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Assessment of stakeholders' knowledge, attitude, and practice in cattle production and supply chain on antimicrobial usage in Kilosa District, Morogoro

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Abstract

Antimicrobial drugs play fundamental roles such as prophylaxis, treatment, and growth promotion in the animal husbandry. The inappropriate use of antimicrobials in livestock production has resulted in a global burden of antimicrobial residues and antimicrobial resistance in humans. The study was conducted to assess the knowledge, attitude, and practice of stakeholders on the use of antimicrobial drugs in livestock production. A cross-sectional study based on a semi-structured questionnaire was conducted to determine the awareness of stakeholders (N = 310) on antimicrobial usage in Kilosa district, Tanzania. Stakeholders were selected using multi-stage stratified random sampling. Data were analyzed using SPSS software, employing descriptive statistics, the Kruskal-Wallis test, the Manny-Whitney U-test, and Spearman rank correlations. Results showed that most stakeholders had a low level of knowledge, with a mean score of 3.4±1.9, while livestock officers exhibited higher knowledge with a mean score of 6.7±0.5 compared to other stakeholders. Knowledge scores were significantly influenced by gender and education ($p<0.05$). Stakeholders generally demonstrated negative attitudes towards antimicrobial usage, with a mean score of 5.5±1.7, except for livestock officers and cattle keepers, who had positive attitudes of 8.7±0.7 and 9.4±2.0, respectively. Consumers and butchers showed negative attitudes, with scores of 6.1±1.4 and 4.0±1.3, respectively. Attitudes were significantly influenced by gender, age, and marital status ($p<0.05$). Poor practices were also revealed among stakeholders, with a mean score of 4.4±1.5, whereas livestock officers demonstrated good practices with a mean score of 16.0±1.4. Practice scores were significantly influenced by age, gender, and education ($p<0.05$). Significant associations between knowledge, attitude, and practice scores across stakeholder groups were found ($p<0.05$), with post hoc analysis confirming statistically significant differences ($p<0.05$). The majority of stakeholders exhibited low knowledge, negative attitudes, and poor practices regarding antimicrobial usage. Implement education programs to enhance stakeholder knowledge and practices.

Keywords: *Antimicrobial usage; Stakeholders; Knowledge; Attitude; Practice; Kilosa*

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Introduction

Antimicrobials are drugs used for prevention and treatment of infectious diseases in humans, animals, and plants (Barton, 2000; Kimera *et al.*, 2020; Muhammad *et al.*, 2020). However, the inappropriate use of antimicrobials by livestock owners and pastoralists in livestock production may lead to a global burden of antimicrobial residues and antimicrobial resistance on humans (Selection *et al.*, 2014; Katakweba *et al.,* 2018; Olasoju *et al.,* 2021). Additionally, unregulated and uninformed use of antimicrobials, such as a lack of understanding regarding their proper course, side effects, standard dosages, and the risks of overdose, can lead to incorrect treatments or misdiagnoses, contributing to antimicrobial resistance (AMR). Additionally, factors like limited public awareness, poverty, and inadequate access to veterinary services have been linked to improper antimicrobial use (Michael *et al.,* 2014).

Globally, a report by the European Food Safety Authority (EFSA) indicated that while European consumers were aware of antimicrobial residues and antimicrobial resistance, their understanding of antimicrobial usage in farming was low (Etienne *et al.*, 2017). Previous studies reported that consumers had limited knowledge of diseases facing livestock and antimicrobial use for therapy and prophylaxis (Goddard *et al.*, 2017; Clark *et al.,* 2019). Most consumers believe that antimicrobial usage in livestock is necessary if authorized by veterinarians for productivity, animal welfare, and food quality (Meeusen *et al.*, 2014). Concerns and intentions regarding antimicrobial usage vary by country: Dutch consumers are less concerned about antimicrobial usage (Meeusen *et al.,* 2014), and about a third of United States consumers reported avoiding purchasing antimicrobial-treated foods despite Food and Drug Administration (FDA) approval (Brewer and Rojas, 2008). These differences likely reflect varying levels of regulation, policy education, consumer awareness, and knowledge.

In developing countries, the misuse of antimicrobials is impaired by their easy availability without prescription, weak regulatory frameworks (Byarugaba, 2004; Gebeyehu *et al.,* 2021), and the preference for retail pharmacies as the first point of care, leading to widespread self-medication (Kwena *et al.,* 2008; Shah *et al.,* 2019). The quality of antimicrobials dispensed in these settings is often questionable, and one-third of the population lacks adequate knowledge about their proper use (Katakweba *et al.,* 2012). Contributing factors to antimicrobial resistance (AMR) in developing countries include limited access to appropriate treatments, weak regulation and surveillance of antimicrobial use (AMU), outdated treatment guidelines, and insufficient continuing education for healthcare providers. Additionally, in animal production and aquaculture, there is a lack of regulatory oversight, with antimicrobials often misused by unskilled individuals, leading to improper dosing, administration, and drug combinations (Karimuribo *et al.,* 2005). Livestock keepers also face challenges due to limited knowledge about AMR and improper waste disposal practices (Mmbando, 2004; Caudell *et al.,* 2017). These issues are compounded by the diminishing development of new antimicrobials, increasing the risk of untreatable infections, particularly in resource-limited settings.

In Tanzania, it has been reported that poor practices regarding antimicrobial use lead to the development of antimicrobial resistance (Karimuribo *et al.,* 2005; Katakweba *et al.,* 2012). This is due to the increased tendency of livestock owners to poorly store drugs in their homes and use unskilled people, such as farmers themselves and animal attendants, to treat the animals. (Gemeda *et al.,* 2020). Al Amin *et al.* (2020) reported that misuse of antimicrobial drugs in the livestock sector is driven by inadequate veterinary healthcare facilities, substandard sanitary conditions, informal veterinary practices, insufficient regulatory surveillance, high disease incidence, and farmers' lack of knowledge about antimicrobial resistance. Additionally, several studies reported a lack of awareness among the communities and farmers regarding antimicrobial usage (Mgonja *et al.,* 2018; Sindato *et al.,* 2020; Geta and Kibret, 2021). Despite several studies conducted to assess the farmer's and communities' awareness of the use of antimicrobials, the levels of knowledge, attitudes, and practices among the key

stakeholders in the meat value chain are largely lacking in Tanzania. Therefore, this study aimed to assess the knowledge, attitude, and practices of livestock officers, cattle keepers, butchers owners, and consumers regarding the use of antimicrobials in Kilosa district, Morogoro.

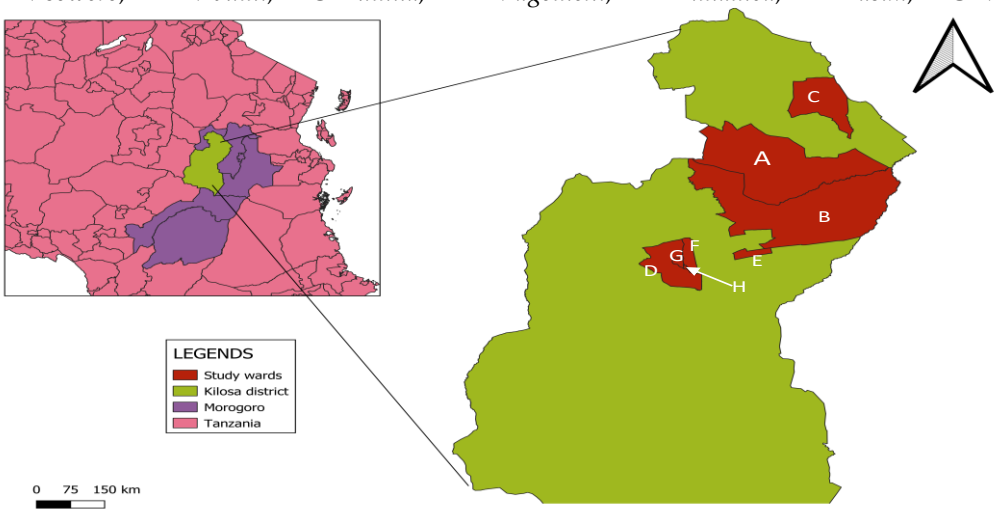
Material and Methods

Study area

The study was conducted in Kilosa district (5°55′–7°53′S, 36°30′–37°30′E), which is located in the Morogoro region (with a population density of 31 per square kilometer), in Eastern Tanzania and is about 300km south of Dar es Salaam. Morogoro region is a livestock production area with many cattle stakeholders (cattle keepers, butcher owners, livestock officers, and consumers). Eight wards (Dumila, Msowero, Mvumi, Kimamba, Magomeni, Kasiki, Mbumi, and Mkwatani) out of 37 in Kilosa district were selected for this study due to their high population of livestock keepers and the presence of more than four livestock markets (Katakweba *et al.*, 2012).
[Figure 1]

Figure 1

A map showing the areas where the study was conducted in Kilosa district, involving 8 wards represented by letters: A-Msowero, B-Mvumi, C-Dumila, D-Magomeni, E-Kimamba, F-Kasiki, G-Mkwatani, H-Mbumi



Study design and sampling procedure

This cross-sectional community-based study, conducted between January and June 2024, the selection procedure involved multiple stages. Initially, wards were purposively selected based on their relevance to cattle production, with eight wards chosen using probability proportional to the human population size. Within these selected wards, households were randomly chosen from a sampling frame provided by the ward office. Livestock officers and butchers were purposively selected due to their key roles in antimicrobial use. Additionally, cattle keepers and consumers were randomly selected from within the sampled households. The sampling frame for households was a comprehensive list from the ward office, while the frames for livestock officers and butchers were identified through local professional directories and industry contacts. The sample size was determined using the formula $N = Z^2p\ (1\text{-}p)/d^2$ by Israel (1992), with a minimum of 296 participants required to achieve a relative precision of 5% with a 95% confidence interval for a finite population (Sindato *et al.*, 2020), assuming a 5% dropout or refusal rate, the

resulting minimum sample size of 310 was estimated to be sufficient for the study.

Data collection

A semi-structured questionnaire was used for data collection for the four groups of stakeholders: cattle keepers, butchers' owners, livestock officers, and consumers. The socio-demographic profiles, such as gender, age, education, and marital status, were assessed together with the knowledge, attitude, and practices. A questionnaire was administered to stakeholders to assess their knowledge, attitude, and practice of antimicrobial usage. A total of 18 questions explored knowledge from different stakeholders; 14 questions focused on attitude; and 21 questions addressed practices towards antimicrobial use from different stakeholders. Questionnaires were pre-tested on 10% of the study population, but their data were not used in the final analysis to validate the instrument. Based on the pilot survey and feedback from various sources, the contents of the data collection tools were slightly modified to ensure that the questionnaire effectively captured the knowledge, attitudes, and practices of stakeholders regarding antimicrobial usage. Before being administered to the final study population.

Table 1 presents a summary of the scoring criteria used to evaluate the knowledge, attitudes, and practices related to antimicrobial usage among different stakeholder groups, including consumers, livestock officers, butchers, and cattle keepers. The scoring thresholds are based on their responses to tailored sets of questions, with clear cut-off points distinguishing between low and high knowledge, negative and positive attitudes, and poor and good practices (ul Haq *et al.,* 2012; Wangmo *et al.,* 2021).

Table 1

Scoring system for assessing antimicrobial usage knowledge, attitude and practices (KAP) among stakeholders

Stakeholder Group	Aspect	Number of Questions	Score Range	Interpretation
Consumers	Knowledge	11	≤6.0	Low Knowledge
			≥7.0	High Knowledge
	Attitude	4	≤8.0	Negative Attitude
			≥9.0	Positive Attitude
	Practice	12	≤6.0	Poor Practice
			≥ 7.0	Good Practice
Livestock Officers	Knowledge	8	< 4.0	Low Knowledge
			≥ 5.0	High Knowledge
	Attitude	4	≤ 8.0	Negative Attitude
			≥ 9.0	Positive Attitude
	Practice	27	≤ 14	Poor Practice
			≥ 15	Good Practice
Butchers owners	Knowledge	9	≤ 5.0	Low Knowledge
			≥ 6.0	High Knowledge
	Attitude	3	≤ 4.0	Negative Attitude
			≥ 5.0	Positive Attitude
	Practice	8	< 4.0	Poor Practice
			≥ 5.0	Good Practice
Cattle Keepers	Knowledge	13	≤ 7.0	Low Knowledge
			≥ 8.0	High Knowledge
	Attitude	3	≤ 4.0	Negative Attitude
			≥ 5.0	Positive Attitude
	Practice	14	≤ 7.0	Poor Practice
			≥ 8.0	Good Practice

Data management and analysis

Assessments of knowledge, attitudes, and practice questions were performed using a scoring system. For knowledge and practice scores, correct responses were designated as YES with a score of 1, incorrect responses as NO with a score of 0, and "I don't know" responses scored 0. Multiple responses to each of the correct options were given correct scores, while no scores were assigned for other responses (Shah *et al.*, 2019). Attitude scores were calculated by using a 4-point Likert scale ranging from 1 to 4 (strongly agree = 4, agree = 3, disagree = 2, and strongly disagree = 1) (Sawalha, 2008). All scores were summed up to get a total score, where a mean score was used as a cut-off point to assess high or low knowledge, positive or negative attitude, and good or poor practice. The data obtained from questionnaires was captured in Excel and imported into Statistical Package for Social Science™ (SPSS) version 25 software. Descriptive statistics were used to summarize the demographic characteristics of stakeholders. Non-parametric data analysis methods such as the Mann-Whitney U test were used to assess the association between genders and the KAP scores of stakeholders, while the Krukal-Wallis test was used to assess the association between age, marital status, and education with the stakeholders KAP scores. A post hoc test was used to compare the groups to identify the differences among stakeholders. Additionally, a ($p < 0.05$) was taken as significant for the Mann-Whitney U test and Kruskal-Wallis test. The relationship between knowledge, attitude, and practice score was evaluated using Spearman's rank correlation test ($p < 0.05$).

Ethical clearance

The ethical license for the study was granted by the Sokoine University of Agriculture Institutional Review Board under reference number SUA/DPRTC/R/186/29. Prior to the study, participants were asked to provide their consent, and only those who agreed to participate were included in the survey.

Results

Demographic characteristics of respondents

The socio-demographic characteristics of respondents are presented in Table 2. A total of 310 were interviewed, with the majority of the consumers being female 106 (51.7%), livestock officers were male 7 (77.7%), all 32 (100%) butchers were male, and cattle keepers were 64 (100%) male. Age-wise, the majority of consumers fell within 21-30 years 78 (38.0%), livestock officers 31-40 years 6 (66.7%), butchers >41 years 13 (41.9%), and cattle keepers 31-40 years 35 (57.8%). With regard to the level of education, primary education was predominant across all groups: consumers 87 (42.4%), butchers 17 (54.8%), and cattle keepers 33 (51.6%). However, all livestock officers 9 (100%) had college education. In terms of marital status, the majority were married across all categories.

Assessment of stakeholders' knowledge regarding antimicrobial use (AMU)

Knowledge of consumers

Among consumers, 84 (41%) were in favor of using antimicrobial drugs to prevent infections in livestock, while 62 (30.2%) are against it, and 59 (28.8%) were unaware. Oxytetracycline was the most known antimicrobial drug among respondents 32 (12.4%), followed by penicillin 24 (9.3%), sulfonamide 21 (8.1%), gentamicin 15 (5.8%), albendazole 7 (2.7%), and tylosin 1 (0.4%). The majority of respondents, 159 (61.4%) were not aware of the drugs used.

Concerning the consequences of excessive use of antimicrobial drugs, 69 (33.7%) acknowledged its role in antimicrobial residues and resistance, while 107 (52.2%) were unclear. Regarding awareness of the presence of residues of antimicrobial drugs in cattle tissues, 92 (44.9%) were aware, 46 (22.4%) were not, and 67 (32.7%) were unsure. Regarding the consumption of beef with residues, 133 (64.9%) believe it can cause adverse effects, 24 (11.7%) disagreed, and 48 (23.4%) were unsure.

Table 2

Socio-demographic characteristics of stakeholders (consumers, livestock officer, butchers owners and cattle keepers) regarding antimicrobial usage (AMU)

Demographic characteristics	Category	Consumers N (%)	Livestock officers N (%)	Butchers owner N (%)	Cattle keepers N (%)
Gender					
	Male	99 (48.3)	7 (77.8)	32 (100)	64 (100)
	Female	106 (51.7)	2 (22.2)	0 (0)	0 (0)
Age					
	18-20yrs	21 (10.2)	0(0)	0 (0)	0 (0)
	21–30yrs	78 (38.0)	2 (22.2)	10 (29.0)	7 (10.9)
	31–40yrs	67 (32.7)	6 (66.7)	9 (29.0)	35 (57.8)
	> 41yrs	39 (19.0)	1 (11.1)	13 (41.9)	20 (31.3)
Education					
	Informal	31 (15.1)	0 (0)	6 (16.1)	16 (25.0)
	Primary	87 (42.4)	0 (0)	17 (54.8)	33 (51.6)
	Secondary	66 (32.2)	0 (0)	9 (29.0)	14 (21.9)
	College	21 (10.3)	9 (100)	0 (0)	1 (1.6)
Marital Status					
	Married	98 (47.8)	7 (77.8)	26 (83.9)	44 (68.8)
	Single	79 (38.5)	1 (11.1)	6 (16.1)	14 (21.9)
	Divorced	18 (8.8)	0 (0)	0 (0)	3 (4.7)
	Widowed	10 (4.9)	1 (11.1)	0 (0)	3 (4.7)

Knowledge of livestock officers

All livestock officers interviewed 9 (100%) reported receiving calls from farmers regarding livestock diseases, and they were all aware of veterinarian shops in Kilosa. Among these shops, professionals provided customer service in the majority 7 (77.8%), while a minority 2 (22.2%) indicated anyone could offer assistance. All the officers were aware of the residues of antimicrobial drugs in cattle tissues 9 (100%).

Regarding the effects of consuming cattle meat with residues, (37.5%) recognized its role in the development of antimicrobial resistance, while (29.2%) reported possible allergies, and (33.3%) noted the rise in medical costs linked to these health impacts.

Knowledge of butcher owners

Among butcher owners, 14 (45.2%) acknowledged the use of antimicrobial drugs for the treatment, prevention, and growth promotion of cattle, while 9 (29.0%) disagreed, and 8 (25.8%) were not aware. Regarding preferred antimicrobial drugs for treating cattle, oxytetracycline was the most commonly known 16 (27.6%), followed by penicillin 9 (15.5%), sulfonamide 8 (13.8%), gentamicin 5 (8.6%), tylosin 5 (8.6%), berlin 1 (1.7%), and 14 (24.1%). Awareness of issues related to antimicrobial drugs residues was reported by the majority 19 (61.3%), while 7 (22.6%)) admitted to not understanding, and 5 (16.1%) remained uncertain.

Knowledge of cattle keepers

According to the findings, common antimicrobial drugs used in cattle treatment include oxytetracycline 55 (22.4%), penicillin 45 (18.4%), and sulfonamide 38 (15.5%). Forty (62.5%) of respondents agreed that excessive antimicrobial drug use led to antimicrobial residues and resistance, while 14 (21.9%) were unaware. Regarding awareness of residues in cattle tissues, 33 (51.6%) were informed, 16 (26.6%) were not, and 14 (21.9%) were unsure. Additionally, 44 (68.8%) acknowledged that animals treated with antibiotics undergo a withdrawal period before being sold, while 15 (23.4%) were uncertain. However, only 6 (10.9%) of respondents were familiar with methods used to prevent residues of antimicrobial drugs, with 35 (54.7%) being unaware and 22 (34.4%) uncertain.

Assessment of stakeholders' attitude regarding antimicrobial use (AMU)

Attitudes of consumers

The majority of consumers disagree with the burden of residue to be reduced by cooking beef at high temperatures 77 (37.6%); on the uses of antimicrobial drugs for animal treatment, most agree 78 (38.0%); and the adequacy of government regulation to reduce the effects of residue was strongly disagreed with 82 (40.0%). While 123 (60%) consumers were unwilling to consume meat containing antimicrobial residues.

Attitudes of livestock officers'

Respondents strongly agreed that residues from antimicrobial drugs can affect human health, with 88 (8.9%) supporting this concern. Additionally, 8 (88.9%) emphasized the importance of observing withdrawal periods before animal slaughter. Furthermore, 9 (100%) of the respondents believed that veterinary officers should educate farmers on proper antimicrobial drug usage.

Attitudes of butcher owners

Butchers strongly agreed 20 (64.5%) that consuming beef with antimicrobial residues can cause harm to human health. Out of 32 butcheries, 25 (80.6%) acknowledged the importance of knowing the health history of cattle, and over half 26 (83.6%) of butchers could not sell meat with residues.

Attitude of cattle keepers

The majority of cattle keepers strongly agreed 33 (51.6%) to adhere to the correct dosage and guidelines for antimicrobial uses, while 36 (56.3%) agreed on highlighting the significance of adhering to withdrawal periods before selling cattle meat. Additionally, 54 (84.4%) acknowledged the risks of excessive antimicrobial use leading to residues and resistance, with 53 (82.8%) expressing concern about the presence of residue in cattle products.

Assessment of stakeholders practice regarding antimicrobial use (AMU)

Practices of consumers'

Consumers dietary preferences by 72 (35.1%) often included beef products, while 127 (62.0%) did so occasionally. When purchasing beef, 121 (47.5%) preferred butcheries, followed by 70 (27.5%) from street vendors and 58 (22.7%) from slaughterhouses. However, only 19 (9.3%) of respondents were able to identify signs of antimicrobial drugs in beef products from cattle treated shortly before slaughter. Concerning avoidance strategies, 150 (44.4%) relied on government regulations, 163 (8.6%) advocated

for reducing antibiotic use, and 46 (13.6%) emphasized withdrawal periods.

Practices of livestock officers'

The livestock officers reported that the commonly preferred drugs for livestock included penicillin, sulfonamide, oxytetracycline, and tylosin, each ranging from 12.1% to 13.6% (n = 8–9). The majority, 7 (77.8%), allow one month before slaughtering animals post-treatment. Nine (34.6%) livestock officers preferred injections; 8 (30.8%) administered drugs orally, while all respondents 9 (100.0%) had received training on antimicrobial drug usage.

Practices of butcher owners

A significant number of respondents, 13 (41.9%), did not practice adding antibiotics to animal feed and drinking water, while 8 (25.8%) did, and 10 (32.3%) were unsure. Most butchers, 16 (51.6%), had never tested for residues, but 26 (83.9%) considered the health history when buying cattle. Strategies to avoid residues included government regulation 28 (57.1%), reducing antibiotic use 12 (24.5%), and adhering to withdrawal periods 6 (12.2%), with monitoring animal feed 3 (6.1%).

Practices of cattle keepers

The majority of cattle keepers, 35 (54.7%), treated sick cattle themselves, and 55 (85.9%) bought drugs from agro-vet shops. Most, 39 (60.9%), observed a one-month waiting period after treatment. However, 30 (46.9%) were unaware of the practice of adding antibiotics to livestock feed. Less than half of the cattle keepers, 38 (47.5%), used antimicrobials for disease prevention, while 37 (46.3%) used them for treating animals. Strategies to avoid residues included implementing regulations 45 (40.2%) and adhering to withdrawal periods 28 (25.0%), while reducing antibiotics 26 (23.2%) and increasing awareness 6 (5.4%) were less common.

The mean scores of stakeholders' knowledge, attitude, and practice regarding the use of antimicrobial drugs (AMU)

Consumers demonstrated low mean scores in knowledge (3.1 ± 1.8), attitude (4.0 ± 1.3), and practice (4.0 ± 1.0). In contrast, livestock officers had the highest scores across all categories, with knowledge (6.7 ± 0.5), attitude (8.7 ± 0.7), and practice (16 ± 1.4). Overall, the combined mean scores for all groups were (3.4 ± 1.9) for knowledge, (5.5 ± 2.7) for attitude, and (4.4 ± 1.5) for practice, reflecting variability in understanding and implementing proper antimicrobial use measures among the different groups as summarized in Table 3.

Table 3

Mean scores of stakeholders' knowledge, attitude, and practice regarding the use of antimicrobial drugs (AMU)

	Knowledge scores	**Attitude scores**	**Practice scores**
Stakeholders	**Mean scores ±S.D**	**Mean score ±S.D**	**Mean score ±S.D**
Consumers	3.1 ± 1.8	4.0 ± 1.3	4.0 ± 1.0
Livestock officers	6.7 ± 0.5	8.7 ± 0.7	16 ± 1.4
Butcher owners	2.9 ± 1.9	6.1 ± 1.4	3.2 ± 1.1
Cattle keepers	4.2 ± 2.1	9.4 ± 2.0	5.8 ± 1.4
Overall	3.4 ± 1.9	5.5 ± 2.7	4.4 ± 1.5

Association between socio-demographic characteristics and the knowledge, attitude, and practices scores of stakeholders regarding the use of antimicrobial drugs (AMU)

The findings from the Mann-Whitney U test revealed that gender significantly influenced stakeholders' knowledge, attitude, and practices regarding antimicrobial usage (AMU). Males demonstrated higher levels of knowledge with a mean rank score of 170.73 (p = 0.001), a positive attitude with a mean rank score of 184.74 (p = 0.000), and good practices with a mean rank score of 168.46 (p = 0.005) compared to females, highlighting the role of gender in antimicrobial stewardship. Additionally, results from the Kruskal-Wallis test showed that age significantly influenced antimicrobial usage (AMU), with stakeholders aged 31-40 years exhibiting a positive attitude with a mean rank score of 176.27

Table 4

Relationship between socio-demographic characteristics and stakeholders' knowledge, attitude, and practice (KAP) scores regarding the use of antimicrobial drugs (AMU)

		Knowledge score			**Attitude score**			**Practice score**		
	Category	**Mean±SD**	**Mean rank**	***P* value**	**Mean±SD**	**Mean rank**	***P* value**	**Mean±SD**	**Mean rank**	***P* value**
Gender**	Male	3.7(2.1)	170.73	0.001	6.3(2.8)	184.74	0.000	4.6(1.6)	168.46	0.005
	Female	2.9(1.6)	125.73		3.9(1.4)	99.65		4.1(1.2)	129.96	
Age*	18-20	3.3(1.7)	146.40	0.220	4.0(1.2)	107.17	0.000	4.0(1.2)	127.31	0.025
	21-30	3.0(1.7)	137.92		4.7(2.2)	131.49		4.2(1.4)	141.29	
	31-40	3.6(2.0)	163.77		6.2(2.9)	176.27		4.7(1.6)	169.28	
	>41	3.6(2.1)	165.64		5.6(2.7)	165.00		4.3(1.4)	157.73	
Education*	Informal	2.9(1.9)	131.08	0.000	5.7(3.1)	157.89	0.845	4.5(1.7)	153.85	0.043
	Primary	3.2(1.8)	143.01		5.5(2.7)	153.35		4.3(1.3)	149.20	
	Secondary	3.6(1.8)	163.14		5.3(2.4)	149.07		4.3(1.4)	149.49	
	College	5.0(2.1)	221.95		5.7(2.5)	169.98		5.2(1.8)	194.67	
M/status*	Married	3.7(2.1)	166.43	0.57	5.9(2.8)	172.19	0.002	4.5(1.6)	165.03	0.056
	Single	3.3(1.7)	148.63		4.9(2.2)	135.38		4.2(1.2)	140.73	
	Divorced	2.7(1.6)	115.00		4.3(2.6)	107.55		4.3(1.5)	138.45	
	Widowed	2.6(2.0)	117.21		5.4(2.7)	150.07		4.5(1.2)	144.32	

***Kruskal-wallis Test, Mann Whitney Test** p< 0.05*

(p = 0.000) and good practices with a mean rank score of 169.28 (p = 0.025) compared to other age groups. Furthermore, the education level of stakeholders had a significant impact on their knowledge and practices related to antimicrobial usage (AMU). Those with a college education demonstrated significantly higher knowledge with a mean rank score of 221.95 (p = 0.000) and good practices in antimicrobial use with a mean rank score of 194.67 (p = 0.043) compared to those with other levels of education. Additionally, marital status significantly influenced stakeholders' attitudes toward antimicrobial usage, with married stakeholders exhibiting a significantly positive attitude with a mean rank score of 172.19 (p = 0.002) compared to other groups. These findings were summarized in

Mean comparisons using post hoc tests were performed to assess the differences among stakeholders in the use of antimicrobial drugs (AMU)

The findings revealed that livestock officers had the highest knowledge scores, significantly exceeding those of cattle keepers, consumers, and butchers, with mean differences of 2.46 (p<0.001), -3.56 (p<0.001), and -3.73 (p<0.001), respectively. Cattle keepers had higher knowledge than consumers, with a mean difference of 1.10 (p = 0.002), but scored lower than livestock officers. However, no significant difference in knowledge was found between consumers and butchers with a mean difference of 0.17 (p = 0.997), suggesting that their knowledge levels regarding antimicrobial usage (AMU) had been similar across both groups. Furthermore, the livestock officers and cattle keepers had significantly higher attitude scores compared to consumers and butchers, indicating that both groups had a positive attitude toward AMU. In contrast, butchers had significantly lower attitude scores, and consumers had the lowest attitude scores, reflecting a negative attitude toward antimicrobial usage.

Livestock officers demonstrated the highest levels of practice regarding antimicrobial usage (AMU), performing significantly better than the other groups, with a mean difference of 1.51 (p = 0.032). Cattle keepers, while not reaching the same levels as livestock officers, still practiced more effectively than consumers and butchers, with mean differences of 1.80 and 2.63 (both p < 0.001). Consumers also showed lower practice levels compared to both cattle keepers and livestock officers, with mean differences of -1.80 (p < 0.001) and -0.83 (p = 0.001). Butchers, however, had the lowest practice levels overall, performing significantly poorer than both cattle keepers and consumers, with mean differences of -2.63 (p < 0.001) and -0.83 (p = 0.001), respectively, indicated in Table 5.

Relationship between knowledge, attitude, and practice regarding antimicrobial use (AMU)

The results from Spearman's rank correlation revealed the relationship between stakeholders' knowledge, attitude, and practice scores on the use of antimicrobial drugs, as presented in Table 6. The criteria used to interpret the correlations were: 0-2.5 = weak correlation, 0.25–0.5 = moderate correlation, 0.5-0.75 = good correlation, and greater than 0.75 = excellent correlation (Cohen, 1988). The correlation analysis showed significant moderate positive correlations between knowledge-attitude ($\rho = 0.374$, $p < 0.05$), knowledge-practice ($\rho = 0.399$, $p < 0.05$), and attitude-practice scores ($\rho = 0.427$, $p < 0.05$). This indicated that an increase in knowledge was associated with more positive attitudes and better practices, and that more positive attitudes were associated with good practices.

The results of the study conducted in Kilosa indicated that stakeholders generally possessed limited knowledge, attitude, and practice regarding the use of antimicrobial drugs. The research demonstrated a low level of knowledge, with an average knowledge score of (3.4±1.9) among the four groups.

Table 5

Mean comparison of knowledge, attitude, and practice (KAP) scores among stakeholders regarding antimicrobial usage (AMU)

		Knowledge score		Attitude score		Practice score	
Group (i)	**Group (j)**	**Mean difference**	***P* value**	**Mean difference**	***P* value**	**Mean difference**	***P* value**
Cattle keepers	consumers	1.09*	.002	5.39*	.000	1.80*	.000
	Butcher owners	1.27*	.024	3.26*	.000	2.63*	.000
	Livestock officers	-2.46*	.000	-0.61	.373	-1.50*	.032
Consumers	Cattle keepers	-1.09*	.002	-5.39*	.000	-1.80*	.000
	Butcher owners	0.17	.997	-2.12*	.000	.83*	.001
	Livestock officers	-3.56*	. 000	-4.78*	.000	-3.30*	.000
Butcher owners	Cattle keepers	-1.27*	.024	-3.26*	.000	-2.63*	.000
	Consumers	-0.17	.997	2.12*	.000	-.8.30*	.001
	Livestock officers	-3.73*	.000	-2.65*	.000	-4.14*	.000
Livestock officers	Cattle keepers	2.46*	.000	0.61	.373	1.50*	.032
	Consumers	3.56*	.000	4.78*	.000	3.31*	.000
	Butcher owners	3.73*	.000	2.65*	.000	4.14*	.000

****Indicating statistically significant***

Table 6

Spearman's rank correlation showing the relationship between knowledge, attitude, and practice scores of stakeholders regarding antimicrobial usage (AMU)

Variable	**Correlation coefficient**	***P* value**
Knowledge - attitude	0.374	< 0.05
Knowledge – practice	0.399	< 0.05
Attitude – practice	0.427	< 0.05

****Correlation significant at 0.05 level (2 tailed).***

Discussion

In contrast, a study conducted in Bhutan (Wangmo *et al.,* 2021) reported a higher mean score of 12.05 ±1.7. Most of the respondents in our study had primary education and lacked experience with antimicrobial usage (AMU). The investigation revealed varying levels of knowledge among stakeholders, with livestock officers displaying a strong understanding of antimicrobial usage, as evidenced by an average knowledge score of 6.7±0.5, as also noted by (Bulcha *et al*., 2024), because livestock officers were the experts in a field of veterinary medicine. The results from the Kruskal-Wallis analysis revealed a significant correlation between the educational background of respondents and their knowledge scores. This finding is consistent with findings from a previous study conducted in Tanzania by (Sindato *et al*., 2020), which demonstrated that knowledge levels are closely linked to educational achievements. In particular, the study highlighted that livestock officers with higher education levels significantly influenced the knowledge of other stakeholders, a trend consistent with the observations of Knust *et al.* (2008). They also found that the educational background of livestock officers served as a primary source of knowledge for other stakeholders.

The most commonly utilized antimicrobial drugs in cattle within the study area were oxytetracycline, penicillin, sulphonamides, gentamicin, tylosin, and albendazole, consistent with previous studies in Tanzania (Nonga *et al.,* 2009; Katakweba *et al.,* 2012; Ojo *et al.,* 2016; Mgonja *et al.,* 2018; Mdegela *et al.,* 2021). The majority of these drugs were sourced from agro-vet shops, a finding supported by research in Kenya (Kemp *et al*., 2021), which noted that agro-vet staff were knowledgeable about drug prescriptions. Livestock officers (100%) were well-informed about issues concerning antimicrobial resistance, contrary to a study by Wangmo *et al.* (2021), which found that most respondents believed the inappropriate use of antibiotics was the main driver of antimicrobial resistance, which was attributed to the frequent use and easy accessibility of drugs in the community. Despite acknowledging that (45.2%) of respondents agreed that cattle were treated with drugs when sick and (65.4%) of butchers could not identify a recently treated animal, indicating minimal awareness of potential health risks to humans, profit gain remains their primary focus. The study found no significant difference in knowledge between butchers and consumers. However, there was a significant difference between livestock officers and cattle keepers, indicating that these two groups had varying levels of understanding.

Livestock officers and cattle keepers displayed positive attitudes towards AMU, with mean scores of 9.4±2.0 and 8.7±0.7, respectively. These results agree with a study conducted by (Geta and Kibret, 2021) but disagree with the findings of (Gebeyehu *et al*., 2021), who reported that a majority of cattle keepers had negative attitudes towards antimicrobial usage (AMU). This difference suggests that cattle keepers in our study are working in collaboration with professional offices. The study also revealed a significant association between gender, age, education, and attitudes towards antimicrobial usage. Males, individuals aged 31–40 years, and married participants were more likely to have a positive attitude towards antimicrobial usage, in contrast to the findings of Gajdács *et al.,* (2020), where education played a significant role in influencing stakeholders' attitudes. Butchers and consumers displayed negative attitudes towards AMU, with mean attitude scores of 6.1±1.4 and 4.0±1.3, respectively, in agreement with a study by (Hassan *et al*., 2021). The latter study found that this negative attitude led to poor practices and was influenced by low levels of knowledge.

The study findings revealed that stakeholders generally had poor practices regarding antimicrobial usage, with a mean practice score of 4.4±1.5, which was lower than the cut-off mean score of 8.5±3.8. However, (66.7%) of livestock officers demonstrated good practices, with a higher mean practice score of 16.0±1.4, similarly to the study conducted in Bhutan (Wangmo *et al.,* 2021). This similarity level of practice among livestock officers could be attributed to their education, regular participation in seminars to stay updated on disease cases, and extensive work experience. The results showed a significant correlation between gender, age, and

education about antimicrobial usage. The majority of respondents who displayed good practice were male (77.8%), aged 31-40 years (66.7%), and had a college education (100%). The study showed a wide range of antimicrobial usage among livestock officers with different preferences and practices. The most preferred drugs were chosen due to their cost-effectiveness, ease of use, and availability compared to other antimicrobial drugs. They were primarily used to treat sick animals and prevent infections, as observed in other studies (Nonga *et al.*, 2009; Katakweba *et al.*, 2012; Chang *et al.*, 2015; Ojo *et al.*, 2016). A significant portion (41.9%) of respondents avoided using antibiotics in animal feed and drinking water for growth promotion, using them mainly for treatment and prevention. This trend mirrored practices in neighboring African countries where such use was restricted (Sarmah *et al.*, 2006) to reduce the risk of developing antimicrobial resistance.

Conclusion

Livestock officers showed higher knowledge and positive attitudes, as well as better practices than other groups. Butchers showed significantly lower knowledge and negative attitudes, along with substandard practices, highlighting potential risks for public health. Cattle keepers and consumers showed mixed attitudes and approaches, highlighting the need for specific educational interventions. The study suggests the necessity for enhanced monitoring practices and increased awareness regarding responsible antimicrobial usage among butcher owners and traders to mitigate the risks associated with antimicrobial residues in beef cattle. To improve antimicrobial usage in Kilosa district, education and training programs for all stakeholders are essential to emphasize the importance of proper drug administration, adherence to withdrawal periods, and the dangers of antimicrobial resistance. Additionally, promoting collaboration among stakeholders, including cattle keepers, butchers, and livestock officers, will enhance knowledge sharing and compliance, ultimately safeguarding public health and ensuring the safety of beef products.

Recommendations

The study recommends implementing targeted education and training programs for all stakeholders, including butchers, cattle keepers, and livestock officers, to improve knowledge, attitudes, and practices related to antimicrobial usage. These programs should emphasize the importance of proper drug administration, adherence to withdrawal periods, and the risks of antimicrobial resistance. Enhanced monitoring and awareness campaigns for butcher owners and traders are crucial to mitigate the risks of antimicrobial residues in beef cattle. Furthermore, promoting collaboration among stakeholders will facilitate knowledge sharing and compliance, ultimately protecting public health and ensuring the safety of beef products.

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