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Factors Associated with Quality Meat Hygiene Handling to Promote Healthy Meat Consumption among Meat Handlers in Kirehe District, Rwanda

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Abstract

Background: Unsafe food causes an estimated 866 million illnesses and 1.5 million deaths every year, with the heaviest burden in Africa and South-East Asia [1]. Meat is a major vehicle of foodborne pathogens, and the behaviour of meat handlers is a critical control point between slaughter and consumption. Evidence on the factors that shape meat-hygiene practice in rural Rwanda is scarce. This study examined socio-economic and socio-cultural factors associated with quality meat-hygiene handling and assessed the availability and implementation of safety standard protocols among meat handlers in Kirehe District, Rwanda.

Methods: A cross-sectional mixed-methods design was used. A structured questionnaire was administered to 423 meat handlers selected by stratified random sampling across butcheries, slaughter slabs, slaughterhouses, meat-grilling points and meat transport. Structured observation was conducted in 60 facilities, and key informant interviews and focus group discussions were analysed thematically. Good practice was defined as a score of at least 80% on 13 practice items. Chi-square tests and multivariable logistic regression were used, and findings were triangulated.

Results: The mean practice score was 80.3% (SD 9.7), and 51.8% of handlers had good practice. Formal hygiene training (AOR = 4.01, 95% CI: 2.10–7.65), monthly income of at least RWF 151,000 (AOR = 3.70, 95% CI: 2.00–6.83), secondary or university education (AOR = 2.88, 95% CI: 1.65–5.03) and perceived responsibility for consumer protection (AOR = 2.79, 95% CI: 1.53–5.08) were positively associated with good practice. Financial constraints (AOR = 0.62), workload barriers (AOR = 0.66) and the belief that normal-looking meat is safe (AOR = 0.57) were negatively associated. Mean observed facility compliance was 60.5%, with the largest gaps in functional refrigeration (30.4%), clean covered transport (40.0%) and evidence of staff training (48.3%).

Conclusion: Meat-hygiene practice in Kirehe District is shaped by interacting individual, economic, cultural and institutional factors. Combined interventions that pair practical training with affordable hygiene inputs, cold-chain support, routine supervision and consumer risk communication are recommended.

Keywords: Meat Hygiene, Meat Handlers, Food Safety, Foodborne Diseases, Mixed Methods, Rwanda

1. Introduction

Foodborne diseases remain a major and preventable public health problem. The most recent estimates of the World Health Organization (WHO), released in 2026, indicate that 42 foodborne hazards cause approximately 866 million illnesses and 1.5 million deaths annually, together with an estimated US$ 310 billion in lost productivity in 2021 [1, 2]. Children younger than five years represent only 9% of the global population but bear nearly one third of foodborne illnesses, and the African and South-East Asian regions together account for nearly three quarters of all foodborne illnesses and 60% of related deaths [1]. Biological hazards, including bacteria such as non-typhoidal Salmonella, caused the large majority of these illnesses, approximately 860 million in 2021 [1, 2].

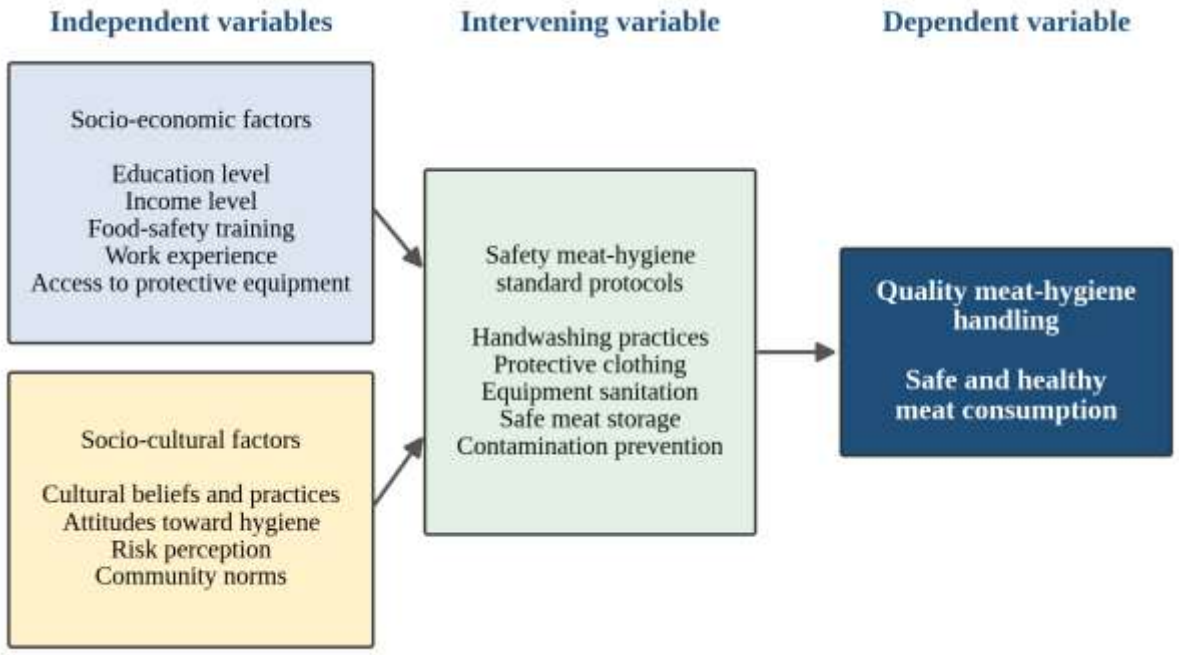
Meat is an important source of high-quality protein and micronutrients, but its high moisture and nutrient content make it highly perishable and susceptible to microbial contamination [3]. Contamination can occur at every stage of the meat chain, including slaughter, carcass dressing, cutting, transport, storage and retail. A recent abattoir study in western Ethiopia found bacterial contamination on 64% of knife swabs and 57% of workers' hand swabs, in a facility with limited handwashing facilities, inconsistent water supply and no refrigeration [4]. In traditional and informal markets, weak infrastructure and limited enforcement further complicate the control of meat-borne zoonoses [5].

In Rwanda, the available evidence on meat safety is limited and largely urban. In Kigali, Salmonella was detected in 19.6% of 270 retail meat samples, with risk linked to meat temperature, cutting-board cleanability and staff hygiene training [6], and in 21.4% of raw meat samples from households [7]. Evidence on the behaviour of food handlers is also concerning: a 2025 meta-analysis of 42 studies and 12,367 food handlers found that only 50.68% of food handlers in sub-Saharan Africa had good hygiene practice [8], and a study in Gatsibo District, also in the Eastern Province of Rwanda, reported good practice among only 31.1% of food handlers [9]. Comparable studies of meat handlers reported satisfactory practice among 44.4% of handlers in Kathmandu, Nepal [10] and 51.3% of butchers in North Shewa, Ethiopia, where only 12.1% had received food-safety training [11].

Kirehe District, in the south-east of Rwanda, has 460,860 residents, of whom 93.7% live in rural areas [12]. Livestock keeping is a core livelihood, and meat is distributed through slaughterhouses, slaughter slabs, butcheries, grilling points and informal transport. However, no published study has examined the factors that shape meat-hygiene practice in this district. Previous research has also tended to examine knowledge and practice separately, with limited attention to how economic resources, cultural beliefs, workplace conditions and regulatory enforcement interact.

This study was guided by the Health Belief Model [13], the Theory of Planned Behavior [14], the Ecological Model [15] and Food Safety Culture Theory [16]. Together, these frameworks propose that hygiene behaviour depends on perceived risk, attitudes and perceived behavioural control, as well as on organizational and policy conditions. The conceptual framework is presented in Figure 1.

Figure 1: Conceptual Framework of Factors Associated with Quality Meat-Hygiene Handling



The general objective was to determine factors associated with quality meat hygiene handling among meat handlers in Kirehe District, Rwanda, in order to promote safe and healthy meat consumption. The specific objectives were:

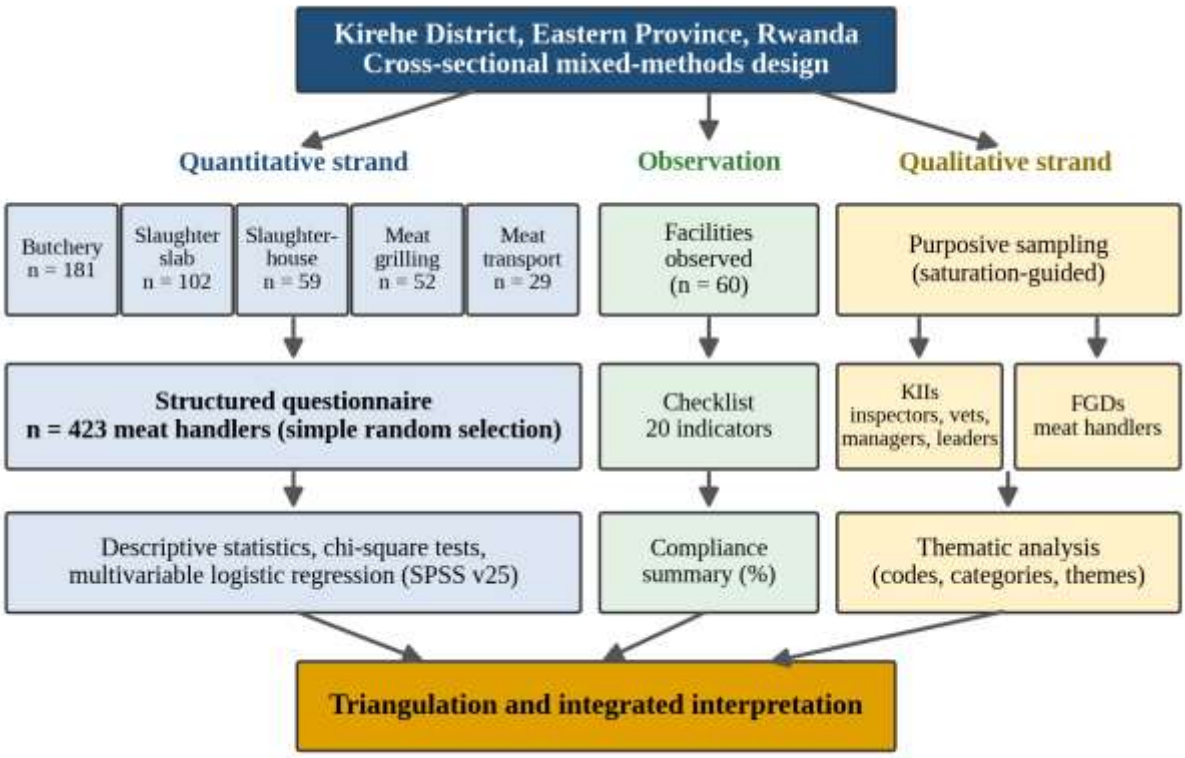
- To determine the socio-economic factors associated with quality meat hygiene handling to promote heathy meat consumption among meat handlers in Kirehe District.
- To evaluate the socio-cultural factors associated with quality meat hygiene handling to promote heathy meat consumption among meat handlers in Kirehe District.
- To assess the availability and implementation of safety standard protocols in slaughterhouses and butcheries that support quality meat hygiene handling in Kirehe District.

2. Materials and Methods

2.1 Study Design and Setting

A cross-sectional mixed-methods design was employed. Quantitative and qualitative data were collected during the same study period and integrated through methodological triangulation. The study was conducted in Kirehe District, Eastern Province, Rwanda, which borders Tanzania and comprises 12 administrative sectors. The district is predominantly agricultural, with 431,821 of its 460,860 residents living in rural areas [12]. The overall study design is summarised in Figure 2.

Figure 2: Study Design, Sampling and Integration of Data Sources



2.2 Study Population and Eligibility

The quantitative study population comprised adults who directly handled meat in slaughterhouses, slaughter slabs, butcheries, meat-grilling points and meat transport in Kirehe District. Handlers aged 18 years or above who were currently engaged in meat handling and who provided informed consent were included. Individuals who were too ill to participate or who did not directly handle meat were excluded. The qualitative component included purposively selected meat handlers and key stakeholders, namely meat inspectors, veterinary and public health officers, facility managers and local authority representatives.

2.3 Sample Size and Sampling

The sample size was estimated using the single-population proportion formula:

$$n = Z^2 \times p \times (1 - p) \div d^2 \quad (1)$$

where $Z = 1.96$ for a 95% confidence level, $p = 0.50$ because no district estimate was available, and $d = 0.05$. This yielded 384.16, rounded to 384 participants. After adding 10% for non-response, the final sample was 423 meat handlers. Handlers were stratified by work setting, the sample was allocated proportionally to each stratum (butchery, 181; slaughter slab, 102; slaughterhouse, 59; meat grilling, 52; meat transport, 29), and respondents were selected by simple random sampling from facility and worker lists. Participants in key informant interviews (KIIs) and focus group discussions (FGDs) were selected purposively, and recruitment was guided by data saturation.

2.4 Data Collection Instruments

Four complementary instruments were used. A structured questionnaire collected socio-demographic and work characteristics, socio-economic factors (income, employment arrangement, training, workload and access to hygiene resources), socio-cultural factors (beliefs, workplace norms, customer pressure and risk

perception), availability of safety protocols and 13 meat-hygiene practice items. A structured observation checklist of 20 indicators was applied in 60 facilities to verify cleanliness of surfaces, handwashing facilities, water and soap, protective clothing, equipment sanitation, waste management, protection of meat, inspection evidence, cold-chain conditions and hygienic transport. Semi-structured guides with 10 questions were used for KIIs and FGDs.

2.5 Outcome Measurement

The primary outcome was quality meat-hygiene handling. Each of the 13 practice items was scored from 4 (always) to 0 (never), non-applicable items were excluded from the denominator, and the total was converted to a percentage of the maximum applicable score. Good practice was defined a priori as a score of at least 80%, and scores below 80% were classified as suboptimal.

2.6 Validity, Reliability and Trustworthiness

Instruments were developed from the study objectives and conceptual framework and were reviewed by public health experts for content validity [17]. A pilot study was conducted among meat handlers in Ngoma District, and pilot participants were excluded from the main study. Internal consistency was assessed using Cronbach's alpha, with a coefficient of at least 0.70 considered acceptable [18]; the practice scale achieved an alpha of 0.83. Qualitative trustworthiness was addressed through credibility (triangulation across sources), transferability (description of the setting), dependability (an audit trail of coding decisions) and confirmability (reflexive notes and systematic coding).

2.7 Data Analysis

Quantitative data were analysed using SPSS version 25. Descriptive statistics were computed for all variables. Bivariable associations between each factor and good practice were examined using chi-square tests. Variables supported by the conceptual framework or associated with the outcome at the bivariable level were entered into a multivariable logistic regression model, and adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported. Statistical significance was set at $p < 0.05$, and multicollinearity and model fit were assessed before interpretation. Qualitative data were transcribed, coded and analysed thematically; codes were grouped into categories, sub-themes and themes aligned with the study objectives while allowing inductive themes to emerge. Observation data were summarised as percentages, and the three data sources were compared for convergence, complementarity or divergence.

2.8 Ethical Considerations

Ethical approval was obtained in accordance with Mount Kigali University requirements, and administrative permission was obtained from Kirehe District and participating facilities. Written informed consent was obtained from all participants, participation was voluntary, and participants could withdraw at any time without penalty. Study codes were used instead of names, and data were stored securely in line with Rwanda's Law No. 058/2021 on the protection of personal data and privacy [19].

3. Results

3.1 Characteristics of Respondents

All 423 targeted records were analysed. Most respondents were male (79.7%) and aged 26–35 years (36.4%) or 36–45 years (30.0%). Secondary education was the most common level (44.7%), and butchery workers formed the largest group (42.8%). More than two thirds (69.7%) had between one and ten years of meat-handling experience (Table 1 and Figure 3a).

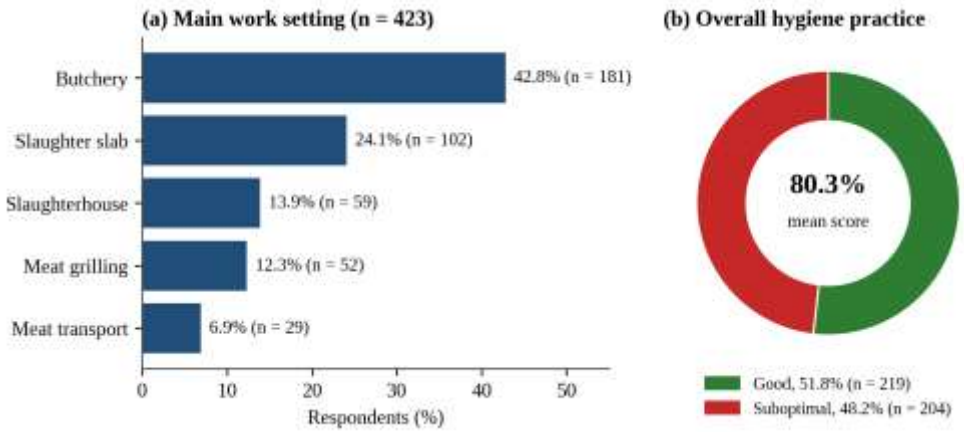
Table 1: Socio-Demographic and Work Characteristics of Respondents (n = 423)

Variable	Category	n	%
Age group (years)	18–25	80	18.9
	26–35	154	36.4
	36–45	127	30.0
	46 and above	62	14.7
Sex	Male	337	79.7
	Female	86	20.3
Education level	No formal education	35	8.3
	Primary	133	31.4
	Secondary	189	44.7
	University	66	15.6
Main work setting	Butchery	181	42.8
	Slaughter slab	102	24.1
	Slaughterhouse	59	13.9
	Meat grilling	52	12.3
	Meat transport	29	6.9
Meat-handling experience	Less than 1 year	64	15.1
	1–5 years	152	35.9
	6–10 years	143	33.8
	More than 10 years	64	15.1

3.2 Level of Meat-Hygiene Practice

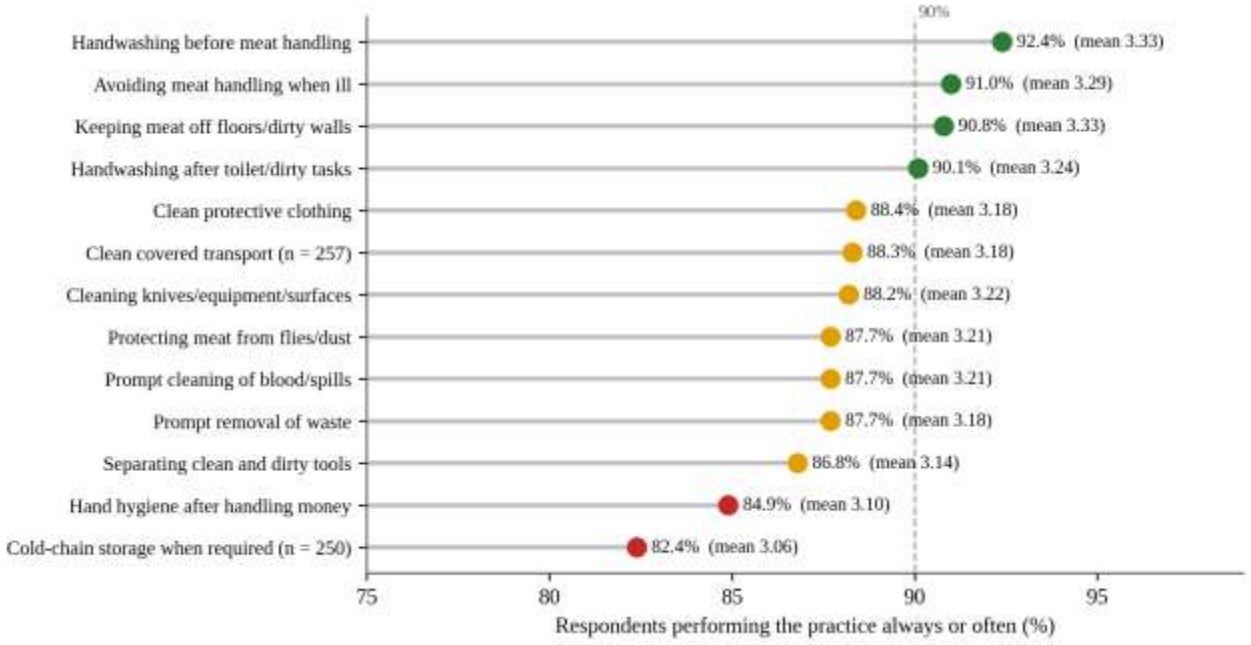
The mean meat-hygiene practice score was 80.3% (SD 9.7), with a median of 80.8%. Using the 80% threshold, 219 respondents (51.8%) had good practice and 204 (48.2%) had suboptimal practice (Figure 3b).

Figure 3: Respondents by Main Work Setting and Overall Meat-Hygiene Practice



Performance varied across individual practices (Figure 4). Handwashing before meat handling (92.4%), avoiding meat handling when ill (91.0%) and keeping meat off floors and dirty walls (90.8%) were most consistently performed. The least consistent practices were cold-chain storage when required (82.4%), hand hygiene after handling money or dirty objects (84.9%) and separation of clean and dirty tools (86.8%). This pattern indicates that the main challenge was sustained adherence across all tasks rather than complete absence of hygiene behaviour.

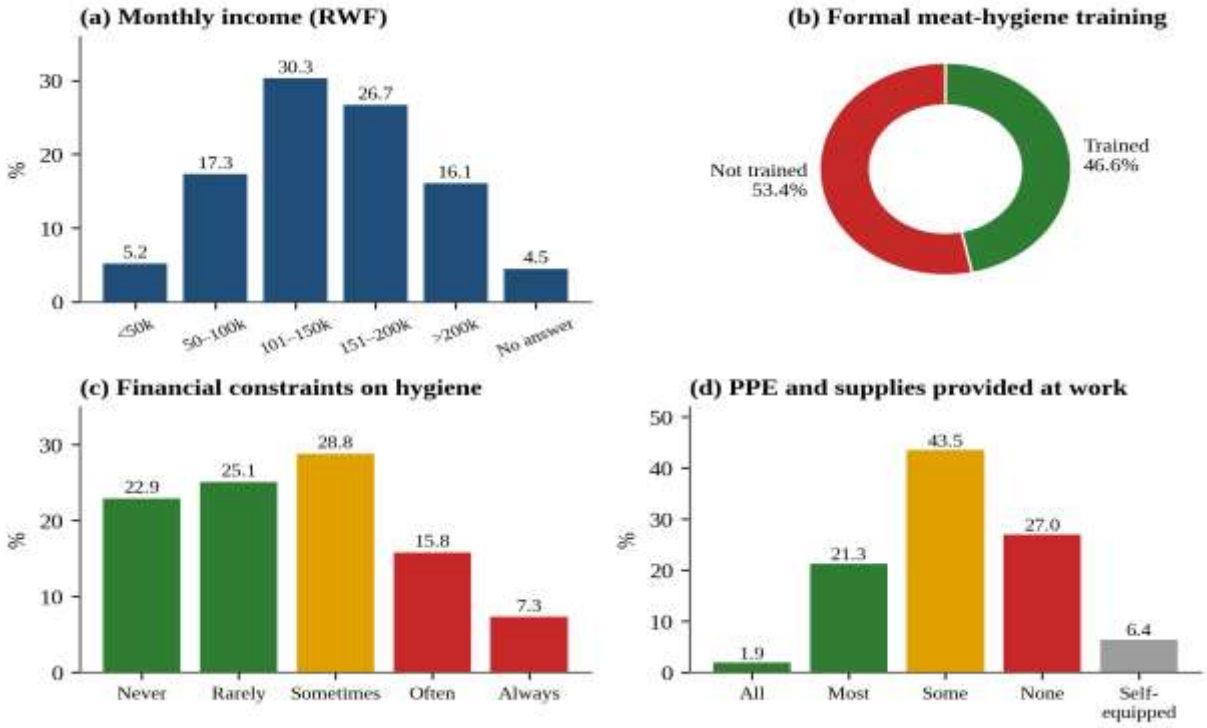
Figure 4: Performance on Individual Meat-Hygiene Practice Items



3.3 Socio-Economic Profile of Meat Handlers

Only 46.6% of respondents had received formal meat-hygiene or food-safety training. More than half (52.0%) reported financial constraints on hygiene at least sometimes, and only 23.2% reported that all or most of the required protective equipment and cleaning supplies were provided at the workplace. About one third (34.0%) reported that workload or staff shortage often or always prevented completion of hygiene procedures, and 31.7% were temporary or casual workers (Figure 5).

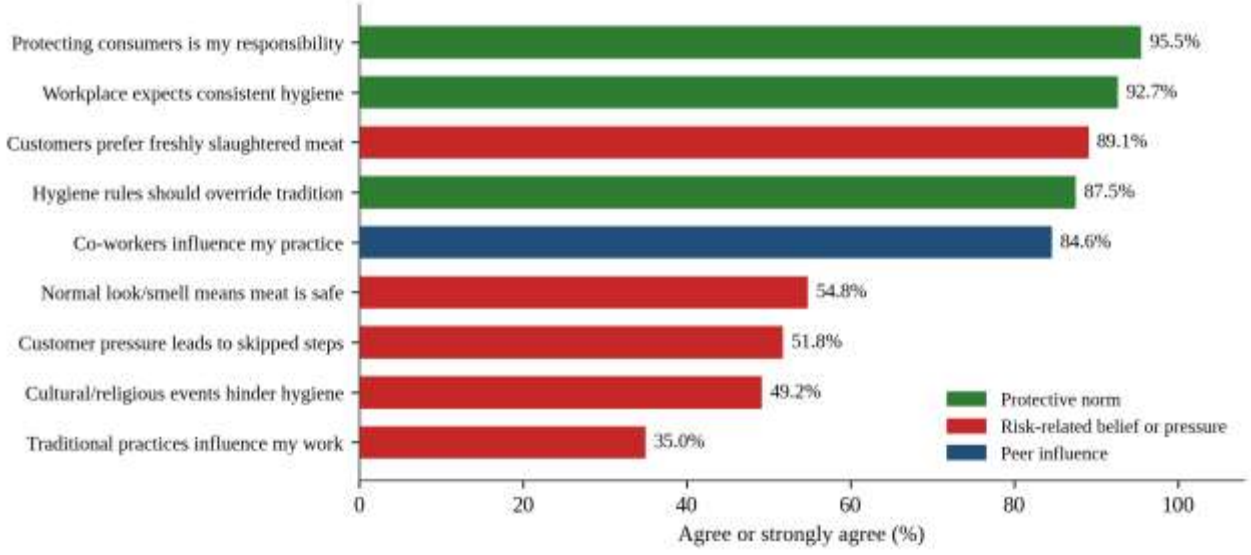
Figure 5: Socio-Economic Characteristics Related to Meat-Hygiene Handling



3.4 Socio-Cultural Beliefs and Norms

Protective workplace norms were widespread: 95.5% of respondents agreed that protecting consumers was a personal responsibility, and 92.7% reported that their workplace expected consistent hygiene. However, strong external pressures and risk-related beliefs were also common. Most respondents perceived a customer preference for freshly slaughtered meat (89.1%), and more than half agreed that meat that looked and smelled normal could be considered safe even when hygiene procedures had not been followed (54.8%) (Figure 6).

Figure 6: Socio-Cultural Beliefs, Norms and Perceived Pressures among Meat Handlers



3.5 Availability and Implementation of Safety Standard Protocols

Protocol availability was uneven and generally close to one half (Figure 7). Written standard operating procedures (SOPs) were reported by 49.9% of respondents, fully available personal protective equipment (PPE) by 45.6%, and an inspection by an authorised officer in the preceding 12 months by 50.1%. Only 49.2% of respondents for whom cold storage was applicable had access to a functional cold-storage facility. The most frequently reported barriers to compliance were customer pressure (40.9%), poor infrastructure (39.7%), lack of soap or disinfectant (37.4%) and weak supervision or inspection (37.1%) (Figure 8).

Figure 7: Self-Reported Availability and Implementation of Meat-Hygiene Safety Protocols

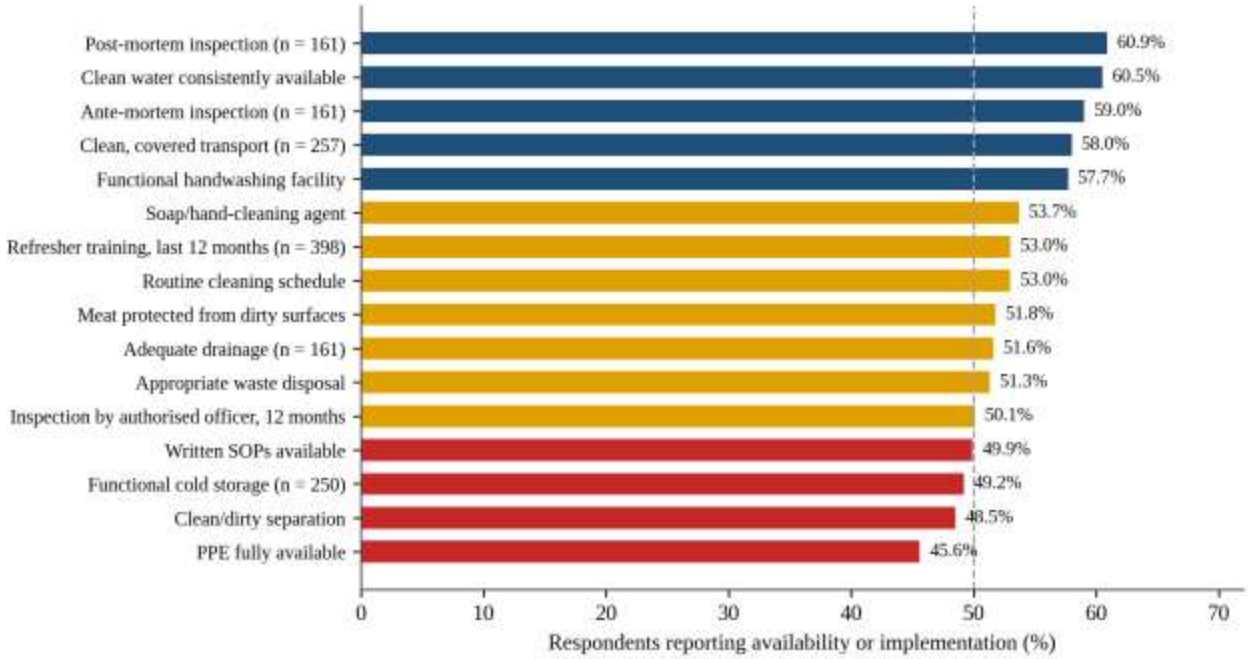
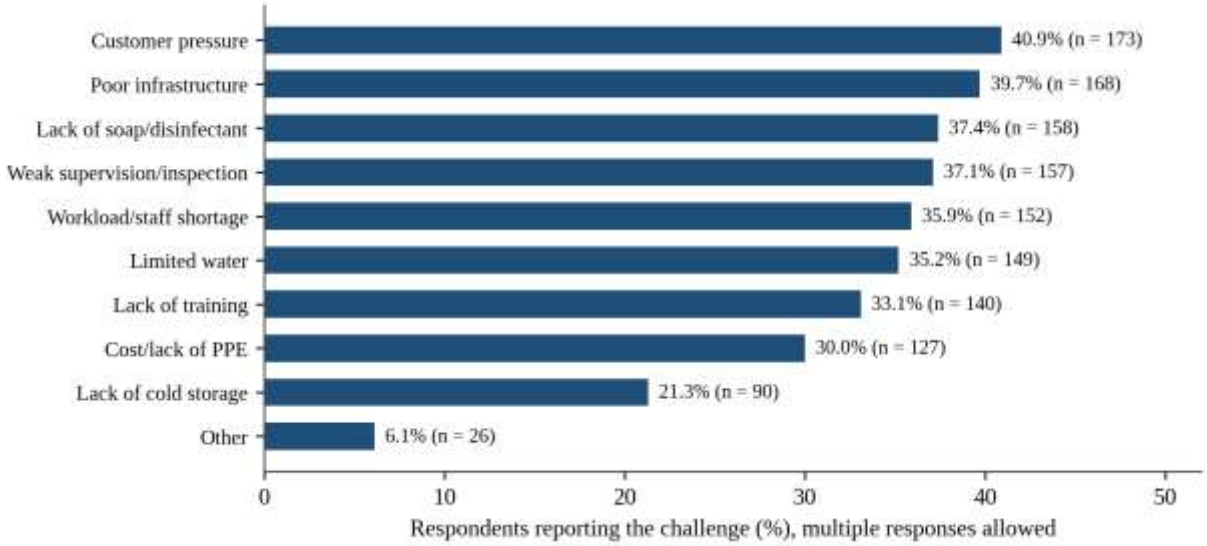


Figure 8: Reported Challenges to Following Meat-Hygiene Standards (n = 423)



3.6 Bivariable Analysis

At the bivariable level, education, income, formal training, financial constraints, provision of supplies and workload were significantly associated with good practice (Table 2). The largest difference was observed for formal training: 75.6% of trained handlers had good practice, compared with 31.0% of untrained handlers ($\chi^2 = 82.30$, $p < 0.001$). Good practice increased steadily with income and education and decreased sharply with financial constraints (Figure 9). Among socio-cultural variables, traditional influence, the sensory belief about meat safety, prioritising hygiene over tradition, workplace expectations and responsibility for consumer protection were significant, whereas perceived customer pressure was not ($p = 0.238$). Among protocol indicators, availability of soap, refresher training, recent inspection, appropriate waste disposal and protection of meat from dirty surfaces were significant, whereas written SOPs were not ($p = 0.526$).

Table 2: Bivariable Analysis of Factors Associated with Good Meat-Hygiene Practice (n = 423)

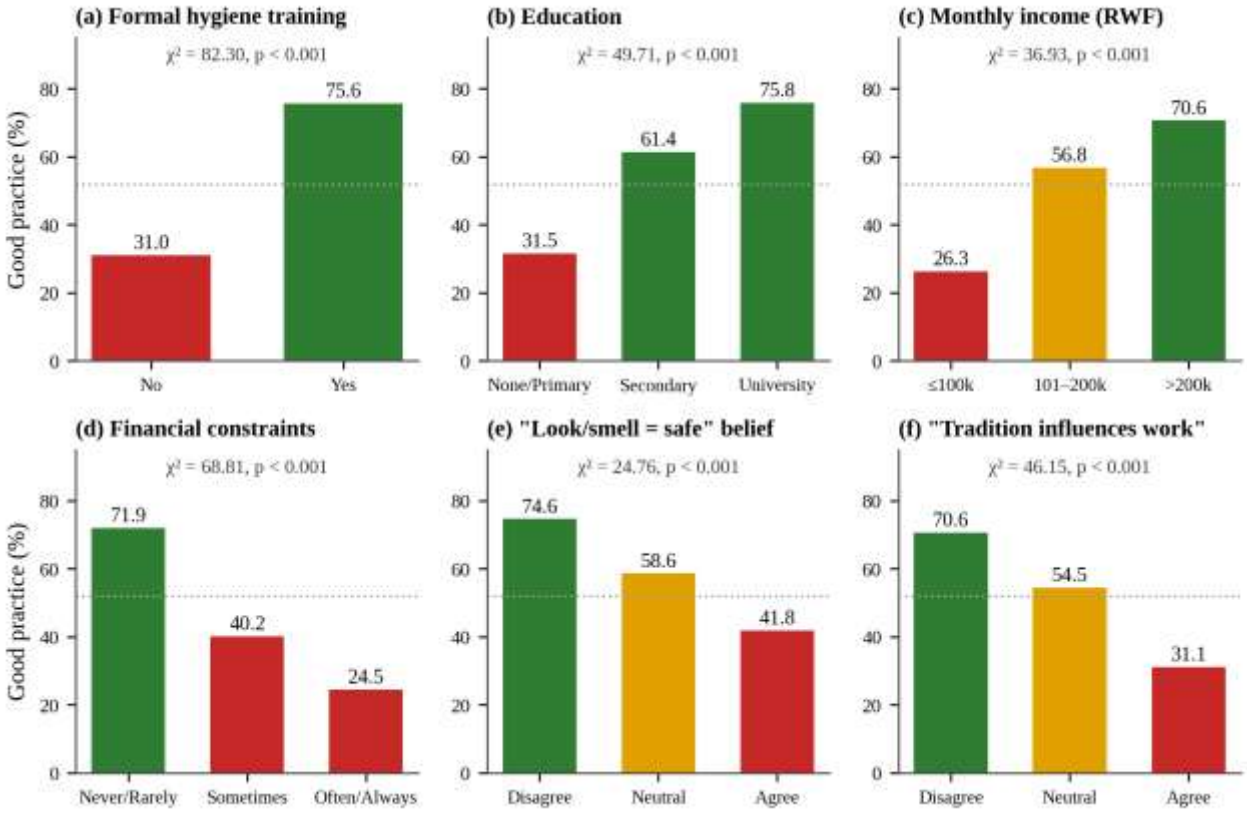
Variable	Category	Good n (%)	Suboptimal n (%)	χ^2	p-value
Socio-economic factors					
Education	No formal/Primary	53 (31.5)	115 (68.5)	49.71	**<0.001**
	Secondary	116 (61.4)	73 (38.6)		
	University	50 (75.8)	16 (24.2)		
Monthly income (RWF)	≤100,000	25 (26.3)	70 (73.7)	36.93	**<0.001**
	101,000–200,000	137 (56.8)	104 (43.2)		
	>200,000	48 (70.6)	20 (29.4)		
	Prefer not to say	9 (47.4)	10 (52.6)		
Formal hygiene training	No	70 (31.0)	156 (69.0)	82.30	**<0.001**
	Yes	149 (75.6)	48 (24.4)		
Financial constraints	Never/Rarely	146 (71.9)	57 (28.1)	68.81	**<0.001**
	Sometimes	49 (40.2)	73 (59.8)		
	Often/Always	24 (24.5)	74 (75.5)		
PPE/supplies provided	All/Most	73 (74.5)	25 (25.5)	30.58	**<0.001**
	Some	88 (47.8)	96 (52.2)		
	None	43 (37.7)	71 (62.3)		
	Self-equipped	15 (55.6)	12 (44.4)		
Working hours per day	<5 hours	50 (63.3)	29 (36.7)	5.18	0.075
	5–8 hours	147 (49.0)	153 (51.0)		
	>8 hours	22 (50.0)	22 (50.0)		
Workload barrier	Never/Rarely	86 (63.7)	49 (36.3)	11.65	**0.003**
	Sometimes	69 (47.9)	75 (52.1)		

Variable	Category	Good n (%)	Suboptimal n (%)	χ^2	p-value
	Often/Always	64 (44.4)	80 (55.6)		
Socio-cultural factors					
Traditional practices influence work	Disagree	101 (70.6)	42 (29.4)	46.15	**<0.001**
	Neutral	72 (54.5)	60 (45.5)		
	Agree	46 (31.1)	102 (68.9)		
Customer pressure causes skipped steps	Disagree	38 (60.3)	25 (39.7)	2.87	0.238
	Neutral	67 (47.5)	74 (52.5)		
	Agree	114 (52.1)	105 (47.9)		
Normal appearance/smell means safe	Disagree	47 (74.6)	16 (25.4)	24.76	**<0.001**
	Neutral	75 (58.6)	53 (41.4)		
	Agree	97 (41.8)	135 (58.2)		
Hygiene rules over tradition	Disagree	1 (33.3)	2 (66.7)	11.32	**0.003**
	Neutral	15 (30.0)	35 (70.0)		
	Agree	203 (54.9)	167 (45.1)		
Workplace expects compliance	Disagree	1 (50.0)	1 (50.0)	7.30	**0.026**
	Neutral	8 (27.6)	21 (72.4)		
	Agree	210 (53.6)	182 (46.4)		
Consumer protection is my responsibility	Neutral	2 (10.5)	17 (89.5)	11.88	**<0.001**
	Agree	217 (53.7)	187 (46.3)		
Safety-protocol indicators					
Written SOPs available	No	106 (50.0)	106 (50.0)	0.40	0.526
	Yes	113 (53.6)	98 (46.4)		
Refresher training, last 12 months	No	86 (46.0)	101 (54.0)	9.13	**0.010**
	Do not know	9 (36.0)	16 (64.0)		
	Yes	124 (58.8)	87 (41.2)		
Clean water available	No	78 (46.7)	89 (53.3)	2.51	0.113
	Yes	141 (55.1)	115 (44.9)		
Soap/hand-cleaning agent available	No	83 (42.3)	113 (57.7)	12.30	**<0.001**
	Yes	136 (59.9)	91 (40.1)		
Routine cleaning schedule	No	95 (47.7)	104 (52.3)	2.15	0.142
	Yes	124 (55.4)	100 (44.6)		
Appropriate waste system	No	95 (46.1)	111 (53.9)	4.71	**0.030**
	Yes	124 (57.1)	93 (42.9)		

Variable	Category	Good n (%)	Suboptimal n (%)	χ^2	p-value
Meat protected from dirty surfaces	No	94 (46.1)	110 (53.9)	4.69	**0.030**
	Yes	125 (57.1)	94 (42.9)		
Inspection, last 12 months	No	94 (44.5)	117 (55.5)	8.23	**0.004**
	Yes	125 (59.0)	87 (41.0)		

Note: p-values in bold are statistically significant at $p < 0.05$.

Figure 9: Proportion of Meat Handlers with Good Practice by Key Factors (Dotted Line Shows the Overall 51.8%)



3.7 Multivariable Logistic Regression

In the adjusted model (Table 3 and Figure 10), formal meat-hygiene training was the strongest independent predictor of good practice (AOR = 4.01, 95% CI: 2.10–7.65), followed by monthly income of at least RWF 151,000 (AOR = 3.70, 95% CI: 2.00–6.83), secondary or university education (AOR = 2.88, 95% CI: 1.65–5.03) and stronger endorsement of consumer protection as a personal responsibility (AOR = 2.79 per Likert point, 95% CI: 1.53–5.08). Each one-category increase in financial constraints reduced the odds of good practice by about 38% (AOR = 0.62, 95% CI: 0.48–0.81), and each one-category increase in workload barriers reduced the odds by about 34% (AOR = 0.66, 95% CI: 0.51–0.85). Stronger agreement that normal appearance or smell indicates safe meat was associated with 43% lower odds of good practice per Likert point (AOR = 0.57, 95% CI: 0.42–0.76). Refresher training, recent inspection and soap

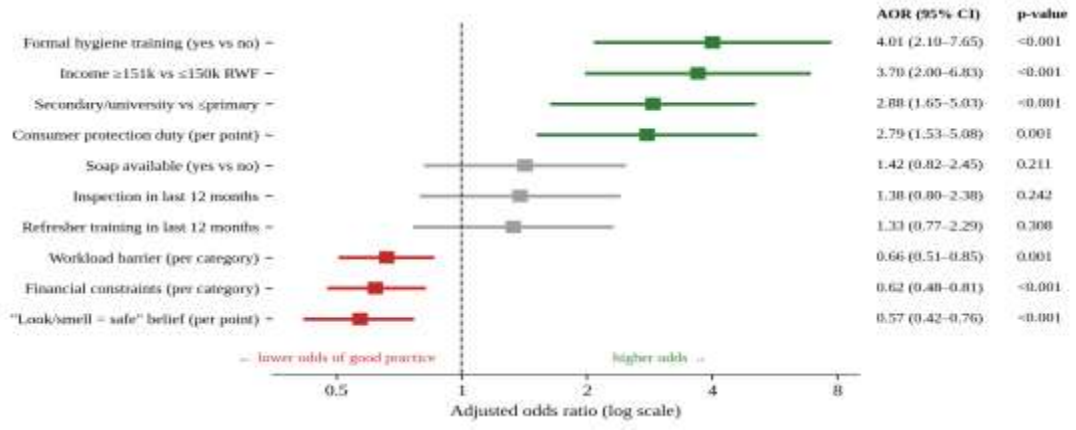
availability remained positively associated with good practice but did not reach statistical significance after adjustment.

Table 3: Multivariable Logistic Regression of Factors Independently Associated with Good Meat-Hygiene Practice

Variable	Category or unit	AOR (95% CI)	p-value
Education	No formal/Primary (ref.)	1.00	–
	Secondary/University	**2.88 (1.65–5.03)**	**<0.001**
Monthly income	≤150,000 RWF (ref.)	1.00	–
	≥151,000 RWF	**3.70 (2.00–6.83)**	**<0.001**
Formal hygiene training	No (ref.)	1.00	–
	Yes	**4.01 (2.10–7.65)**	**<0.001**
Financial constraints	Per one-category increase	**0.62 (0.48–0.81)**	**<0.001**
Workload/staff shortage barrier	Per one-category increase	**0.66 (0.51–0.85)**	**0.001**
Appearance/smell perceived as evidence of safety	Per Likert-point increase	**0.57 (0.42–0.76)**	**<0.001**
Consumer protection as personal responsibility	Per Likert-point increase	**2.79 (1.53–5.08)**	**0.001**
Refresher training, last 12 months	No/Do not know (ref.)	1.00	–
	Yes	1.33 (0.77–2.29)	0.308
Inspection, last 12 months	No (ref.)	1.00	–
	Yes	1.38 (0.80–2.38)	0.242
Soap/hand-cleaning agent available	No (ref.)	1.00	–
	Yes	1.42 (0.82–2.45)	0.211

Note: AOR = adjusted odds ratio; CI = confidence interval; ref. = reference category. Values in bold are statistically significant at $p < 0.05$.

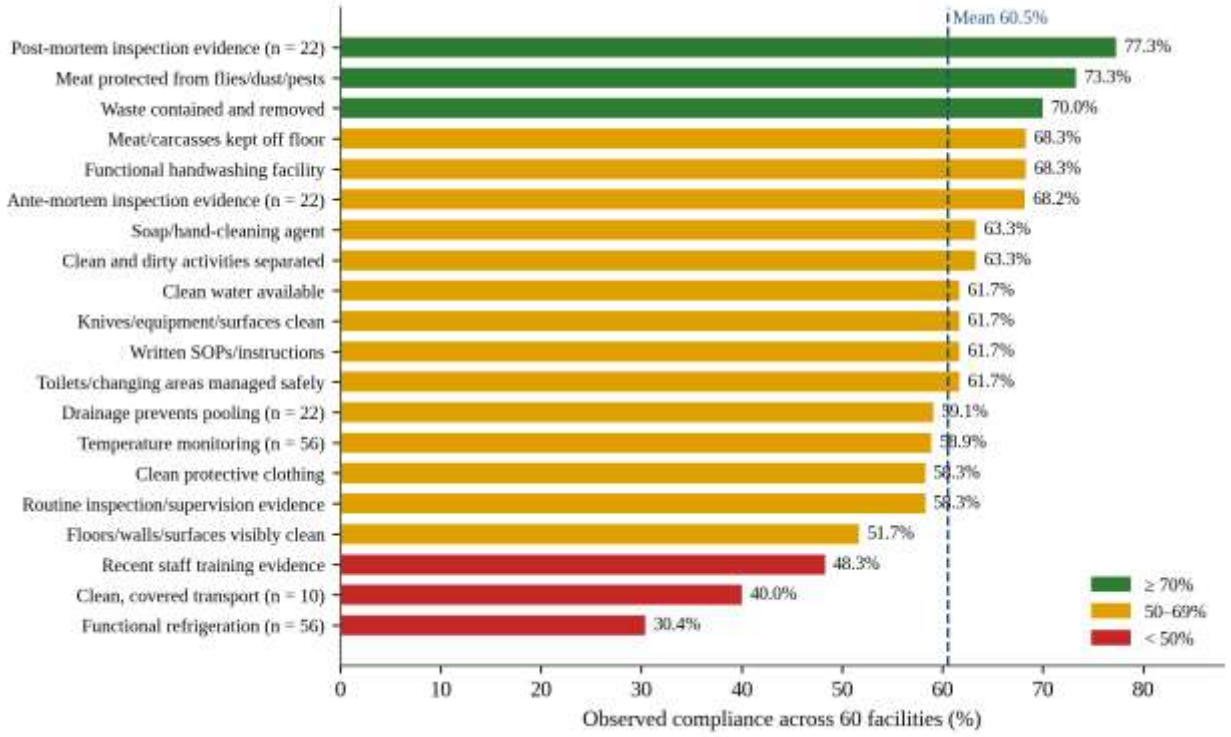
Figure 10: Forest Plot of Adjusted Odds Ratios for Good Meat-Hygiene Practice



3.8 Structured Observation of Facilities

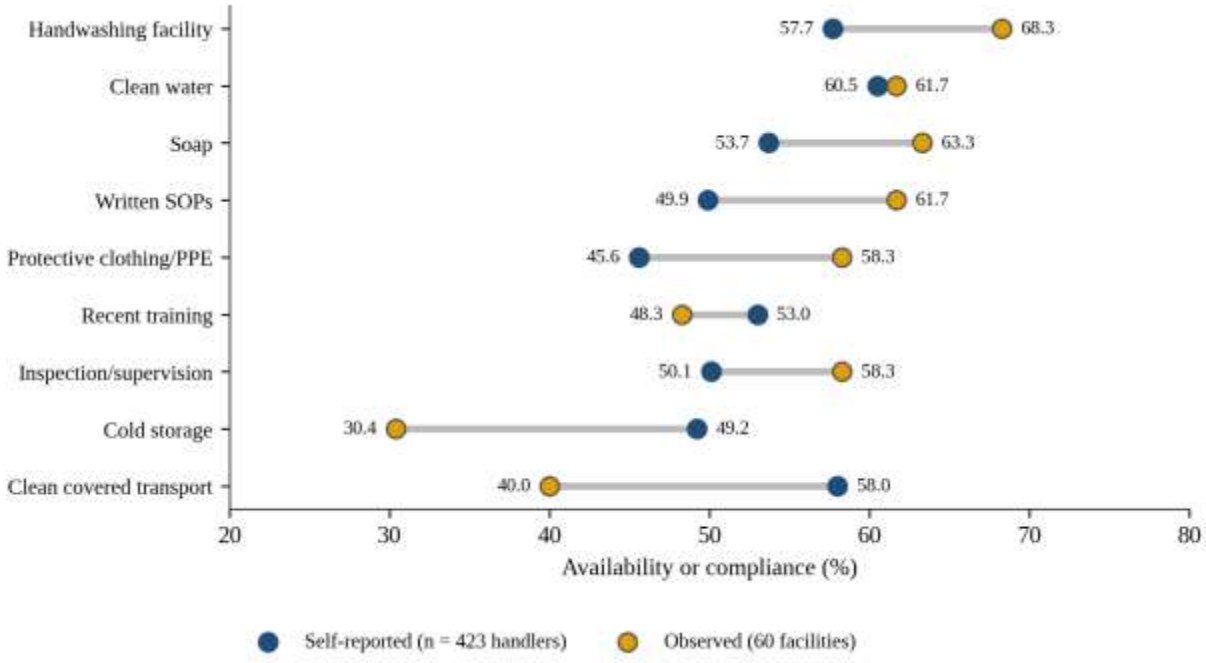
Mean observed compliance across the 20 checklist indicators in 60 facilities was 60.5% (Figure 11). The highest compliance was observed for post-mortem inspection evidence (77.3% of applicable slaughter facilities), protection of meat from flies, dust and pests (73.3%) and containment and removal of waste (70.0%). The lowest compliance was observed for functional refrigeration where required (30.4%), clean and covered transport (40.0%) and evidence of recent staff hygiene training (48.3%). Visible routine sanitation was therefore implemented more consistently than infrastructure-intensive and documentation-dependent requirements.

Figure 11: Observed Compliance with Meat-Hygiene Indicators in 60 Facilities



Comparison of self-reported and observed indicators (Figure 12) showed that basic facilities such as handwashing stations, soap and written SOPs were observed more often than they were reported by individual handlers, whereas cold storage, covered transport and training were reported more often than they were observed. Because the questionnaire measured individual access and the checklist measured facility conditions, the two sources were interpreted as complementary rather than identical measures.

Figure 12: Comparison of Self-Reported and Observed Availability of Selected Protocols



3.9 Qualitative Findings

Thematic analysis of KII and FGD data produced eight related themes: socio-economic barriers, socio-cultural influences, protective norms, safety protocols, implementation gaps, governance and enforcement, behaviour-change needs and practical solutions (Figure 13). Participants described hygiene as partly dependent on whether workers and facilities could afford protective clothing, soap and disinfectant, and on whether staffing allowed all steps to be completed during busy periods. Customer preference for same-day meat and reliance on colour, smell and appearance were described as reasons why invisible contamination could be underestimated and refrigeration avoided. Participants also described inspection as uneven across facilities, with some sites visited mainly after complaints or campaigns, and favoured combining practical refresher training with minimum facility requirements. Illustrative statements are summarised in Table 4.

Figure 13: Thematic Map of Qualitative Findings

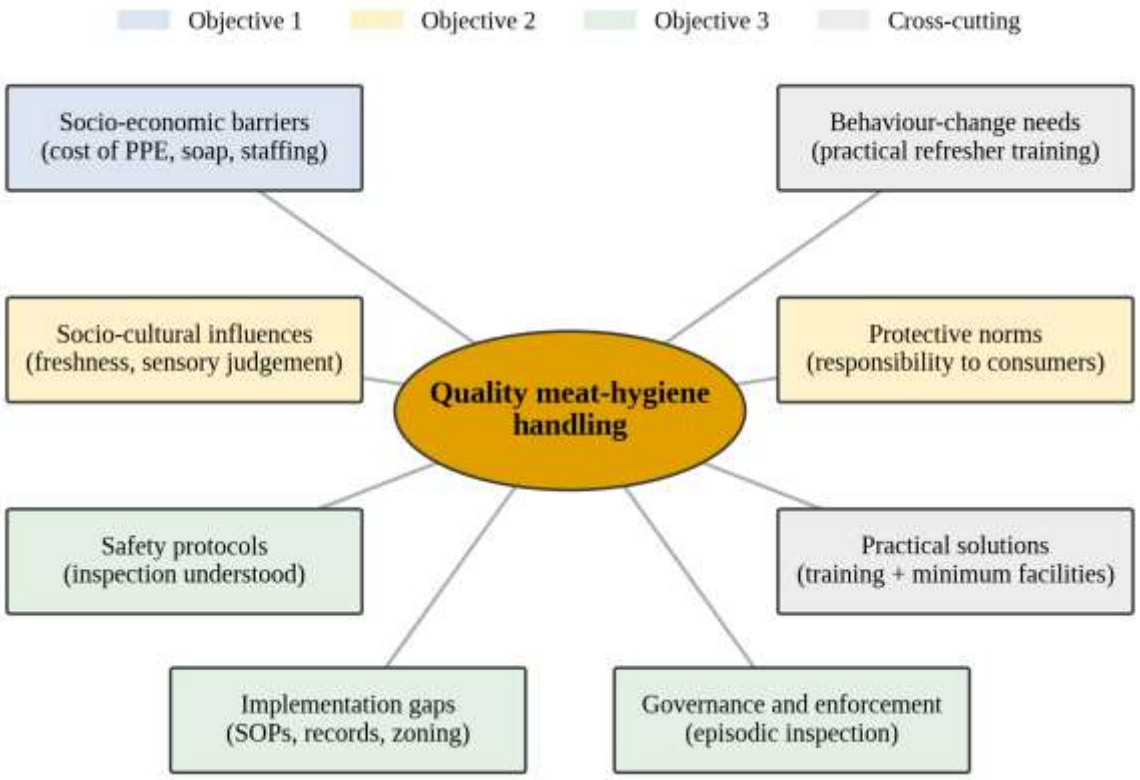


Table 4: Summary of Qualitative Themes with Illustrative Statements

Theme	Sub-theme	Source	Illustrative statement
Socio-economic barriers	Affordability of hygiene inputs	FGD-01, meat handlers	"When money is short, soap, disinfectant and protective clothing are the first items to be reduced."
Socio-economic barriers	Workload and staffing	KII-04, butchery manager	"Long working hours and too few staff make it difficult to follow every hygiene step during busy periods."
Socio-cultural influences	Fresh-meat preference	KII-05, sector veterinary officer	"Many customers equate freshness with safety and prefer meat slaughtered the same day. This can discourage cold storage."
Socio-cultural influences	Invisible contamination risk	FGD-03, meat handlers	"If it looks normal, they may underestimate contamination that cannot be seen."
Governance and enforcement	Uneven inspection frequency	KII-11, veterinary officer	"Some places receive regular visits while others are mainly visited when there is a complaint or a specific campaign."

Theme	Sub-theme	Source	Illustrative statement
Implementation gaps	Documentation and zoning	KII-12, meat inspector	"Written SOPs, records and clear separation of clean and dirty zones are inconsistent."
Practical solutions	Training plus infrastructure	KII-09, local authority representative	"Regular practical training should be combined with minimum facility requirements for water, soap, PPE and waste management."

3.10 Triangulation of Findings

The three data sources converged on four of the five domains examined (Table 5). The quantitative effects of training, financial constraints, workload and sensory beliefs were supported by qualitative explanations and by observed gaps in training evidence, cold storage and supplies. For safety protocols, the sources were complementary: the survey described coverage, the observation described facility compliance and the interviews explained why implementation was uneven.

Table 5: Joint Display of Quantitative, Observational and Qualitative Findings

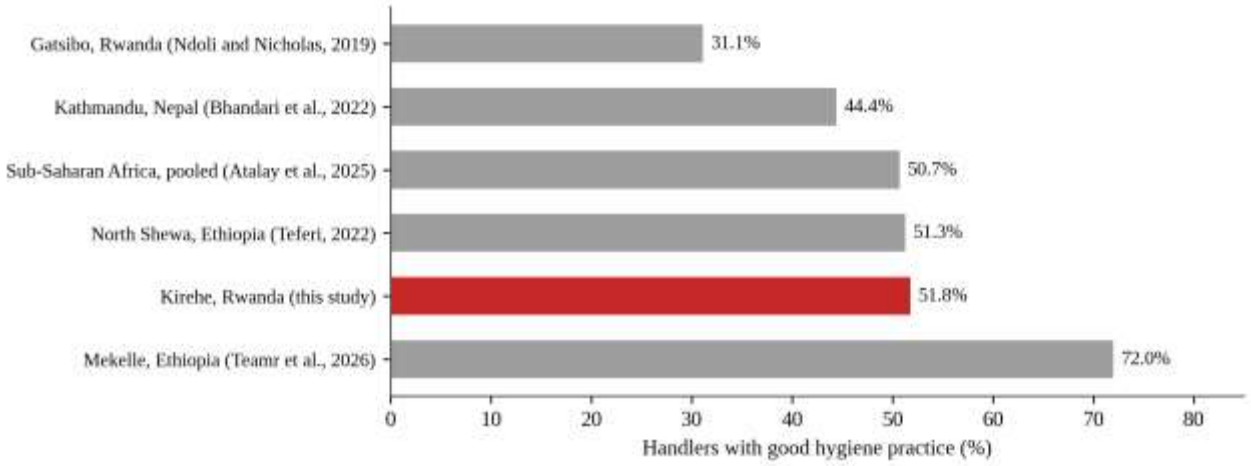
Domain	Survey (n = 423)	Observation (n = 60)	KIIs and FGDs	Meta-inference
Training	46.6% trained; AOR 4.01	Training evidence in 48.3% of facilities	Practical refresher training requested	Convergent
Resources	Financial constraints AOR 0.62; 76.8% lacked all or most supplies	Soap observed in 63.3%; protective clothing in 58.3%	Soap, disinfectant and PPE reduced first when money is short	Convergent
Workload	Workload barrier AOR 0.66; 34.0% often or always affected	Surfaces visibly clean in 51.7%	Busy periods with few staff lead to skipped steps	Convergent
Beliefs	54.8% endorse sensory belief; AOR 0.57	Functional refrigeration in 30.4%	Freshness equated with safety; refrigeration avoided	Convergent
Protocols	SOPs 49.9%; inspection 50.1%	Mean compliance 60.5%	Inspection episodic; records inconsistent	Complementary

4. Discussion

This study found that slightly more than half (51.8%) of meat handlers in Kirehe District achieved good meat-hygiene practice. This level is similar to the pooled estimate of 50.68% for food handlers in sub-Saharan Africa [8] and to the 51.3% reported among butchers in North Shewa, Ethiopia [11], higher than the 44.4% reported in Kathmandu, Nepal [10] and the 31.1% reported in Gatsibo District, Rwanda [9], and lower than the 71.98% reported among retail meat handlers in Mekelle, Ethiopia [20] (Figure 14).

Differences in cut-off points and measurement tools limit direct comparison, but the overall pattern indicates that inconsistent hygiene practice is common across low-resource settings.

Figure 14: Proportion of Handlers with Good Hygiene Practice in This and Comparable Studies



Formal meat-hygiene training was the strongest independent predictor of good practice. This is consistent with Al Banna et al. (2021), who linked food-safety practice among meat handlers in Bangladesh to training and education [21], and with the sub-Saharan African meta-analysis, which identified lack of food-safety training as a factor associated with poor hygiene practice [8]. The qualitative data add that one-off instruction was considered insufficient and that practical, repeated refresher training was preferred, while observation showed documented training in fewer than half of facilities.

Education and income were also independently associated with good practice. The educational effect (AOR = 2.88) closely matches the effect reported in Kathmandu (AOR = 2.8) [10], and education was also a strong predictor in North Shewa [11]. Education may improve understanding of invisible contamination risk, whereas income may increase the capacity to obtain protective clothing, soap and disinfectant. Conversely, financial constraints and workload barriers reduced the odds of good practice. These findings are consistent with the resource and infrastructure constraints described among meat and milk value-chain actors in Ethiopia [22] and can be interpreted through the Theory of Planned Behavior: even motivated workers have limited perceived behavioural control when supplies, staff and time are inadequate [14].

The socio-cultural findings show that beliefs about what makes meat "safe" can either support or undermine hygiene. The belief that normal-looking and normal-smelling meat is safe was endorsed by more than half of respondents and independently reduced the odds of good practice. This is consistent with evidence from Nairobi that consumers judge animal-source foods mainly by freshness and appearance [23] and, in Health Belief Model terms, reflects low perceived susceptibility to invisible hazards [13]. In contrast, a strong sense of responsibility for consumer protection was associated with nearly three times the odds of good practice, suggesting that professional identity is a food-safety culture asset that interventions can build on [16].

Safety-protocol implementation was incomplete. About half of handlers reported written SOPs, full PPE, cold storage or recent inspection, and observation confirmed large gaps in refrigeration, covered transport and training records. The absence of an association between written SOPs and good practice, and the loss

of significance for soap, inspection and refresher training after adjustment, suggest that protocols are effective only when they are supported by resources, capacity and supervision. These findings align with calls for structured food-safety programmes in slaughterhouses [24] and for stronger water, sanitation and hygiene infrastructure in Africa [25], and with recent evidence that contamination of knives and hands is high where handwashing, disinfection and refrigeration are lacking [4]. Consistent with the Ecological Model [15], no single intervention is likely to be sufficient.

4.1 Strengths and Limitations

The main strength of this study is the integration of a large stratified survey, facility observation and qualitative inquiry, which allowed self-reported associations to be verified and explained. The adjusted model also examined socio-economic, socio-cultural and protocol factors together. Several limitations should be noted. The cross-sectional design does not allow causal inference. Self-reported practice may be affected by social desirability bias, although observation was used to reduce this risk. Microbiological testing was not performed, so hygiene practice was used as a proxy for meat safety. Some observation subgroups, particularly meat transport (n = 10), were small and should be interpreted with caution.

5. Conclusion

Quality meat-hygiene handling in Kirehe District is the product of interacting individual, economic, cultural, workplace and regulatory conditions rather than knowledge alone. Training, education and adequate income support good practice, whereas financial strain, workload and the belief that normal-looking meat is safe undermine it. Safety protocols exist but are inconsistently implemented, particularly for refrigeration, transport and documented training.

6. Recommendations

- Kirehe District veterinary and public-health authorities should introduce risk-based, documented inspection with corrective follow-up and regular practical refresher training that reaches new and casual workers.
- Facility owners and managers should ensure continuous availability of water, soap, PPE and disinfectants, display SOPs, separate clean and dirty zones and provide adequate staffing and cold storage.
- National regulatory institutions should set realistic minimum standards for small rural outlets and support affordable access to hygiene inputs through cooperatives or phased compliance.
- Community risk communication should emphasise that fresh-looking meat can still be contaminated and requires hygienic handling and refrigeration.
- Future studies should combine behavioural assessment with microbiological testing and evaluate the effect of combined interventions.

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