facility management was practised only in export-oriented slaughter facilities and processing plants. In Kenya, Occupational Safety and Health Act (OSHA) (2007) necessitated employers to provide PPEs to employees for protection from work-related injuries, illnesses and mortalities, highlighting the provision of clothing, footwear, gloves, head covering and goggles where necessary. Flayers reported that flaying operations would not be well executed while wearing synthetic gloves due to reduced grip. Throughout this study, only one halal slaughter worker was observed wearing a steel mesh butcher glove. This corresponds to previous studies where neither meat handlers (Cook et al., 2017) nor meat transporters (Kago, 2015) were observed wearing gloves. The role of PPEs in reducing carcass contamination by worker's hands (Sofos, 2005) and in reducing workers exposure to zoonoses (Nabukenya et al., 2013) is well recognized. Exposure of slaughterhouse workers to zoonoses poses risk to other workers and their households. Large households suffer a greater likelihood of getting infected through internal transmission because of the larger number of contacts (House & Keeling, 2009). Considering the mean household size for this study was 4.05 persons per household with almost 18% of the workers having household size ranges from 6 to 10 persons per household, provision and proper dressing of adequate PPEs should be highlighted for slaughterhouse workers in reducing their exposure to numerous work-related injuries and maladies.

4.1 | Knowledge levels of slaughterhouse workers

Knowledge is reportedly acquired by either learning formally or informally by personal experience or sharing experience with others (Jianu and Goleț, 2014). In this study, over half of the workers scored highly on overall knowledge. Middle-aged workers scored significantly higher than the younger workers and the elderly. With training being inadequate, this study attributes the lower scores of younger workers to shorter period in acquiring on-the-job practical knowledge, whereas the elderly scores were attributed to a lack of acquisition of new knowledge since training in these slaughterhouses is focused on the induction of new recruits. Like in other employment sectors, the profound experience of elderly workers is counted on to mentor the newer workers (Shawn et al., 2014). The study attributed high scores in personal hygiene knowledge to the effects of the year-long, nation-wide Covid-19 advocacy on preventive measures at the workplace. Although 78.2% of workers knew that handwashing with water alone may not render hands clean, the study observed that only two slaughterhouses, M2B and M3, had flushable toilets and provided handwashing sinks, water and soap; the other five slaughterhouses had pit latrines that lacked these amenities. In comparison to the study of meat handlers in Nairobi, 86.4% reported to wash hands before handling meat, whereas only 15% affirmed to wash their hands with soap (Wambui, 2016). Kunyanga et al. (2021) reported inadequate handwashing practice, siting low frequency.

Although most workers (87.2%) knew that PPEs should not be taken out of the slaughterhouse for cleaning, the slaughterhouses did not have laundry services, nor designated areas for washing PPEs. This study observed individuals and small businesses located immediately adjacent to the slaughterhouses providing laundry and rental services for coats, and overalls. Furthermore, some meat inspectors reported that the PPEs were washed at the workers homes. Previous studies have not addressed the cleaning of PPEs in slaughter facilities; however, this practice is thought to be common across other category B slaughterhouses. Concerning biohazard control, the study observed workers walking in and out of the slaughterhouses with their work gumboots, in the absence of a foot bath. Similar observation was made in Western Kenyan slaughterhouses (Cook et al., 2017).

Knowledge gaps were identified in the other three sub-sections, where 59%, 55.9% and 77% of the workers attained moderate-to-low

TABLE 10 Practice mean scores of slaughterhouse workers across slaughterhouses.

Worker characteristics		*N*	Practice score	*p*-Value
Slaughterhouse	M1A	7	57.3 (1.3)[b]	**0.006**
	M1B	6	59.2 (1.8)[ab]	
	M1C	10	60 (2.8)[ab]	
	M2A	9	62.6 (2.4)[a]	
	M2B	20	57.4 (3.8)[b]	
	M3	19	60.1 (3.6)[ab]	
	M4	7	59.7 (3.5)[ab]	
Age category	24–34 years	26	58.6 (3.8)	0.511
	35–44 years	25	59.8 (3.3)	
	45–54 years	16	59.9 (3)	
	55 years and above	11	58.8 (3.9)	
Education	No school	5	60 (2.9)	0.793
	Primary	49	59.5 (3.3)	
	Secondary	22	58.7 (4)	
	Tertiary	2	58 (4.2)	
Roles	Cleaner	6	58.7 (5.9)	0.515
	FSE	40	59.2 (2.9)	
	Halal slaughter	7	59.6 (4.2)	
	Selling and transportation	14	59.1 (3.9)	
	Stunning	1	53 (-)	
	Washing offal	10	60.6 (2.8)	
Work experience (years)	≤3 years	16	59.9 (4.2)	0.491
	4–10 years	29	59.6 (2.7)	
	11–20 years	19	58.2 (3.7)	
	>20 years	14	59.5 (3.8)	

Note: Key: Means along columns with similar superscripts are not significantly different.

scores in carcass contamination, meat-borne illnesses and intervention by temperature control, respectively. With more than half of respondents performing flaying roles, that none were able to identify cattle hide as a source of carcass contamination brings doubt to the syllabus and quality of training offered. The main training outcome reported by the trained flayers was that 'I become better at flaying by reducing the number of hide losses through cuts'. Similarly, none of the workers in meat selling and transportation could identify the meat-transporting containers as a source of carcass contamination en route to the butchery, whereas cleaners could not identify the environment or blood as possible carcass contaminants. The lack of knowledge across worker roles and slaughterhouses suggests that training, standardizing standard operating procedures (SOPs) and improving worker supervision can enhance good slaughter practices in SMS.

Most workers (98.7%) knew that cleaning equipment and surfaces after slaughter operations is vital in reducing cross-contamination, and 80.8% knew hot water would reduce the risk of contamination. However, in practice, cold water is used in all cleaning operations, contrary to the provisions of the Meat Control Act, which require cleaning water to be above 82°C. This renders sanitization operations in Kajiado slaughterhouses inadequate. Similar practices were reported in butcheries ($n = 250$), where working surfaces and equipment were washed with cold water and soap (Kago, 2015). As such, these results suggest that the upgrade of sanitation infrastructure, particularly hot water systems, can enhance disinfection operations at SMS.

Poor knowledge was recorded in intervention by temperature control as 76.9% responded that bacteria will not grow under refrigeration temperatures. *Yersinia enterocolitica*, *Listeria monocytogenes*, *Salmonella* spp. and diarrhoeagenic *E. coli* are known to be the most relevant beef pathogens when assessing the effects of refrigerated beef on public health risk (EFSA, 2016). With minimum growth temperatures of *Y. enterocolitica*, *L. monocytogenes*, *Salmonella* and *E. coli* O157:H7 being −1.3, −0.4, 5.2–7 and 7.0–8.0°C, respectively, these pathogens are a cause for concern even under acceptable refrigeration temperature conditions (Sofos, 2005). All the studied slaughterhouses lacked refrigeration facilities: refrigeration being opted by some retailing butchers. With the Kenyan consumer preference for meat slaughtered on the same day (considered 'fresh'), together with inconsistent power supply, many slaughterhouses and butchers lack the incentive to invest in refrigeration equipment (KMT, 2019).

TABLE 11 Number and frequency of slaughterhouse responses to practice statement.

Practice statements	Always	Often	Sometimes	Rarely	Never
You wash your hands after going to the toilet	75 (96.2)	1(1.3)	2 (2.6)	-	-
You wear an apron at the slaughterhouse daily	78 (100)	-	-	-	-
You wear a mask at the slaughterhouse daily	77 (98.7)	-	1 (1.3)	-	-
You wear a cap at the slaughterhouse daily	77 (98.7)	-	1 (1.3)	-	-
You wear gloves whenever you handle meat	11 (14.1)	2 (2.6)	9 (11.5)	5 (6.4)	51 (65.4)
You take a medical test every 6 months	74 (94.9)	-	3 (3.8)	1(1.3)	-
Carcass hygiene practice					
You wash your hands before handling the carcass	72 (92.3)	3 (3.8)	1 (1.3)	1(1.3)	1 (1.3)
You wash your hands with soap before handling carcass	38 (48.7)	4 (5.1)	15 (19.2)	8(10.3)	13 (16.7)
You keep short nails without accessories before starting slaughter operations	73 (93.6)	1 (1.3)	2 (2.6)	-	2 (2.6)
You handle meat in the slaughterhouse when sick with diarrhoea	-	-	4 (5.1)	1(1.3)	73 (93.6)
Do you smoke, drink, eat or chew while working in the slaughterhouse?	-	-	-	-	78 (100)
You handle meat in the slaughterhouse when you have cuts on your hands	-	-	1 (1.3)	2(2.6)	75 (96.2)
Sanitation					
You disinfect contact surfaces and cutting equipment	64 (82.1)	1 (1.3)	5 (6.4)	3 (3.8)	5 (6.4)

TABLE 12 Carcass decontamination interventions employed across slaughterhouses and roles.

		Manual wash							
Slaughterhouse	*N*	Water wash + wet cloth	Water wash	Water wash + brush	Water wash + knife scrap	Cut-out part	Don't know	Meat Inspector's intervention	Percentage of worker compliance
M1A	7	-	3	-	4	-	-	Water wash	42.9
M1B	6	1	2	2	1	-	-	Water wash	33.3
M1C	10	1	5	-	5	-	-	Water wash	50
M2A	9	2	2	3	2	-	-	Water wash + brush	33.3
M2B	20	-	12	-	3	7	1	Water wash	60
M3	19	-	8	6	1	3	2	Water wash + brush	31.6
M4	7	1	5	-	2	-	-	Water wash	71.4
Roles									
Cleaner	6	-	5	1	-	-	-		
FSE	40	5	18	5	11	3	-		
Halal slaughter	7	-	2	1	2	1	1		
Sell & transport	14	-	6	3	3	3	2		
Stunning	1	-	-	-	-	1	-		
Washing offal	10	-	6	1	2	2	-		
Total		5 (6.4%)	37 (47.4%)	11 (14.1%)	18 (23.1%)	10 (12.8%)	3 (3.8%)		

Abbreviation: FSE, flaying, splitting and evisceration.

TABLE 13 Association between worker roles and carcass decontamination knowledge.

Worker characteristics	N	Faeces	Blood	Dirty hands	Dirty knives	Dirty PPEs	Dirty water	Environment	Container	Hide
M1A	7	-	3 (42.9)	-	4 (57.1)	-	-	7	-	3 (42.9)
M1B	6	1 (16.7)	2 (33.3)	2 (33.3)	1 (16.7)	-	-	6	1 (16.7)	2 (33.3)
M1C	10	1 (10)	5 (50)	-	5 (50)	-	-	10	1 (10)	5 (50)
M2A	9	2 (22.2)	2 (22.2)	3 (33.3)	2 (22.2)	-	-	9	2 (22.2)	2 (22.2)
M2B	20	-	12 (60)	-	3 (15)	7 (35)	1 (5)	20	-	12 (60)
M3	19	-	8 (42.1)	6 (31.6)	1 (5.3)	3 (15.8)	2 (10.5)	19	-	8 (42.1)
M4	7	1 (14.3)	5 (71.4)	-	2 (28.6)	-	-	7	1 (14.3)	5 (71.4)
Slaughterhouse *p*-value		**0.04**	0.46	**0.01**	**0.03**	0.89			**0.04**	0.46
Cleaner	6	6 (100)	-	6 (100)	6 (100)	-	6 (100)	-	1 (16.7)	-
FSE	40	35 (87.5)	4 (10)	39 (97.5)	38 (95)	-	37 (92.5)	1 (2.5)	-	-
Halal slaughter	7	6 (85.7)	2 (28.6)	7 (100)	5 (71.4)	-	6 (85.7)	-	-	-
Selling and transportation	14	14 (100)	2 (14.3)	14 (100)	14 (100)	-	14 (100)	-	-	-
Stunning	1	-	-	1 (100)	-	1 (100)	1 (100)	-	-	-
Washing offal	10	7 (70)	-	9 (90)	9 (90)	-	8 (80)	-	-	-
Roles *p*-value		0.06	0.44	0.58	**0.04**		0.36			

Note: NB: A fisher's exact test was used to test for association. $p < 0.05$.
Abbreviations: FSE, flaying, splitting and evisceration; PPE, personal protective equipment.

TABLE 14 Medical testing practice across slaughterhouses and workers profiles.

Worker characteristics		N	M1A	M1B	M1C	M2A	M2B	M3	M4	*p*-Value
Period passed since last medical test	≤6 months	41	2	1	2	7	15	8	6	<0.001
	7–12 months	24	5	5	-	1	4	9	-	
	>12 months	8	-	-	6	1	1	-	-	
	Not tested	5	-	-	2	-	-	2	1	
	% good practice	52.6%	28.6%	20%	20%	77.7%	75%	42.1%	85.7%	

4.2 | Attitude

Majority of the workers (96.2%) responded that meat handling was their responsibility of whom 74.4% strongly agreed with the statement. Poor attitude towards responsibility was displayed by 3.8% who felt it was the meat inspectors' responsibility. Although 78.2% of the workers felt that dirt on PPE's and on meat cutting equipment would not pause a risk to meat contamination, 80.7% found it difficult to keep clean within the slaughterhouse. The study observed the untidy and unsanitary status of the workers' clothing, with most workers seen with wet, blood- and ruminal matter-stained overalls while carrying carcasses over their shoulders, washing offal and cleaning the slaughter hall. Most of the outer PPE's are not water-resistant and hence workers remained wet during operations. Overall, 75.6% of the workers disagreed with the statement that expressed priority is given to speed of work over carcass hygiene, revealing a positive attitude towards attentiveness while handling carcasses.

Majority of the workers (85.9%) agreed that cooked meat is always safe, with 44.9% strongly agreeing. This perception may have stemmed from the country's common beef-cooking methods involving high-temperature long-time treatments like boiling, simmering and roasting that utilize temperature upwards of 95°C and over 30 min (Mitra et al., 2017) and that are likely to denature vegetative cells of meat pathogens compared to low-temperature short-time cooking treatments preferred in developed countries that have resulted in outbreaks of meat-borne illnesses (EFSA & ECDC, 2019). Second, the diagnosis and under-reporting of foodborne illness (Grace, 2015) may result in a lack of consumer sensitization and policy prioritization. Majority of the workers (93.6%) agreed it was important to receive meat safety training at work. This positive attitude suggests that training efforts could spur positive learning outcomes in the workers.

Significant differences in attitude scores across slaughterhouses may be explained by a few factors. First, supervision challenges, where complacent workers fail to adhere to standard operating procedures

TABLE 15 Distribution of workers diagnosed and treated for diseases.

Worker self-declaration of diseases diagnosed after testing	n	M1A 7	M1B 6	M1C 10	M2A 9	M2B 20	M3 19	M4 7
Skin infection	1	-	-	-	-	-	-	1
Typhoid	1	-	-	-	-	-	1	-
Malaria	1	-	-	-	-	1	-	-
Tetanus	3	-	-	2	-	1	-	-
Helminthes	4	-	2	-	-	-	2	-
Bacteremia	1	-	-	-	-	-	1	-
Tuberculosis	1	-	-	-	-	-	1	-
% of workers diagnosed	15.4%	0%	33.3%	20%	0.0%	10%	26.3%	14.3%

and management's contravention of the Meat Control Act and OSHA. Second, a poor work culture, where on busy days (usually market days) workers are inclined to working fast over keeping attention to detail. Third, slaughterhouses had different levels of facilitation of hygiene and sanitation materials, PPEs and training. These results imply that adequate supervision of workers and adherence to regulations will improve the occupational welfare of the workers and reduce public health threats to slaughterhouse workers, their households and meat consumers.

4.3 | Practices

Workers (92.3%) reported to always wash their hands before carcass handling, whereas 48.7% reported to always wash hands with soap inside the slaughter hall. Contrary to these declarations, the study observed that handwashing with soap was not practiced inside the slaughter halls. Meat inspectors informed that handwashing soaps or detergents were not provided inside the slaughtering halls to discourage workers from potentially leaving soap residues on their hands and subsequently contaminating carcasses. Majority of the workers (96.2%) asserted to always wash their hands after using the toilets. However, as previously mentioned, handwashing amenities are not adequate, with sinks observed not to have running water nor soap. These results suggest that availing sanitation facilities and materials can increase handwashing practice by workers and consequently enhance slaughter hygiene and meat safety.

Majority of workers reported to always wear adequate PPEs, such as aprons (100%), masks (98.7) and caps (98.7); however, gloves were reported never to be worn by 65.4% of the workers. The workers self-declarations agreed with the study's observations throughout the data collection period that all workers had good practice in wearing aprons, caps, masks and gumboots. Only 6.4% of the workers reported to have handled meat when sick with diarrhoea, whereas 3.8% reported to have handled meat with hand wounds. This revelation implies slaughterhouse workers pose as potential sources of contamination to carcasses and equally risk acquiring slaughterhouse-borne zoonoses. Although all workers reported never having smoked, drunk, ate or chewed in the slaughterhouse, a worker was seen smoking inside the slaughter hall of M4.

Workers (82.1%) reported to always disinfect contact surfaces and cutting equipment; overall, 11.5% reported disinfecting occasionally, whereas 6.4% reported to never having disinfected. Considering the absence of hot water supply in all these facilities, the cleaning of floors and equipment with cold water and the inability of the workers to identify disinfectants other than mentioning use of liquid or powdered detergents, the study reports the lack of disinfection activities of the slaughter hall, contact surfaces and cutting equipment.

The poor worker adherence to the meat inspector's method of carcass decontamination may be attributed to either poor outlining of decontamination procedures, inadequate supervision of decontamination steps or meat inspectors' acceptance of the various methods being utilized. The study observed carcasses were washed in a hanging position, and water in buckets would be poured by hand onto the inner parts of the carcass from higher to the lower regions. Wet clothes, brushes and knife scrapping would be used to facilitate the process. These materials would then be rinsed in the bucket and used to clean other carcasses. One bucketful of water would be used repeatedly on several carcasses before it is disposed. The outer part of the carcass is never washed (as reported by workers and meat inspectors), this is believed to cause carcass 'swelling' and hasten meat spoilage. The study, however, observed cleaning of the mid–outer parts of a contaminated carcass with cloth, whereas the lower parts (front limbs) with bare hands, brushes and cloth. This study finds the manual washing of carcasses to be ineffective in reducing microbial contamination and points to the reused water, buckets and cleaning aids, such as cloths, brushes and knives, as possible sources of contamination and cross-contamination of carcasses. A previous study (Wambui, 2016) reported that carcasses were handwashed with a cloth dipped in cold water to remove blood and bone splinters and enhance the visual quality of the carcasses. However, whether using hot or cold water, spraying or washing may redistribute microbial contamination from regions of high concentration to clean areas (Galland, 1997). Cutting off or trimming of the carcass tissue visually observed to be contaminated during the slaughter process has been found to be effective subject to the sanitary state of the knife, and the attentiveness of the worker. On the

other hand, this method may further expose the carcass to bacterial penetration (Galland, 1997).

Medical testing of slaughterhouse workers purposes to safeguard the health and safety of the workers and consumers. Worker's ignorance of their health status together with poor carcass handling practices may result in disease transmission (Kumar et al., 2019). Poor medical examination practice was recorded among the workers, with only 52.6% having been tested as required. The diagnosis of tuberculosis in a worker indicates the high occupational risk of slaughterhouse workers, their households and meat consumers to contracting zoonotic TB (Khattak et al., 2016). Typhoid, diagnosed in one worker, is a zoonotic disease caused by the bacteria *Salmonella typhi*, which leads to diarrhoea and vomiting. It has been reported that cattle faeces can contain salmonellae levels as much as 10^8/g (Sofos, 2005). Proper hide removal, evisceration and hygienic carcass handling are key in reducing the carcass contamination and exposure risk of workers and meat consumers to *Salmonella* spp., pathogenic *E. coli* and *Campylobacter* spp. (Dickson & Acuff, 2017). Diagnosis of tetanus in 3.8% of workers following cuts and lacerations during operations highlights their occupational hazards. The study observed hand and arm wound scars on an undetermined number of workers. Broken skin due to lesions or lacerations could increase the exposure of workers to zoonoses. With hydatidosis and helminths identified by meat inspectors as among leading causes of organ condemnation across the slaughterhouses, the diagnosis of 5.1% of workers with helminths reveals the likelihood of risk exposures of workers to the zoonotic parasites. Malaria has previously been reported in 47% (n = 738) of slaughterhouse workers in Western Kenya (Cook et al., 2017) and 7% (n = 232) in Kampala, Uganda (Nabukenya et al., 2013). In the absence of diagnostic kits, the misdiagnosis as malaria is a common occurrence as its clinical human symptoms are similar to those of Brucellosis and other febrile illnesses that may be missed and under-reported (Njeru et al., 2016). The Meat Control Act bars admission of persons with any communicable disease at a transmissible stage from accessing the slaughterhouse or getting in contact with meat. These results suggest that the laxity of slaughterhouse management in enforcing timely worker testing will increase the risk exposure of workers, their households and meat consumers to zoonoses. Similarly, the provision and proper wearing of appropriate PPEs and safe handling of livestock and carcasses can greatly reduce the risk of occupational hazards and zoonoses transmission.

4.4 | Training

Training is a key component in a food control system (Yeargin et al., 2021). In this study, only 7.7% of workers asserted to receive slaughter hygiene and meat safety training, whereas 5 and 3 received training on good flaying techniques and halal slaughter, respectively. Meat inspectors from three slaughterhouses (M1B, M1C and M4) reported that no training was offered to their workers, whereas some declared training was done selectively across roles. For instance, flayers at M1A were offered flaying training annually, whereas those at M2B were trained during induction to the slaughterhouse. Cleaners and flayers at M2A and M3 were trained on slaughter hygiene and meat safety only at induction. Previous studies have reported low levels of training among slaughterhouse workers. In a study of meat handlers across Nairobi, Limuru and Eldoret town, it was reported that 6.9% and 40.6% of butchery attendants and meat transporters, respectively, had received training on meat hygiene from the meat inspector and private organizations (Kago, 2015). Other studies reported training of slaughterhouse workers at 33%; n = 31 (Kunyanga et al., 2021) and 40%; n = 207 (Wambui, 2016). Both the present and past studies indicate non-compliance to the Meat Control Act that requires all personnel in category B slaughterhouses to receive no less than two food safety trainings per calendar year.

Although the trained workers in this study could not remember the dates of training, training duration and topics, they were able to mention learning outcomes, which included: 'I have become cleaner than I was', n = 2; 'I have become aware of hygienic requirements', n = 2; 'better bleeding', n = 2; 'better flaying', n = 7; 'I don't wear jewelry and other accessorize', n = 1; 'I have become more efficient at work', n = 2. Training of slaughterhouse workers appears to be verbalized, unstructured and irreproducible. The lack of a distinct syllabus and training programme renders these previous training efforts ineffective in delivering slaughter hygiene and meat safety knowledge and effecting improved behavioural change of workers. Although training of food handlers is reported to improve knowledge and practice (Adekosan et al., 2015; Wambui, 2016), the absence of working facilities reduces the implementation of good practices. Our study suggests that the lack of structured training in slaughter hygiene and meat safety can diminish the knowledge, attitude and good practices in slaughterhouse workers.

5 | LIMITATIONS

Due to the nature of Kajiado SMS, majority of which are in rural and peri-urban area with a small slaughtering capacity of between 10 and 40 cattle per day, the number of workers present is small. Although this pilot study was able to draw valid conclusions on workers KAPs, future studies could consider increasing the number of slaughterhouses to obtain more precise results. To the best of our knowledge, this was the first paper to address slaughterhouse worker knowledge of carcass contaminants. Data on carcass decontamination interventions and medical testing practice in SMSs in Kenya is limited. This is a research gap that can be developed further by future studies.

6 | CONCLUSION

Slaughterhouse workers in SMSs in Kajiado have moderate-to-low knowledge, neutral attitude towards slaughter hygiene and meat safety and poor practices in carcass decontamination interventions and medical testing. Inadequate worker supervision during slaughter and laxity in enforcing medical testing will continue to pose risk for the transmission of zoonoses to workers and the public. This is

exacerbated by the lack of training of workers in slaughter hygiene and meat safety, inadequate PPEs, lack of hygiene and disinfection facilities and gross non-compliance to regulatory provisions. If this situation is left unchecked, slaughterhouse workers and meat consumers will remain exposed to present and emerging public health hazards.

7 | RECOMMENDATION

The study recommends the routine training of slaughterhouse workers, with a well-structured and standardized syllabus, tailored to specific to worker roles, specific tasks, to address meat-borne risks, hazards and their corrective interventions. Similarly, our study proposes the retraining of meat inspectors to improve worker instruction and supervision, by addressing the training design and delivery. Furthermore, in addition to recommending improving compliance to regulatory provisions, it would be prudent for SMSs to develop their sanitation infrastructures and enhance food safety capacities.

AUTHOR CONTRIBUTIONS

Conceptualization; funding acquisition; investigation; methodology; writing – original draft; writing – review and editing: Victoria Kimindu. *Conceptualization; project administration; supervision; validation; visualization; writing – review and editing*: Dasel Kaindi, Lucy Njue and Samwel Githigia.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest among all the contributors of this manuscript.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study is available from the corresponding author upon reasonable request.

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PEER REVIEW

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ETHICS STATEMENT

The study was granted permission to conduct research by the Department of Veterinary Services, Ministry of Agriculture, Livestock, Fisheries and Irrigation, Kajiado County and the National Commission for Science, Technology, and Innovation. Participant's names and slaughterhouse identities were withheld throughout the research to guarantee confidentiality.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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