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Antibiotic use and antimicrobial resistance: Knowledge, attitudes, and practices among smallholder chicken farmers in Southern Mozambique

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Intensive production systems face challenges in treating individual chickens due to the large number of animals, resulting in the indiscriminate use of antibiotics as the only alternative. The use of antibiotics in poultry production has adverse effects on humans, as prolonged consumption of contaminated meat can lead to the development of antibiotic resistance in intestinal bacteria. A cross-sectional survey involving 395 smallholder farmers was conducted through face-to-face interviews to assess knowledge, attitudes, and practices (KAP) regarding antibiotic use in urban and peri-urban areas of Southern Mozambique. Data were analyzed using SPSS version 27. The findings revealed that 60% of respondents were female, 28.6% had received training on antibiotic use, and 73.2% identified poultry production as their primary source of income. Approximately 72.2% were unaware of antimicrobial resistance, while oxytetracycline (22.8%) was the most commonly used antibiotic on farms. In cases of disease, 96.99% of farmers self-administered antibiotics, and 30.9% reported consuming meat from chickens that had died during or after antibiotic treatment. Chi-square and regression analyses (p=0.000) revealed significant associations, indicating that training positively influenced knowledge regarding the appropriate use of antibiotics. Education level also influenced antibiotic use (p=0.000); farmers with higher education levels were more likely to believe that medicinal plants could serve as alternatives to antibiotics. This study revealed that antibiotic use contributes to the contamination of broiler chickens with antibiotic residues and promotes antimicrobial resistance, primarily due to inadequate knowledge, attitudes, and practices resulting from insufficient training in antibiotic application. To reduce, prevent, and eliminate the indiscriminate use of antibiotics and the spread of antimicrobial resistance, it is essential for the government to educate, train, and monitor veterinary professionals, smallholder farmers, and resellers on the proper use of antibiotics in poultry production.

Key words: Smallholder chicken farmers, knowledge, attitudes, and practices (KAP), antibiotics, antimicrobial resistance.

INTRODUCTION

Poultry farming is one of the fastest-growing agricultural activities worldwide, providing affordable and nutritious meats for low-income populations. Poultry products also contribute significantly to food security and help reduce the prevalence of malnutrition among children in several African countries (Assefa et al., 2023; Bah and Gajigo,

2019; da Conceição et al., 2011; Garsow et al., 2022; Mak et al., 2022). In Mozambique, poultry farming plays a vital role in improving nutrition, serving as a primary and accessible source of animal protein for consumers (dos Muchangos, 2012; da Conceição et al., 2011). In chicken production, antimicrobials are frequently used for disease treatment, growth promotion, and disease prevention. In African poultry production systems, antibiotic use is particularly high in intensive systems, which contributes to the emergence of resistant bacterial strains (Ramtahal et al., 2022). Intensive poultry production is also a significant contributor to the spread of infectious diseases and environmental pollution. Due to inadequate monitoring, poor biosecurity, and the lack of laboratory diagnostic capacity, the use of antibiotics in poultry production is widespread in many countries (Kalam et al., 2022; Khalil et al., 2023).

Furthermore, in Sub-Saharan Africa, there is limited information regarding the quantity and quality of veterinary medicines (Azabo et al., 2022), and studies on knowledge, attitudes, and practices (KAP) concerning antimicrobial use remain scarce (Kalam et al., 2022). However, good practices—such as improving biosecurity, vaccination, and ensuring adequate nutrition and housing—can help prevent disease outbreaks and reduce the need for antibiotics in poultry production (Khalil et al., 2023; Siddiky et al., 2022). Many studies have emphasized that the indiscriminate use of antibiotics poses a serious public health threat due to the spread of antimicrobial-resistant bacteria to humans and the environment (Emes et al., 2023; Islam et al., 2023; Johnson et al., 2019; Kimera et al., 2020; Mak et al., 2022). Additionally, Mudenda et al. (2022) and Pym (2013) reported that in small-scale poultry production, antibiotics are often used to compensate for poor performance resulting from a lack of experience with intensive production systems, thereby exposing consumers to antibiotic residues and resistant microorganisms. According to Siddiky et al. (2022), farmers in Bangladesh have overused antibiotics and violated regulations due to weak government oversight, leading to the presence of antibiotic residues in meat. The authors recommend that, to reduce the misuse and overuse of antimicrobials, producers should receive education, motivation, training, and awareness on good farming practices.

The antibiotics most commonly used in poultry production and human medicine include tetracycline, amoxicillin, erythromycin, gentamicin, doxycycline, sulfadimidine, and sulfamethoxazole/trimethoprim, all of which are generally accessible without a prescription (Khalil et al., 2023; Mudenda et al., 2022).

Small-scale chicken farmers frequently use antibiotics indiscriminately because they are often in a hurry to sell their chickens, are unaware of the withdrawal period, and lack sufficient knowledge about the impact of antibiotics on both humans and animals (Kalam et al., 2022; Tijani et al., 2023). According to Hassan et al. (2021), chicken farmers are risk factors in the antimicrobial resistance chain because many lack formal training in poultry farming, which promotes the careless and excessive use of antibiotics, leading to the emergence and spread of antimicrobial resistance (AMR). To minimize the widespread and unnecessary use of antibiotics, the authors recommend educating farmers about proper antibiotic use through awareness and training campaigns. Mudenda et al. (2022) emphasize that observing withdrawal periods is essential for the proper administration of antibiotics, as it prevents the consumption of antibiotic residues through the food chain. Mozambique has developed a National Action Plan Against Antimicrobial Resistance (PNA) 2019–2023, which aims to ensure the correct preparation and use of antimicrobials by farmers and other supply chain actors through education, inspection, research, and regulatory enforcement. This plan seeks to prevent the emergence of antimicrobial resistance.

However, there is limited research on antibiotic use among chicken farmers in Mozambique. Similarly, Mudenda et al. (2022) noted that although AMR has been reported in poultry, little is known about farmers' KAP regarding antibiotic use. Understanding KAP is therefore an important strategy for developing effective programs to monitor antibiotic use and control AMR. According to Sawadogo et al. (2023) and Tufa et al. (2023), most low- and middle-income countries still lack a comprehensive understanding of the KAP factors that influence farmers' decisions to use antibiotics.

The purpose of this study was to assess the KAP of chicken farmers regarding antibiotic use and the measures taken to prevent the development of antibiotic resistance. The findings of this study will provide valuable insights into farmers' knowledge and practices in broiler production, support initiatives to promote healthy poultry farming, and offer recommendations for interventions to reduce the threat of AMR among smallholder farmers.

MATERIALS AND METHODS

Study area

The study was conducted in two purposively selected areas—peri-urban and urban—across three provinces in the Southern Region of Mozambique. This region was chosen because it hosts a large concentration of poultry production activities and serves as a strategic meat distribution hub for the country, particularly for the capital city. Sampling was carried out in five districts across the three provinces: KaMavota, KaMubukwana, and KaNlamakulu in

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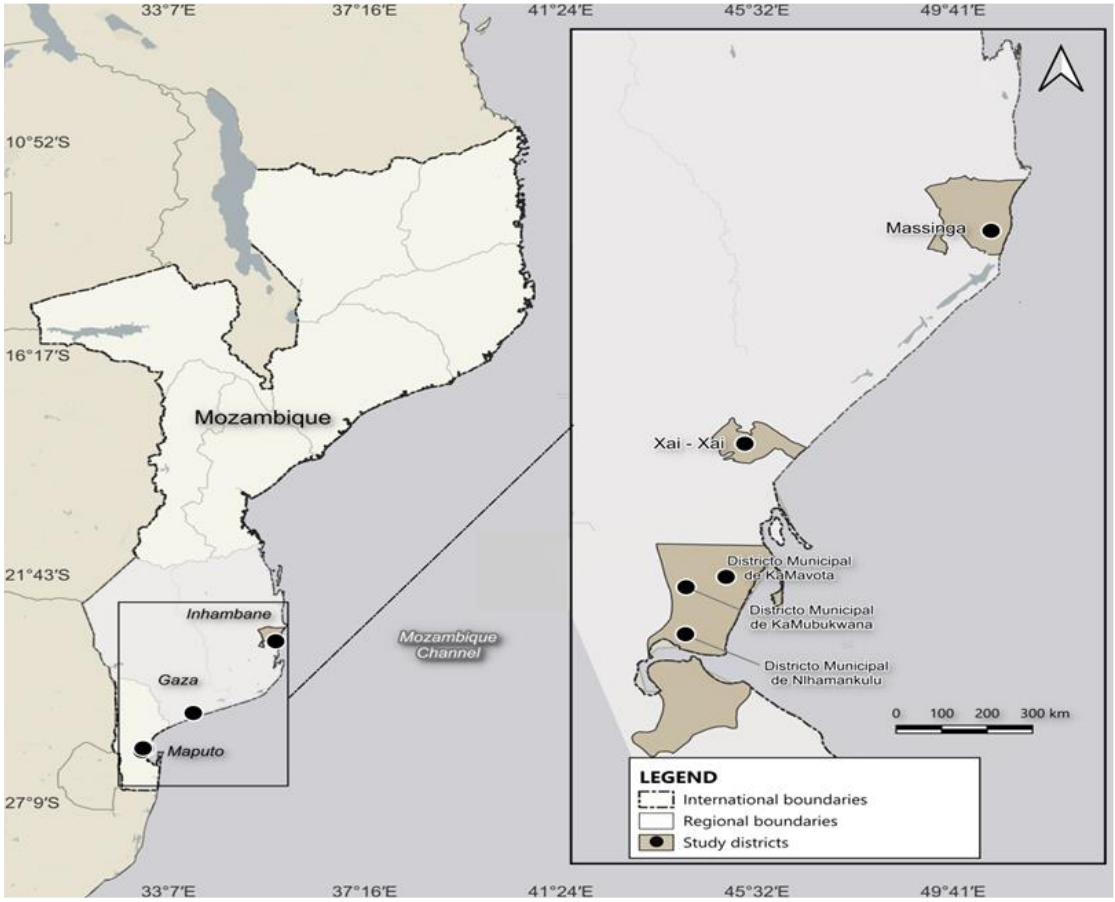

Figure 1. Map of study area.

Maputo (the capital city), Xai-Xai in Gaza Province, and Massinga in Inhambane Province (Figure 1). Within these districts, data were collected from both urban and peri-urban areas. Broiler chicken production in urban centers occurs mainly in the provinces of Gaza and Inhambane, which are densely populated and characterized by both formal and informal municipal markets. In peri-urban areas, production is concentrated in Maputo Province, where it takes place in transitional zones that combine residential and agricultural activities and are dominated by informal market structures. These areas represent the main channels for the distribution and supply of broiler chicken meat to consumers in the region.

Determination of districts and smallholder farmers

The Directorate of Commerce was contacted and provided a list of districts prior to data collection, while the National Directorate of Animal Health supplied a list of producers and assigned two field assistants. Additionally, the secretary and president of the Mozambican Poultry Farmers Association (AMA) provided another list of producers. Field assistants and members of AMA assisted in selecting districts, and smallholders raising broiler chickens and administering antibiotics to their flocks were randomly selected for participation. To minimize bias in the survey data, a comprehensive list of farmer locations across all districts was compiled for the data collection phase. Producers who refused to participate, as well as veterinarians, were excluded from the study. Given the lack of reliable data on the total number of broiler producers, along with practical constraints such as limited access to individual farms, resource limitations, and the need for producer cooperation, a purposive sampling strategy was adopted.

Research design and sample size

A seven-month cross-sectional study was conducted between October 5, 2023, and April 11, 2024. The target population comprised all smallholder farms with broiler chickens receiving antibiotic treatment in five designated districts during the sampling period. The minimum required sample size of 384 was calculated using Cochran's formula for an unknown population, which represents the most statistically conservative approach. This method ensures that the sample size has sufficient power to yield reliable conclusions regardless of the true prevalence. The following parameters were applied: a 95% confidence interval (CI), corresponding to a Z-score of 1.96; an estimated prevalence (P) of 50% (P = 0.5); and a 5% margin of error.

$$n = \frac{z^2(1-p)}{E^2}$$

where n = sample size (384), Z = standard constant for the confidence interval, P = estimated prevalence (0.5), and E = margin of error (5%). Due to the accessibility of smallholders in Maputo Province and to enhance the statistical power and precision of the study, an additional 11 samples were collected, resulting in a total

sample size of 395. This increased sample size improved statistical power, reduced the margin of error, and strengthened the generalizability of the findings across urban and peri-urban areas of the Southern Region, thereby enhancing the reliability of the results.

Data collection tools

Data were collected using a structured questionnaire and an observational checklist. The questionnaire employed in this study was adapted from the International Livestock Research Institute's (ILRI) *Antimicrobial Use in Livestock Production Systems* tool, which was designed to facilitate the standardized collection of data on farmers' KAP within the conceptual framework of AMR in low- and middle-income countries (Wieland et al., 2019). Several modifications were made based on similar studies (Hossen et al., 2020; Sawadogo et al., 2023). The closed-ended questionnaire was designed to gather information on smallholders' sociodemographic characteristics, knowledge, attitudes, and antibiotic use behaviors. Observational data on compliance with antibiotic use on farms were recorded using the checklist. The questionnaire was initially developed in English using data from previous studies, and then translated into Portuguese. Interviews were conducted in Portuguese or in local languages (Xitsonga, Xichangana, and Xitswa), depending on the farmer's level of education (Khalil et al., 2023).

Pilot test

A small-scale pilot study involving ten smallholder farmers was conducted to pre-test the questionnaire. This pilot was primarily designed to evaluate the logistical feasibility of the sampling technique, assess the clarity of the questions, estimate the time required for data collection, and verify the reliability of both the questionnaire and checklist. A panel of experts assessed the content validity of the survey to ensure that the instruments were appropriate for the intended research objectives and relevant to data collection. Following instrument validation, the principal investigator visited the selected districts at different times of the day, accompanied by trained members of the AMA and field assistants.

Informed consent was obtained from each participant prior to the interview, and the purpose of the study was clearly explained to ensure voluntary participation. Data were collected through face-to-face interviews lasting approximately twenty-five minutes each, while observation sessions lasted about ten minutes. To minimize interviewer bias, all research assistants involved in data collection were trained to maintain a neutral stance, emphasize participant anonymity before each interview, and inform respondents that they could withdraw from the interview at any time if they felt uncomfortable.

Assessment of food safety knowledge regarding antibiotics use of smallholder farmers

A total of 14 questions were developed to assess smallholders' knowledge regarding antibiotic use and the occurrence of foodborne diseases. These included topics such as understanding the indiscriminate use of antibiotics, appropriate antibiotic usage, purposes of antibiotic application (treatment, prevention, or growth promotion), awareness of the withdrawal period, and the relationship between antibiotic use, resistance, residues, and human health. Each knowledge question had two possible responses. To minimize response bias, multiple-choice answers of "Yes" and "No" were coded as 1 and 0, respectively (Yes = 1 for good knowledge or correct answers; No = 0 for poor knowledge or incorrect answers). The total knowledge score ranged from 0 to 14 (Hossen et al., 2020).

Assessment of food safety attitude regarding antibiotics use of smallholder chicken farmers

To evaluate the perspectives of smallholder producers, the study aimed to assess the extent of antibiotic overuse in broiler chicken production, the potential contribution of antibiotic use to antimicrobial resistance, the role of antibiotics as growth promoters, and the perceived benefits of restricting antibiotic use while adopting natural remedies, among other factors. Smallholder farmers were asked to rate their agreement with nine statements related to antibiotic use on a three-point Likert scale, where *2* indicated "strongly agree," *1* indicated "agree," and *0* indicated "disagree." The total attitude score ranged from 0 to 27, which was subsequently standardized to a 100-point scale (Hossen et al., 2020).

Assessment of food safety attitude regarding antibiotics use of smallholder chicken farmers

A total of nine questions were used to assess good practices related to antibiotic use (e.g., use of antibiotics to treat animal diseases, use of antibiotics as growth promoters, increasing the dose or frequency when disease persists, and selling chickens during antibiotic administration). Respondents were asked to rate the frequency of each practice using a three-point scale, where *two* indicated "always," *one* indicated "sometimes," and *zero* indicated "never." The total practice score ranged from 0 to 27. In addition, 11 questions with more than three multiple-choice options were designed to explore practices related to the types of antibiotics used in production, the frequency and source of antibiotic procurement, and the management of drug residues and manure (Wieland et al., 2019).

The raw KAP score (the total number of points obtained by each participant) was converted to a standardized scale of 100 points to represent the level of food safety proficiency as a percentage, allowing for comparison of results. Cut-off points were used to categorize participants into performance levels along a continuous numerical scale (0–100) and a corresponding categorical scale (poor, medium, and good). A score below 50 was considered *poor*, scores between 50 and 75 were classified as *medium*, and scores above 75 were categorized as *good* levels of knowledge, attitude, and practice regarding antibiotic use in poultry farming (Hossen et al., 2020).

Ethical clearance

A research permit was obtained from the Vice Chancellor of Sokoine University of Agriculture (SUA), Tanzania, and the study was approved by the Directorate of Postgraduate Studies, Research, Technology Transfer and Consultancy (DPRTC) of SUA. Institutional approval was also granted by the Ministry of Agriculture and Food Security of Mozambique through the National Animal Health Service (Reference No. 1635/SAECM/DAP/11/23). Farmers were assured of confidentiality during data collection and processing.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 27. Demographic variables were summarized using descriptive statistics, including frequencies and means. Chi-square tests were employed to determine associations between categorical variables, while regression analysis was

Table 1. Socio-demographic characteristics of smallholder chicken farmers.

Variable	Category	Freq	(%)
Gender	Female	237	60.0
	Male	158	40.0
Age of respondent	Less than 20 years	22	5.60
	20-40 years	129	32.7
	41-60 years	210	53.2
	Above 60 years	34	8.6
Marital status	Married	185	46.8
	Unmarried, living with a partner	123	31.10
	Unmarried, living without a partner	58	14.70
	Separated	15	3.80
	Divorced	1	0.30
	Widowed	13	3.30
Education level	High school level (Over 12)	62	15.70
	Secondary school level (grade 7-12)	238	60.30
	Primary school level (grade 1-6)	53	13.40
	No formal education	42	10.60
Experience in the use of antibiotics in chicken production	Less than 5 years	47	11.90
	5-9 years	153	38.70
	10-20 years	137	34.70
	More than 20 years	58	14.70
Residence area	Peri-urban	303	76.70
	Urban	92	23.30
Have you ever attended a training course on antibiotic use?	No	282	71.40
	Yes	113	28.60
Is chicken production your main source of income?	No	106	26.80
	Yes	289	73.20
In which District do you produce chickens?	KaNlhamakulu	87	22.00
	KaMavota	111	28.10
	KaMubukwana	105	26.60
	Xai-Xai	49	12.40
	Massinga	43	10.90

conducted to evaluate the effects of various factors on food safety knowledge, attitudes, and practices. Analysis of Variance (ANOVA) was used to assess group differences identified in the regression analysis. P-values ≤ 0.001 were considered extremely significant, while P-values < 0.05 were regarded as statistically significant.

RESULTS

Socio-demographic characteristics of smallholder chicken farmers

The socio-demographic characteristics of smallholder chicken farmers are presented in Table 1. The results indicate a heterogeneous population consisting primarily of females (60.0%) compared to males (40.0%). Most respondents were aged between 41 and 60 years (53.2%), while 46.8% were married. In terms of education, 60.3% had attained secondary education, whereas 10.6% had no formal education. The majority of producers (76.7%) resided in peri-urban areas. Chicken production was identified as the main source of income by 73.2% of respondents, and 38.7% reported having between 5 and 9 years of experience using antibiotics in chicken production. Notably, most producers (71.4%) had not received any training on antibiotic use, indicating a knowledge gap that could affect production quality and contribute to the emergence of antibiotic-resistant microorganisms.

Food safety knowledge regarding the antibiotic-use among smallholder chicken farmers

The assessment of knowledge regarding antibiotic use among smallholder chicken farmers across districts is presented in Table 2. Knowledge about antimicrobial resistance showed substantial variation among districts (χ^2 = 40.321, p = 0.000), with notably higher scores observed in KaMubukwana, Massinga, and Xai-Xai compared to other districts.

Similarly, beliefs about the potential to reduce antimicrobial use in chickens also varied significantly (χ^2 = 38.639, p = 0.000). Respondents' awareness that antimicrobials can pose risks to human health exhibited the greatest variability (χ^2 = 114.73, p = 0.000), with lower knowledge scores recorded in Xai-Xai and Massinga. In contrast, variables related to the correct use and understanding of antibiotics (C, D, and G) did not show statistically significant differences, indicating relatively uniform knowledge in these areas across districts.

The impact of gender, age, educational level, residential location, and training qualifications on smallholder chicken farmers' knowledge concerning antibiotic use is presented in Table 3. Male respondents demonstrated slightly higher knowledge levels (40.5%) compared to females (32.9%); however, the association between gender and knowledge level was not statistically significant (p^+ = 0.142), and gender did not have a significant effect on knowledge scores (p = 0.802). Farmers with a high school education showed higher knowledge scores (48.4%; mean score = 79.95) than those with only primary education (20.8%; mean score = 69.27), with both the association and effect being statistically significant (p^+ = 0.017; p = 0.008), confirming that education level is significantly associated with knowledge. Respondents who had received training on food safety and antibiotic use demonstrated significantly higher levels of good knowledge (62.2%; mean score = 83.53; p^+ = 0.000; p = 0.000) compared to those without training (25.2%; mean score = 71.18), indicating that participation in training substantially improves understanding of antibiotic use.

Assessment of knowledge of foodborne disease occurrence and antibiotic use

Table 4 presents the incidence of foodborne infections and patterns of antibiotic use. Behaviors such as increasing the dose and frequency of antibiotics when poultry diseases persist (Variable B) and the belief that antimicrobials should be added to feed to prevent diseases (Variable C) showed significant variation by education level (p = 0.002 and p = 0.000, respectively), with higher occurrences among respondents with no formal education. Awareness of common antimicrobial-resistant foodborne pathogens was also significantly greater among respondents with higher education levels (p = 0.006). These findings suggest that education level has a significant influence on awareness, antibiotic use practices, and perceptions related to antimicrobial resistance.

Evaluation of smallholder chicken farmers' attitudes toward antibiotic use

The assessment of smallholder chicken farmers' attitudes toward antibiotic use is presented in Table 5. The data reveal a divided perception regarding the misuse of antimicrobials in chicken production, with 51.9% disagreeing, indicating that a substantial proportion of farmers do not view misuse as a critical issue. Only 20.5% strongly agreed that antimicrobials can lead to AMR and residues, while 6.6% disagreed that missing doses of antimicrobials can contribute to AMR. Additionally, 77.7% of respondents disagreed with adding antimicrobials to feed as growth promoters.

Regarding the replacement of antimicrobials with natural remedies, 45.1% disagreed, indicating some level of skepticism. Significant associations were observed between education and several attitude statements: higher agreement that antimicrobials are misused (Variable A) was found among respondents without formal education (p = 0.000), while stronger belief in substituting antimicrobials with natural medicines (Variable F) was also more common among the least educated (p = 0.000). These findings underscore the influence of education on farmers' attitudes toward antibiotic use and safety practices in chicken production.

The influence of demographic characteristics on the attitudes of smallholder chicken farmers toward antibiotic use is presented in Table 6. The findings show no significant association between gender and attitude categories (χ^2 = 0.227, p^+ = 0.636) or in the regression analysis (p = 0.151), indicating that males (mean = 68.31 ± 10.09) and females (mean = 68.23 ± 10.41) exhibited similar attitudes toward antibiotic use. There was also no significant correlation between age and attitude, as demonstrated by non-significant values (p^+ = 0.572; p = 0.462), although farmers aged 20–40 years recorded the highest mean score (69.85 ± 9.71). Residential area, however, showed a statistically significant relationship (p^+ = 0.255), with farmers in urban areas achieving higher average scores (72.3 ± 5.42) compared to those in peri-urban areas. Regression analysis further confirmed that attitudes toward antibiotic use were significantly influenced by place of residence, with urban farmers displaying more positive attitudes (p = 0.000).

Additionally, chicken farmers who had attended food safety and antibiotic use training demonstrated significantly better attitudes, with 40.5% showing good attitudes and a mean score of 73.51 ± 9.98. Both p^+ and p = 0.000 confirmed that training had a significant positive impact on farmers' attitudes toward food safety and antibiotic use.

Table 2. Smallholder chicken farmers' food safety knowledge on the use of antibiotics.

Variable	Total (%)	Name of district					Chi-square test	
		KaMavota (%)	KaMubukwana (%)	KaNlhamakulu (%)	Xai-Xai (%)	Massinga (%)	χ2	P Value
A	110 (27.8)	25 (22.5)	39 (37.1)	5 (5.7)	23 (46.9)	18 (41.9)	40.321	0.000
B	110 (27.8)	25 (80)	39 (74.3)	5 (80)	23 (21.7)	18 (83.3)	38.639	0.000
C	389 (98.5)	108 (97.3)	103 (98.1)	86 (98.9)	49 (100)	43 (100)	2.643	0.619
D	384 (97.2)	109 (98.2)	100 (95.2)	87 (100)	49 (100)	39 (90.7)	12.555	0.014
E	372 (94.2)	100 (90.1)	102 (97.1)	84 (96.6)	49 (100)	37 (86)	14.173	0.007
F	311 (78.7)	99 (89.2)	95 (90.5)	78 (89.7)	12 (24.5)	27(62.8)	114.73	0.000
G	365 (92.4)	103 (92.8)	95 (90.5)	78 (89.7)	48 (98)	41(95.3)	4.203	0.379

A-Did you hear of antimicrobial resistance; B-If yes, is it possible to reduce antimicrobial use in chickens; C-Use an antimicrobial withdrawal period to prevent antibiotic residues in chicken; D-Administering correct amounts of antibiotics reduces antimicrobial resistance; E-Antimicrobials are required for all chickens when one is sick; F-Did you know that the use of antimicrobials can pose risks to human health; and G-Indiscriminate use of antibiotics leads to residues, resistance, and side effects, p = Significance value.

Assessment of smallholder chicken farmers' antibiotics use practices

Table 7 presents the antibiotic use practices among smallholder chicken farmers. The data reveal that years of farming experience are significantly associated with several antibiotic use practices. Most practices showed strong relationships with experience, including treatment ($\chi^2 = 17.59$, $p = 0.007$) and prevention ($\chi^2 = 24.31$, $p = 0.000$). Additionally, the practice of discarding antibiotics after expiration ($\chi^2 = 24.29$, $p = 0.000$) exhibited significant differences, with farmers having fewer years of experience showing more favorable practices. However, the use of antibiotics for growth promotion did not differ significantly by experience level ($\chi^2 = 8.816$, $p = 0.184$), suggesting that this behavior is consistently distributed regardless of farming experience. Practices such as storing antibiotics at home ($\chi^2 = 17.26$, $p = 0.008$) and increasing dosage when diseases persist ($\chi^2 = 20.4$, $p = 0.002$) also varied significantly with years of experience, indicating that risky behaviors are more prevalent among farmers with longer experience. Awareness and adherence to recommended withdrawal periods before slaughter ($\chi^2 = 14.51$, $p = 0.024$) likewise differed significantly, highlighting the need for targeted training on safe antibiotic practices, particularly for experienced farmers, to mitigate the risk of antimicrobial resistance and ensure food safety.

The effects of various demographic characteristics on antibiotic use practices among smallholder chicken farmers are presented in Table 8. Gender shows a significant effect ($p = 0.004$), with males exhibiting a higher mean score (76.86 ± 6.2) than females (75.34 ± 6.1) in appropriate antibiotic use, suggesting that male respondents tend to follow better antibiotic use practices than females. Education level shows a near-significant effect in the chi-square test ($p^+ = 0.052$) and a significant effect in the regression analysis ($p = 0.015$). Respondents with secondary education recorded the highest mean scores (76.25 ± 6.37), indicating that higher education levels are associated with improved food safety practices. However, respondents with higher education had the lowest percentage (33.9%) of good practices and the lowest mean score (74.13 ± 6.16); suggesting that education beyond secondary school may not have a substantial impact on antibiotic use practices.

Table 9 presents a correlation matrix evaluating the relationships among demographic factors and food safety variables, specifically knowledge of antibiotic use (FSKA), attitudes (FSAA), and practices (FSPA). Significant positive correlations were observed between training and both FSKA ($r = 0.351$, $p < 0.01$) and FSAA ($r = 0.318$, $p < 0.01$), indicating that training substantially improves knowledge and attitudes. Gender showed a weak positive correlation with FSPA ($r = 0.121$, $p < 0.05$), suggesting slight gender-related differences in food safety and antibiotic use practices. A negative correlation was found between FSAA and FSPA ($r = –0.222$, $p < 0.01$), implying potential inconsistencies between attitudes and actual practices. These findings suggest that while training enhances knowledge and attitudes, additional factors may influence the translation of positive attitudes into proper antibiotic use practices.

Table 3. The effect of demographic parameters on the farmer's knowledge regarding the use of antibiotics.

Characteristic	Number of respondents (%)			P+-value	Mean ± SD	Range	P-value
	Poor (<50) n (%)	Medium (≥50 to <75) n (%)	Good (≥75) n (%)				
Gender							
Female	14 (5.90)	145 (61.20)	78 (32.90)	0.142	74.62 ± 14.8	14.29-100	0.802
Male	13 (8.20)	81 (51.30)	64 (40.50)		74.95 ± 17.42	0-100	
Age of respondent							
Less than 20 years	2 (9.10)	11 (50.00)	9 (40.90)	0.125	74.03 ± 22.32	0-100	0.912
20-40 years	11 (8.50)	61 (47.30)	57 (44.20)		75.53 ± 16.48	0-100	
41-60 years	11 (5.20)	132 (62.90)	67 (31.90)		74.76 ± 14.71	14.29-100	
Above 60 years	3 (8.80)	22 (64.70)	9 (26.50)		72.27 ± 16.09	28.57-100	
Marital status							
Married	10 (5.40)	104 (56.20)	71 (38.40)	0.383	76.53 ± 14.76	28.57-100	0.19
Unmarried, living with a partner	13 (10.60)	69 (56.10)	41 (33.30)		73.05 ± 16.28	14.29-100	
Unmarried, living without a partner	4 (6.90)	33 (56.90)	21 (36.20)		72.91 ± 19.24	0-100	
Separated	0 (0.00)	9 (60.00)	6 (40.00)		76.19 ± 11.66	57.14-100	
Divorced	0 (0.00)	0 (0.00)	1 (100.00)		100	1001-100	
Widowed	0 (0.00)	11 (84.60)	2 (15.40)		70.33 ± 12.32	57.14-100	
Education level							
High school level (Over 12)	2 (3.20)	30 (48.40)	30 (48.40)	0.017	79.95 ± 15.18	42.86-100	0.008
Secondary school level (grade 7-12)	17 (7.10)	141 (59.20)	80 (33.60)		74.61 ± 15.05	0-100	
Primary school level (grade 1-6)	4 (7.5%)	38 (71.7%)	11 (20.80)		69.27 ± 17.36	0-100	
No formal education	4 (9.50)	17 (40.50)	21 (50.00)		74.83 ± 17.51	42.86-100	
Residence area							
Peri-urban	24 (7.90)	175 (57.80)	104 (34.30)	0.255	74.87 ± 16.35	0-100	0.211
Urban	3 (3.30)	51 (55.40)	38 (41.30)		74.38 ± 14.29	42.86-100	
Have you ever attended a training course on antibiotic use							
No	24 (8.50)	187 (66.30)	71 (25.20)	0.000	71.18 ± 14.98	0-100	0.000
Yes	3 (2.70)	39 (35.10)	69 (62.20)		83.53 ± 14.57	42.86-100	

n= Number of processors, SD = Standard deviation, p^+-value = for association by Chi-square test, p-value = for effect by one-way ANOVA, ** significance at $p < 0.05$, *** significance at $p < 0.001$ and if there no star at p means no significance.

Table 4. Foodborne disease occurrence and use of antibiotics.

Variable	Total (%)	Education level				Chi-square test	
		High school level (Over 12) (%)	Secondary school level (grade 7-12) (%)	Primary school level (grade 1-6) (%)	No formal education (%)	χ^2	P-value
A	386 (97.7)	61 (98.4)	234 (98.3)	50 (94.3)	41 (97.6)	3.23	0.358
B	65 (16.5)	7 (11.3)	24 (10.1)	13 (24.5)	21 (50)	45.12	0.002
C	67 (17)	5 (8.1)	37 (15.5)	8 (15.1)	17 (40.5)	20.44	0.000
D	389 (98.5)	62 (100)	234 (98.3)	51 (96.2)	42 (100)	3.447	0.328
E	378 (95.7)	61 (98.4)	228 (95.8)	48 (90.6)	41 (97.6)	4.86	0.182
F	89 (22.5)	22 (35.5)	44 (18.5)	11 (20.8)	12 (28.6)	9.163	0.027
G	89 (22.5)	23 (37.1)	42 (17.6)	11 (20.8)	13 (31)	12.59	0.006

A- Some microorganisms can cause foodborne illnesses in chickens and consumers, B- Do you increase the dose and frequency when poultry disease persists, C- Antimicrobials should be added with feed to prevent diseases at any time, D- Good hygiene practices can help reduce foodborne illnesses and resistance, E- Foodborne illnesses affect public health and the economy, F- Have you ever heard of Salmonella, Campylobacter, *E. coli*, and *S. aureus*, G- These are among the most common antimicrobial-resistant foodborne pathogens in chicken, p = Significance value.

Assessment of smallholder chicken farmers' antibiotic use practices

Table 10 outlines the antibiotic usage practices among chicken producers. The most commonly used antibiotic was oxytetracycline (22.80%), while ciprofloxacin (0.52%) was among the least used. When illnesses occurred, nearly half (49.57%) of smallholder chicken farmers consulted a public veterinarian, whereas 8.53% used veterinary medicines without a prescription. In terms of frequency, 45.81% reported using antibiotics monthly to control disease outbreaks, while 38.58% used them only when their chickens were sick. The majority of farmers (86.6%) obtained antibiotics from private animal health service providers.

DISCUSSION

Smallholder farmers face challenges in reducing antibiotic use, as many studies have revealed that farmers believe it is difficult to maintain the health of commercial chickens without antibiotics—a situation exacerbated by intensive production systems that favor the emergence of disease outbreaks. In broiler chicken farms, antibiotics are often used to compensate for a lack of biosecurity experience, thereby putting consumers at risk of ingesting resistant microorganisms or antibiotic residues (Pym, 2013). Several studies have reported a risk of spreading anti-microbial resistance in sub-Saharan Africa due to insufficient data on knowledge, attitudes, and practices related to antibiotic prescription and use (Bedekelabou et al., 2022; Chilawa et al., 2022; Hassan et al., 2021; Mate et al., 2019; Siddiky et al., 2022). This study examined smallholders' KAP regarding antibiotic use in chicken farming, in which 60% of participants were women and 40% were men. These findings may disproportionately represent the characteristics of smallholder farmers in each area due to the purposive sampling method employed, introducing potential selection bias. Therefore, the high proportion of women reported here should be interpreted as a reflection of the districts studied rather than a true representation of all smallholder farmers in southern Mozambique. However, this result aligns with findings from Tanzania and Zambia, where women accounted for 52.2 and 56% of poultry producers, respectively (Kimera et al., 2020; Mirisho et al., 2023). In contrast, studies conducted in Burkina Faso (Sawadogo et al., 2023), southern Togo (Bedekelabou et al., 2022), and Zambia (Chilawa et al., 2022) reported higher proportions of male producers—93, 87, and 58%, respectively. These differences may be attributed to the nature of broiler chicken production, which often takes place in backyard settings where women and young people are responsible for both household and livestock management while men work outside the home. For many women, poultry farming serves as a means of supplementing household income and meeting basic family needs. Garsow et al. (2022) reported, after reviewing the literature, that women and youth constitute the main poultry producers in the smallholder value chain in Kenya. Similar findings from Zambia indicated that broiler production requires a relatively small initial investment and offers high returns, enabling women to engage in this activity to support school expenses, improve nutritional security, and enhance household food access (Mirisho et al., 2023).

The majority of respondents (46.8%) were married, 60.3% had secondary education, 76.7% lived in peri-urban areas, 53% were between 41 and 60 years old, and 38.7% had between 5 and 9 years of experience using antibiotics in chicken production. Chilawa et al. (2022) reported similar findings, where most respondents were between 20 and 35 years old and 54.7% had secondary education. Likewise, Kimera et al. (2020) found that participants were aged between 18 and 69

Table 5. Smallholder chicken farmers' attitudes on antibiotic use.

Variable		Total (%)	Education level				Test statistics		
			High school level (%)	Secondary school level (%)	Primary school level (%)	No formal education (%)	χ2	df	P value
A	Strongly Agree	104 (26.3)	17 (27.4)	56 (23.5)	16 (30.2)	15 (35.7)	40.045	6	0.000
	Agree	86 (21.8)	8 (12.9)	40 (16.8)	18 (34)	20 (47.6)			
	Disagree	205 (51.9)	37 (59.7)	142 (59.7)	19 (35.8)	7 (16.7)			
B	Strongly Agree	81 (20.5)	19 (30.6)	49 (20.6)	8 (15.1)	5 (11.9)	15.957	6	0.014
	Agree	288 (72.9)	42 (67.7)	171 (71.8)	38 (71.7)	37 (88.1)			
	Disagree	26 (6.6)	1 (1.6)	18 (7.6)	7 (13.2)	0 (0)			
C	Strongly Agree	86 (21.8)	20 (32.3)	51 (21.4)	8 (15.1)	7 (16.7)	10.647	6	0.1
	Agree	296 (74.9)	41 (66.1)	179 (75.2)	41 (77.4)	35 (83.3)			
	Disagree	13 (3.3)	1 (1.6)	8 (3.4)	4 (7.5)	0 (0)			
D	Strongly Agree	97 (24.6)	22 (35.5)	52 (21.8)	12 (22.6)	11 (26.2)	6.576	6	0.362
	Agree	286 (72.4)	38 (61.3)	178 (74.8)	39 (73.6)	31 (73.8)			
	Disagree	12 (3)	2 (3.2)	8 (3.4)	2 (3.8)	0 (0)			
E	Strongly Agree	33 (8.4)	6 (9.7)	18 (7.6)	3 (5.7)	6 (14.3)	11.136	6	0.084
	Agree	55 (13.9)	5 (8.1)	29 (12.2)	11 (20.8)	10 (23.8)			
	Disagree	307 (77.7)	51 (82.3)	191 (80.3)	39 (73.6)	26 (61.9)			
F	Strongly Agree	74 (18.7)	14 (22.6)	32 (13.4)	10 (18.9)	18 (42.9)	38.94	6	0.000
	Agree	143 (36.2)	28 (45.2)	75 (31.5)	21 (39.6)	19 (45.2)			
	Disagree	178 (45.1)	20 (32.3)	131 (55)	22 (41.5)	5 (11.9)			
G	Strongly Agree	105 (26.6)	25 (40.3)	58 (24.4)	15 (28.3)	7 (16.7)	14.262	6	0.027
	Agree	265 (67.1)	32 (51.6)	167 (70.2)	32 (60.4)	34 (81)			
	Disagree	25 (6.3)	5 (8.1)	13 (5.5)	6 (11.3)	1 (2.4)			
H	Strongly Agree	201 (50.9)	45 (72.6)	108 (45.4)	23 (43.4)	25 (59.5)	17.682	6	0.007
	Agree	188 (47.6)	17 (27.4)	126 (52.9)	29 (54.7)	16 (38.1)			
	Disagree	6 (1.5)	0 (0)	4 (1.7)	1 (1.9)	1 (2.4)			
I	Strongly Agree	164 (41.5)	32 (51.6)	94 (39.5)	20 (37.7)	18 (42.9)	4.813	6	0.568
	Agree	228 (57.7)	30 (48.4)	142 (59.7)	32 (60.4)	24 (57.1)			
	Disagree	3 (0.8)	0 (0)	2 (0.8)	1 (1.9)	0 (0)			

A- Antimicrobials are misused in poultry production, B- Use of antimicrobials may lead to AMR and residues, C- Missing dose of antimicrobial can lead to AMR and residues, D- Restricting use of antimicrobials benefits consumers, E- Antimicrobials should be added to feed to promote growth, F- Antimicrobials can be substituted with natural medicines, G- Antimicrobials must be stored in a specific space, H- Need guidance from pharmaceutical experts on administration, I- Antimicrobials should be discarded after expiry, p = Significance value.

Table 6. Effect of gender, age, education level, residence area, and training credentials on the food safety and use of antibiotics attitude of farmers.

Characteristic	Number of respondents (%)			P⁺-value	Mean ± SD	Range	P-value
	Poor (<50)	Medium (≥50 to <75)	Good (≥75)				
	n (%)	n (%)	n (%)				
Gender							
Female	3 (1.30)	179 (75.50)	55 (23.20)	0.636	68.23 ± 10.41	48.15-96.3	0.151
Male	4 (2.50)	119 (75.30)	35 (22.20)		68.31 ± 10.09	40.74-92.59	
Age of respondent							
Less than 20 years	0 (0.00)	18 (81.80)	4 (18.20)	0.572	68.01 ± 9.8	55.56-88.89	0.462
20-40 years	2 (1.60)	98 (76.00)	29 (22.50)		69.85 ± 9.71	40.74-96.3	
41-60 years	3 (1.40)	156 (74.30)	51 (24.30)		67.72 ± 10.55	48.15-92.59	
Above 60 years	2 (5.90)	26 (76.50)	6 (17.60)		65.69 ± 10.45	48.15-88.89	
Marital status							
Married	4 (2.20)	137 (74.10)	44 (23.80)	0.622	67.75 ± 10.76	40.74-92.59	0.639
Unmarried, living with a partner	3 (2.40)	91 (74.00)	29 (23.60)		68.08 ± 10.74	40.74-96.3	
Unmarried, living without a partner	0 (0.00)	49 (84.50)	9 (15.50)		68.52 ± 7.89	51.85-85.19	
Separated	0 (0.00)	12 (80.00)	3 (20.00)		72.35 ± 6.98	59.26-85.19	
Divorced	0 (0.00)	0 (0.00)	1 (100.00)		85.19	85.19-85.19	
Widowed	0 (0.00)	9 (69.20)	4 (30.80)		70.09 ± 10.53	55.56-85.19	
Education level							
High school level (Over 12)	1 (1.60)	44 (71.00)	17 (27.40)	0.552	71.62 ± 10.43	48.15-96.3	0.814
Secondary school level (grade 7-12)	4 (1.70)	185 (77.70)	49 (20.60)		66.68 ± 10.29	40.74-92.59	
Primary school level (grade 1-6)	2 (3.80)	40 (75.50)	11 (20.80)		67.65 ± 10.2	48.15-88.89	
No formal education	0 (0.00)	29 (69.00)	13 (31.00)		73.02 ± 7.28	55.56-92.59	
Residence area							
Rural	0 (0.00)	0 (0.00)	0 (0.00)	0.255	-	-	0.000
Peri-urban	7 (2.30)	230 (75.90)	66 (21.80)		67.03 ± 11.06	40.74-96.3	
Urban	0 (0.00)	68 (73.90)	24 (26.10)		72.3 ± 5.42	59.26-85.19	
Have you ever attended a training course on antibiotic use							
No	6 (2.10)	231 (81.90)	45 (160)	0.000	66.26 ± 9.67	40.74-92.59	0.000
Yes	1 (0.90)	65 (58.60)	45 (40.50)		73.51 ± 9.98	40.74-96.3	

n= Number of processors SD = Standard deviation, p⁺-value = for association by Chi-square test, p-value = for effect by one-way ANOVA, **Significance at p < 0.05, ***Significance at p < 0.001 and if there no star at p means no significance.

Table 7. Assessment of smallholder chicken farmers' practices on use of antibiotics.

Variable		Total (%)	Experience in the use of antibiotics in chickens				Test Statistics		
			Less than 5 years (%)	5-9 years (%)	10-20 years (%)	More than 20 years (%)	χ2	df	P value
A	Always	342 (86.6)	45 (93.8)	130 (86.7)	113 (79.6)	54 (98.2)			
	Sometimes	50 (12.7)	3 (6.3)	20 (13.3)	26 (18.3)	1 (1.8)	17.59	6	0.007
	Never	3 (0.8)	0 (0)	0 (0)	3 (2.1)	0 (0)			
B	Always	343 (86.8)	46 (95.8)	134 (89.3)	110 (77.5)	53 (96.4)			
	Sometimes	44 (11.1)	1 (2.1)	16 (10.7)	25 (17.6)	2 (3.6)	24.31	6	0.000
	Never	8 (2)	1 (2.1)	0 (0)	7 (4.9)	0 (0)			
C	Always	169 (42.8)	19 (39.6)	71 (47.3)	59 (41.5)	20 (36.4)			
	Sometimes	178 (45.1)	26 (54.2)	62 (41.3)	67 (47.2)	23 (41.8)	8.816	6	0.184
	Never	48 (12.2)	3 (6.3)	17 (11.3)	16 (11.3)	12 (21.8)			
D	Always	42 (10.6)	7 (14.6)	22 (14.7)	12 (8.5)	1 (1.8)			
	Sometimes	83 (21)	8 (16.7)	41 (27.3)	26 (18.3)	8 (14.5)	17.26	6	0.008
	Never	270 (68.4)	33 (68.8)	87 (58)	104 (73.2)	46 (83.6)			
E	Always	13(3.3)	0 (0)	4 (2.7)	8 (5.6)	1 (1.8)			
	Sometimes	69 (17.5)	7 (14.6)	31 (20.7)	31 (21.8)	0 (0)	20.4	6	0.002
	Never	313 (79.2)	41 (85.4)	115 (76.7)	103 (72.5)	54 (98.2)			
F	Always	339 (85.8)	45 (93.8)	125 (83.3)	116 (81.7)	53 (96.4)			
	Sometimes	43 (10.9)	1 (2.1)	21 (14)	21 (14.8)	0 (0)	14.51	6	0.024
	Never	13 (3.3)	2 (4.2)	4 (2.7)	5 (3.5)	2 (3.6)			
G	Always	118 (29.9)	2 (4.2)	46 (30.7)	52 (36.6)	18 (32.7)			
	Sometimes	27 (6.8)	2 (4.2)	12 (8)	12 (8.5)	1 (1.8)	24.14	6	0.000
	Never	250 (63.3)	44 (91.7)	92 (61.3)	78 (54.9)	36 (65.5)			
H	Always	270 (68.4)	45 (93.8)	100 (66.7)	88 (62)	37 (67.3%)			
	Sometimes	25 (6.3)	3 (6.3)	13 (8.7)	8 (5.6)	1 (1.8)	24.29	6	0.000
	Never	100 (25.3)	0 (0)	37 (24.7)	46 (32.4)	17 (30.9)			
I	Always	359 (90.9)	45 (93.8)	136 (90.7)	124 (87.3)	54 (98.2)			
	Sometimes	36 (9.1)	3 (6.3)	14 (9.3)	18 (12.7)	1 (1.8)	6.194	6	0.103
	Never	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)			

A- Do you use antibiotics to treat diseases in chickens, B- Do you use antibiotics to prevent diseases in chickens, C- Do you use antibiotics to promote growth in chickens, D- Do you store antibiotics at home, E- Do you increase the dose and frequency when poultry disease persists, F- Do you observe the withdrawal period before chicken slaughter, G- Do you sell chicken during the use of antimicrobials, H- Do you discard antimicrobials after expiry, I- Do you obtain information about the use of antibiotics from veterinary experts, p = Significance value.

Table 8. Effect of gender, age, education level, residence area, training credentials on use of antibiotics practices of producers.

Characteristic	Number of respondents (%)			P+-value	Mean ± SD	Range	P-value
	Poor (<50) n (%)	Medium (≥50 to <75) n (%)	Good (≥75) n (%)				
Gender							
Female	1 (0.40)	118 (49.80)	118 (49.80)	0.129	75.34 ± 6.1	48.15-96.3	0.004
Male	0 (0.00)	64 (40.50)	94 (59.50)		76.86 ± 6.2	55.56-92.59	
Age of respondent							
Less than 20 years	1 (4.50)	13 (59.10)	8 (36.40)	0.004	72.05 ± 8.76	48.15-81.48	0.664
20-40 years	0 (0.00)	61 (47.30)	68 (52.70)		76.51 ± 6.84	62.96-96.3	
41-60 years	0 (0.00)	93 (44.30)	117 (55.70)		76.07 ± 5.52	55.56-92.59	
Above 60 years	0 (0.00)	15 (44.10)	19 (55.90)		75.6 ± 4.48	62.96-88.89	
Marital status							
Married	0 (0.00)	89 (48.10)	96 (51.90)	0.272	76 ± 5.5	55.56-92.59	0.916
Unmarried, living with a partner	0 (0.00)	51 (41.50)	72 (58.50)		76.48 ± 7	55.56-96.3	
Unmarried, living without a partner	1 (1.70)	27 (46.60)	30 (51.70)		75.16 ± 6.97	48.15-88.89	
Separated	0 (0.00)	10 (66.70)	5 (33.30)		74.07 ± 5.6	66.67-85.19	
Divorced	0 (0.00)	1 (100.00)	0 (0.00)		74.07	74.07-74.07	
Widowed	0 (0.00)	4 (30.80)	9 (69.20)		76.07 ± 3.25	66.67-77.78	
Education level							
High school level (Over 12)	0 (0.00)	41 (66.10)	21 (33.90)	0.052	74.13 ± 6.16	55.56-88.89	0.015
Secondary school level (grade 7-12)	1 (0.40)	100 (42.00)	137 (57.60)		76.25 ± 6.37	48.15-96.3	
Primary school level (grade 1-6)	0 (0.00)	23 (43.40)	30 (56.60)		75.96 ± 5.01	62.96-88.89	
No formal education	0 (0.00)	18 (42.90)	24 (57.10)		76.9 ± 6.06	66.67-88.89	
Residence area							
Rural	0 (0.00)	0 (0.00)	0 (0.00)				
Peri-urban	0 (0.00)	135 (44.60)	168 (55.40)	0.095	76.37 ± 5.46	55.56-96.3	0.001
Urban	1 (1.10)	47 (51.10)	44 (47.80)		74.56 ± 7.96	48.15-88.89	
Have you ever attended a training course on food safety and antibiotic use							
No	1 (0.40)	119 (42.20)	162 (57.40)	0.03	76.25 ± 5.89	48.15-96.3	0.019
Yes	0 (0.00)	63 (56.80)	48 (43.20)		75.01 ± 6.73	55.56-92.59	

n: Number of processors SD: Standard deviation, p+-value: for association by Chi-square test, p-value: for effect by one-way ANOVA, **significance at p < 0.05, ***significance at p < 0.001, and if there is no star at p means no significance.

Table 9. Correlation matrix of demographic factors and food safety regarding antibiotic use variables.

Variable	Gender	Age	MS	EL	RA	Training	FSKA	FSAA	FSPA
Gender	1								
Age	-0.176**	1							
MS	-0.01	-0.173**	1						
EL	0.125*	0.075	0.083	1					
RA	0.174**	-0.265**	0.271**	0.258**	1				
Training	0.077	-0.026	-0.043	0.019	-0.067	1			
FSKA	0.01	-0.034	-0.076	-0.117*	-0.013	0.351**	1		
FSAA	0.004	-0.097	0.082	0.047	0.217**	0.318**	0.131**	1	
FSPA	0.121*	0.05	-0.04	0.096	-0.124*	-0.091	0.095	-0.222**	1

MS is marital status, EL is educational level, RA is residence area, FSKA is food safety regarding use of antibiotics knowledge, FSAA is food safety regarding use of antibiotics attitude, FSPA is food safety regarding use of antibiotics practice, ** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (1-tailed).

years, with 46.9% having secondary education; in addition, 63.7% were married, and most had been involved in chicken production for more than six months. These results are comparable to those of Sawadogo et al. (2023), who found that participants' ages ranged from 17 to 32 years, with more than 50% falling within this range, and 28.71% having no formal education. Similarly, Tonny (2022) reported that most chicken producers were between 36 and 45 years old (27.06%), and 36.47% had primary education, which closely aligns with the findings of this study.

Results from the present study also revealed that most smallholders were concentrated in peri-urban areas (76.7%), 71.4% had not received any training on antibiotic use, and 73.2% reported that chicken production was their main source of income. The high concentration of smallholders in peri-urban areas, particularly in Maputo Province, can be attributed to the province's status as the capital of the country, characterized by a high population density and proximity to major markets. Producers in these areas take advantage of the peri-urban setting to raise broiler chickens and supply urban markets. In Mozambique, most of the chicken meat sold originates from broiler chickens produced by smallholders, primarily located in urban and peri-urban areas, especially within Maputo Province (Bah and Gajigo, 2019; dos Muchangos, 2012; Pym, 2013).

Parallel studies by Hossain et al. (2022) and Sawadogo et al. (2023) also reported that few smallholders received formal training in poultry production—48.1 and 17.13%, respectively. Broiler chicken production has become an alternative source of livelihood in many developing countries, providing employment opportunities where formal jobs are scarce. Consistent with this, findings by Hassan et al. (2021) and Siddiky et al. (2022) indicated that poultry production serves as the primary source of income for most smallholders, surpassing agriculture and fishing in economic importance.

The results indicate notable disparities in knowledge regarding antimicrobial resistance (AMR) among the studied locations. Producers from KaMubukwana (37.1%), Massinga (41.1%), and Xai-Xai (46.9%) demonstrated greater awareness compared to other districts. Overall, a significant majority of farmers (72.1%) were unaware of AMR. Conversely, 27.8% believed it was possible to reduce antibiotic use in chickens. Additionally, 78.7% of producers acknowledged that antibiotic use can pose risks to human health, while 92.4% understood that indiscriminate antibiotic use can lead to residues, resistance, and adverse effects. Several previous studies have reported differing perspectives on the use of antibiotics in poultry production. Siddiky et al. (2022) reported findings consistent with the current study, showing that most farmers believe antibiotic use contributes to AMR, which affects human and animal health, the environment, and the economy. The authors further noted that poultry farmers often believe that commercial chicken production would not be viable without antibiotics, as disease prevalence would increase on farms—an attitude that encourages inappropriate antibiotic use. Similarly, Chilawa et al. (2022) found that poultry farmers had low knowledge about AMR (29.2%) and antibiotic use (46.2%). These results highlight a significant knowledge gap that can lead to irrational antibiotic use, as many farmers are unaware of the consequences of misuse. This underscores the need to raise awareness among producers about responsible antibiotic use.

Other researchers have observed that education level influences farmers' knowledge, with lower education associated with a higher risk of antibiotic overuse. Bedekelabou et al. (2022) reported poor antibiotic use among 43% of farmers, particularly those with limited education. However, disease management and biosecurity training have been shown to improve farmers' understanding of antibiotics and AMR (Tufa et al., 2023). Similarly, field school interventions in Kenya and Ghana enhanced antibiotic knowledge, attitudes, and practices,

Table 10. Assessment of smallholder chicken farmers' antibiotic use practices.

Variable	Frequency	Percentage
What are the common antibiotics you use?		
Tetracycline	214	18.62
Doxycycline	202	17.58
Ciprofloxacin	6	0.52
Enrofloxacin	183	15.93
Gentamycin	37	3.22
Amoxicillin	61	5.31
Ampi-cloxacillin	11	0.96
Metronidazole	22	1.91
Chloramphenicol	42	3.66
Oxytetracycline	262	22.80
Sulfamethazine	22	1.91
Sulfaquinoxaline	19	1.65
Sulfadiazine	22	1.91
Erythromycin	31	2.70
Streptomycin	15	1.31
What do you do when illnesses occur		
Use veterinary medicines without a prescription	63	9.11
Consult a public veterinarian	343	49.57
Consult a private veterinarian	169	24.42
Uses traditional medicines	105	15.17
others	12	1.73
What is the frequency of antibiotic use		
Once a month	317	45.81
Once a week	49	7.08
Use when the chicken is sick	267	38.58
Use antibiotics as growth promoters (1st and 2nd week)	59	8.53
Where do you get veterinary drugs?		
Veterinary pharmacy/agroveterinary	322	81.5
Private/Animal service provider	342	86.6
Friends/neighbors	3	0.8
Traditional healers	2	0.5
Buy in the Human pharmacy	7	1.8
Who administered the medicine/ antibiotics		
Myself	387	96.99
Veterinarian	1	0.25
Employee	11	2.76
Friends	0	0.00
How do you quantify the antibiotics to administer to the chicken?		
Observe the manufacturer’s instructions on the label	390	55.48
Do mental calculation	10	1.42
The veterinary agent gives instructions	303	43.10
Who shows you resources about the use of antibiotics		
Family members	161	27.33
Friends	104	17.66

Table 10. Cont'd

Neighbors	57	9.68
Veterinary professional	267	45.33
Where do you find for withdrawal period information?		
Veterinary professional	277	45.79
Label	280	46.28
Family member	48	7.93
What do you do when a chicken dies before or after treatment		
Normally use	186	30.90
Bury the dead animal	137	22.76
Burn the dead animal	102	16.94
Throw it away	11	1.83
Throw in the public trash container	137	22.76
others	29	4.82
How do you dispose of solid waste containing drugs left over after use		
Disposes directly into the environment	96	22.12
Throw in the public trash container	252	58.06
Dispose of in the farm pit	86	19.82
What do you do with the manure after removing the chickens		
Use as fertilizer	191	30.46
Sell	261	41.63
Offers	148	23.61
Dumped on farm facilities	27	4.31

ultimately eliminating antibiotic use in production systems (Caudell et al., 2022). These findings suggest effective strategies for reducing antibiotic misuse and curbing antimicrobial resistance. In Zambia, Chilawa et al. (2022) reported that farmers used 83% more oxytetracycline and had limited knowledge of AMR (46.2%), along with unfavorable attitudes and poor practices. In contrast, Siddiky et al. (2022) found that about half of the farmers (51.35%) had heard of AMR and believed that higher antibiotic doses could improve treatment outcomes, while 66.22% recognized the importance of observing the withdrawal period before selling or slaughtering chickens.

The potential for reducing antibiotic use and minimizing the associated health risks to consumers from chickens containing antibiotic residues was found to have statistically significant variables ($p = 0.000$), alongside a low level of knowledge observed in the Xai-Xai district (24.5%). An overwhelming majority of respondents agreed that observing an antimicrobial withdrawal period prevents antibiotic residues in chicken (98.5%), that administering the correct amount of antibiotics reduces AMR (97.2%), and that antimicrobials should be administered to all chickens when one is sick (94.2%). Consistent with the present findings, a study conducted in Bangladesh reported that most farmers stopped administering antimicrobials before completing the full treatment course and did not keep leftover antibiotics (Islam et al., 2023). Another study found that many farmers stored veterinary medicines at home, which increases the risk of poor handling and improper storage. Some producers also applied antibiotics to healthy animals, thereby heightening the likelihood of AMR development and the accumulation of drug residues in chicken meat (Kimera et al., 2020).

However, smallholders in the present study demonstrated good knowledge of the importance of observing the withdrawal period before selling chickens, administering antibiotics correctly, recognizing the adverse health effects of indiscriminate antibiotic use, and avoiding the treatment of entire flocks when only a few birds are sick. It was expected that knowledge about antimicrobial resistance and proper antibiotic use would vary across districts due to differences in farmer behavior. Many farmers reported receiving some training from chick supplier teams, but participation was not mandatory, which may have limited their overall understanding of the topic.

In Zambia, pharmacists demonstrated positive attitudes by encouraging smallholders to observe the withdrawal period and avoid selling broilers still under medication to

prevent the transmission of antimicrobial resistance to humans. They also advised farmers not to stop antibiotic administration once broilers showed improvement, emphasizing the importance of completing the full treatment course (Mudenda et al., 2022). In contrast, a study revealed that 84.8 and 93.2% of farmers sold chickens while still medicating them, suggesting that antibiotics were underdosed and potentially contributing to the AMR problem (Johnson et al., 2019). The authors noted that even when product labels lacked specific withdrawal period information, farmers were still required to observe it before selling their products. Improper use of antimicrobials due to inadequate labeling can lead to residues and antimicrobial resistance. Siddiky et al. (2022) reported that 44.59% of farmers strongly agreed that the antibiotic withdrawal period should be observed before selling chickens for human consumption. They were also encouraged to seek veterinary advice before using antibiotics, and those expressing interest in learning more about antibiotic use generally displayed positive attitudes. Regarding appropriate antibiotic use, smallholders reported receiving guidance at the point of purchase—covering dosage and duration of use—and were advised against selling chickens still undergoing treatment.

According to analogous studies conducted by Hassan et al. (2021) and Islam et al. (2023), farmers reported using antimicrobials either singly or in combination with other antimicrobials for disease treatment, and often added antibiotics to drinking water. Most smallholders reported adherence to the recommended antimicrobial withdrawal period. Farmers are required to comply with withdrawal periods to prevent antibiotic residues in broilers, thereby reducing risks to consumer health associated with antimicrobial resistance.

In a study by Abd-Elwahed et al. (2023), 56.2% of farmers lacked adequate knowledge of occupational health risks on chicken farms, and 58.7% had inadequate safety measures in place to address these risks. Kimera et al. (2020) found that farm activities such as antibiotic use and animal feed handling were not monitored. It was also observed that informal feed manufacturers were not regulated regarding the amount of antibiotics used, reflecting the indiscriminate use of antimicrobials.

The majority of smallholder chicken farmers (51.9%) in this study disagreed that antibiotics are underused; 72.9% agreed that excessive use can cause antimicrobial resistance and antibiotic residues in meat; 72.9% also agreed that restricting antibiotic use benefits consumers; 77.7% disagreed that antimicrobials should be added to feed to promote growth; and 18.7% strongly agreed that natural medicines could serve as alternatives. Similar observations were reported by Chilawa et al. (2022), who revealed that 83% of farmers used antibiotics on their farms for treatment (93.2%), prevention (89.8%), and growth promotion (19.3%), indicating that knowledge of antibiotics influences attitudes and practices regarding their appropriate use. The authors recommended farmer education on antimicrobial use (AMU) and AMR to raise awareness and promote prudent antibiotic application, thereby mitigating AMR.

A study conducted in Ghana similarly found that farmers used antibiotics for both therapeutic and prophylactic purposes, with 47% administering antibiotics weekly through drinking water, while others used both drinking water and feed (Johnson et al., 2019).

The study revealed that although some chicken farmers strongly agreed that misuse of antibiotics contributes to antimicrobial resistance, the majority lacked awareness of the actual risks associated with AMR due to limited access to information. Most farmers (41.5%) disposed of antibiotic packaging in waste containers after use to prevent environmental contamination.

According to Azabo et al. (2022), inappropriate antimicrobial use is often linked to weak regulatory enforcement in developing countries. The authors emphasized the need for public awareness on antibiotic use in animals, the integration of AMR surveillance data, and the establishment of measures to promote the judicious use of antimicrobials.

A significant negative relationship was observed between production location and attitudes toward antibiotic use ($p < 0.01$). Evidence suggests that farmers in peri-urban areas tend to use antibiotics indiscriminately, disregarding the recommendations of experts and drug suppliers. Kimera et al. (2020) also established a significant association between educational attainment and reduced antibiotic consumption ($\chi^2 = 13.03$, $p = 0.01$).

Moreover, 66.4% of participants expressed concern that antibiotic use in production poses risks to consumer health, while 53.1% believed it is possible to reduce antibiotic usage while maintaining high productivity. There was also a significant association between farming experience and good practices in antibiotic use: those with fewer years of experience were more likely to use antibiotics frequently for treatment and prevention, increase dosages when diseases persisted, and neglect withdrawal periods. These findings highlight the need for mandatory training for chicken farmers, focusing on appropriate antibiotic use.

Interestingly, female farmers demonstrated better practices in antibiotic use compared to males. This finding aligns closely with the observations of Tijani et al. (2023), who reported that farmers had limited knowledge of drug withdrawal periods—50.3% had never heard of them, 57.1% had never checked withdrawal information on medication labels before use, and 53.2% had sold broilers while they were still under medication. These results demonstrate that many farmers fail to observe the required treatment durations or withdrawal periods for antibiotics.

According to Hassan et al. (2021), AMR is linked to the improper and irrational use of antibiotics, incomplete

medication cycles, and a lack of knowledge about antimicrobial use. The authors added that reducing AMR requires the involvement of all stakeholders, including farmers, who are considered end users. According to Kimera et al. (2020), the high use of antibiotics in poultry farms can be associated with poor adoption of good hygiene practices, such as daily cleaning of poultry houses and equipment, disinfection before and after each production cycle, vaccination, and protecting poultry against disease vectors. A comparable study conducted in Bangladesh revealed that antibiotics were often used even in the absence of clinical signs, withdrawal periods were not observed, antimicrobials were sold without prescriptions from licensed veterinarians, and self-medication was common. This behavior was attributed to pharmacists who prioritize sales and provide veterinary assistance through resellers to smallholders, thereby promoting indiscriminate antibiotic use (Siddiky et al., 2022).

In the areas studied in the present research, the most commonly used antibiotics were oxytetracycline (22.8%) and tetracycline (18.62%). Approximately 49.57% of chicken farmers consulted public veterinarians when diseases occurred, 24.42% turned to private veterinarians, and 18.7% strongly agreed, while 36.2% agreed, to use traditional herbal medicines. However, few farmers reported using antipyretic drugs such as paracetamol to treat sick broilers. Poultry farmers also used medicinal plants such as boldo leaves, garlic mixed with lemon, aloe vera leaves mixed with garlic, hummingbird tree, cactus leaves, castor leaves, dried papaya leaves and moringa leaves to control respiratory diseases and diarrhea. Some farmers reported using detergent, hypochloric acid, and potassium chloride to deworm chickens in cases of diarrhea, a practice that may contribute to the accumulation of chemical residues that can cause cancer in humans.

To control disease outbreaks, 45.81% of farmers reported using antibiotics once a month, 8.35% used them as growth promoters, and 81.5% purchased antibiotics from public pharmacies. This finding was strikingly similar to that of Kimera et al. (2020), who reported that farmers use antibiotics for both treatment and prevention due to the high frequency of disease occurrence and the ease of purchasing antibiotics from private veterinary drug sellers. These sellers often encourage producers to buy antibiotics by claiming that doing so ensures higher productivity. Additionally, another study revealed that most veterinarians had poor knowledge of selecting appropriate antibiotics, determining correct doses and routes of administration, and interpreting laboratory results (Kalam et al., 2022). The authors attributed this to the fact that most veterinarians had only moderate educational levels and limited experience with antibiotic use. Almost all farmers (96.99%) administered antibiotics themselves, and 43.1% of veterinary agents explained the procedures for antibiotic use. Veterinary professionals provided instructions for antibiotic administration, and this approach was accessible to farmers since they were not required to pay travel fees for veterinary staff.

A related study in Burkina Faso reported that smallholders practiced self-medication, which was linked to their level of education. Those with higher education levels tended to use more antibiotics preventively or as growth promoters, often in an abusive manner (Sawadogo et al., 2023). In Tanzania, a similar study found that respondents were unaware of existing laws and regulations restricting the use of veterinary medicines. Consequently, they purchased antibiotics without prescriptions and faced no barriers to obtaining them. Treatment decisions were often based solely on clinical signs, which could lead to misdiagnosis, incorrect medication, and inappropriate dosing (Kimera et al., 2020).

In Bangladesh, 94.59% of farmers purchased antibiotics from private pharmacies, 87.84% reported using antibiotics according to manufacturers' instructions, and 90.54% disposed of expired and leftover antibiotics in open environments (Siddiky et al., 2022).

This evidence was similarly reported by Chilawa et al. (2022), who found that 87.8% of farmers obtained antibiotics from veterinary professionals, 23.1% consulted professionals regarding antibiotic use, and 46.3% relied directly on manufacturers' instructions. The most commonly used antibiotics were tetracycline (86.4%) and gentamicin (35.2%). Antibiotic use was also verified among 90% of farmers, who used them for both therapeutic and prophylactic purposes, with most antibiotics being purchased from veterinary pharmacies (Islam et al., 2023). The authors noted that self-administration of antibiotics among farmers may result in underdosage in chickens, leading to antimicrobial misuse.

Similarly, Sawadogo et al. (2023) found that farmers in Burkina Faso used leftover veterinary medications during disease outbreaks, even when advised against doing so by veterinarians. In Bangladesh, the lack of laboratory confirmation of poultry diseases and antibiotic susceptibility testing, coupled with communication challenges and farmers' low confidence levels, discourages them from consulting veterinary hospitals (Siddiky et al., 2022). As a result, farmers often overuse antimicrobials for preventive purposes, relying on personal experience or perceived disease risk. In addition, farmers in our survey acknowledged using antibiotics as growth promoters, particularly when supplied with "galito" chicks—a type that requires over 30 days to reach market weight—which negatively affects productivity.

Furthermore, 45.33% of farmers reported being introduced to antibiotics by veterinary professionals, while 27.33% learned about their use from family members. This finding was expected, as veterinary professionals often share their experiences with farmers during

antibiotic purchases, and family or friends commonly exchange profitable practices to enhance income and mutual support.

Comparable results were reported in Tanzania, where the majority of farmers (95.6%) administered antibiotics independently based on clinical signs and obtained them from veterinary services (84.1%). The study also found a significant association between the level of education and frequency of antibiotic use ($p = 0.04$), with 62.8% of farmers keeping antibiotic stocks at home (Kimera et al., 2020). Similarly, Kalam et al. (2022, 2021) observed indiscriminate antibiotic use in Bangladeshi poultry production, where some veterinarians prescribed multiple antibiotics without clinical monitoring and often used higher doses to hasten recovery.

In contrast, a study conducted in Zambia reported positive attitudes among pharmacists, who encouraged smallholders to observe the withdrawal period and refrain from selling chickens while still under medication to prevent the transmission of antimicrobial resistance to humans. Farmers were also advised not to stop administering antibiotics once the chickens showed improvement, as completing the full course of treatment is essential for effective recovery (Mudenda et al., 2022). Additionally, 45.79% of farmers consulted veterinary professionals about withdrawal periods, while 46.28% relied on product labels.

Similar findings were reported in Tanzania, where farmers acknowledged the importance of the withdrawal period but often ignored it to avoid economic losses. The lack of regulatory enforcement specifying withdrawal periods further contributed to non-compliance (Kimera et al., 2020). In Burkina Faso, antibiotics were also used as growth promoters, with farmers often accessing them through public veterinarians. Higher levels of formal education were associated with reduced antibiotic use among farmers (Emes et al., 2023).

Johnson et al. (2019) found that only 35.6% of farmers were aware of withdrawal periods, yet 84.8% sold chickens still undergoing antibiotic treatment. Farmers explained that they did not observe the withdrawal period due to production costs. Similar to the present study, it was concluded that factors such as low educational levels, limited exposure to training on proper antimicrobial use, inadequate awareness programs, and the habit of purchasing antibiotics from feed and drug retailers—often with dosage manipulation—contribute to the indiscriminate use of antibiotics (Hassan et al., 2021).

However, when chickens die before or after treatment, 30.9% of farmers reported consuming them, 22.76% discarded them in garbage containers, and 4.82% offered or sold them to others, including dog and cattle breeders who use them as feed for their animals. Although farmers are aware that the appropriate practice is to bury dead chickens, the associated costs often discourage them, and birds that die after three weeks are typically reused. In Burkina Faso, approximately 70% of participants reported consuming eggs and poultry meat from birds that were under treatment, recently treated, or had died, demonstrating a lack of biosecurity and an increased risk of transmitting infectious diseases to consumers (Sawadogo et al., 2023). Comparable findings were reported in Bangladesh, where 58.10% of farmers buried dead chickens, 9.45% discarded them in fields, and 13.51% disposed of them in water bodies (Siddiky et al., 2022). Similarly, Khalil et al. (2023) found that when treatment proved ineffective, farmers either consumed the chickens or sold them in local or neighboring markets. The authors noted that indiscriminate antibiotic use and the sale of chickens still undergoing treatment contribute to the spread of AMR.

Regarding the management of solid antibiotic waste, 58% of farmers disposed of it in public trash cans, 22.12% dumped it on the ground, and 19.82% placed it in pits. Improper disposal of such waste into the environment can result in pollution and the emergence of antimicrobial resistance. Another study found that nearly all farmers left expired and leftover antibiotics exposed in open environments (Siddiky et al., 2022). In terms of manure management, 4.3% of smallholders disposed of manure in the poultry courtyard, 41.6% sold it to vegetable producers, 30.46% used it as fertilizer on their own farms, and 23.6% provided it to gardeners and other farmers. Although manure reuse can be beneficial, applying it without prior composting poses serious risks to humans, plants, and the environment. According to Checcucci et al. (2020) and Sawadogo et al. (2023), the use of poultry manure as organic fertilizer can be detrimental to both environmental and human health, as it may contain antibiotic residues that persist for extended periods and contaminate crops or vegetables consumed by humans and animals. The authors argue that the disposal of untreated manure—either through open dumping or direct field application—can facilitate the spread of waste, antimicrobial-resistant organisms, and pathogens within the environment and food chain.

Additionally, farmers often dispose of contaminated litter and other waste materials directly into the environment, which attracts flies and poses further sanitary risks (Islam et al., 2023). Another study similarly reported that 90% of smallholders used manure as fertilizer in vegetable gardens, with some leaving fecal matter on their farms (Sawadogo et al., 2023). In Bangladesh, manure was managed differently depending on the farmer; it was kept in open areas, used in fish farming, utilized for biogas production, or applied to agricultural land (Siddiky et al., 2022).

A limitation of the KAP data collection approach is the potential for response bias caused by face-to-face interviews. Participants who recognized that the questions related to food safety may have provided socially desirable answers regarding good knowledge and practices, rather than reporting their actual behavior. Although enumerators were trained to mitigate this issue,

the findings categorized as “Good Practices” may reflect idealized knowledge rather than real-world practice.

This study represents the first assessment of KAP concerning antimicrobial use and resistance among smallholder farmers in southern Mozambique. The findings underscore the need for training programs aimed at promoting appropriate antibiotic use and adherence to withdrawal periods to prevent antibiotic residue accumulation in poultry meat. Furthermore, there is a need to raise awareness about the benefits of vaccination and the responsible application of medicinal plants for disease management to reduce the indiscriminate use of antibiotics and address the growing challenge of anti-microbial resistance.

Conclusions

This study evaluated smallholder farmers’ knowledge, attitudes, and practices regarding antibiotic use and resistance, revealing significant gaps in understanding related to waste management, antimicrobial resistance, and the sale of chickens undergoing antibiotic treatment, as well as the associated public health implications. The majority of participants were untrained and relied on commonly available human antibiotics such as oxytetracycline, tetracycline, and doxycycline. These inappropriate practices compromise the production of safe broiler chickens for human consumption and pose a serious public health concern due to the horizontal transmission of antibiotic-resistant microorganisms between animals and humans, particularly resistant and zoonotic bacteria such as *Salmonella*, *Campylobacter*, *Escherichia coli*, and *Staphylococcus aureus*.

Government-led initiatives are essential to educate smallholder farmers on the judicious use of antibiotics and proper waste management practices to mitigate environmental contamination and curb the spread of antimicrobial resistance. To reduce antimicrobial resistance and antibiotic residues, producers should receive targeted training and resources that promote responsible antibiotic use, especially for drugs shared between human and veterinary medicine.

The findings of this study provide critical insights for the development of antibiotic use monitoring programs, regulatory policies, and intervention strategies aimed at reducing the production and consumption of chicken contaminated with antibiotic-resistant microorganisms and residues, thereby minimizing public health risks and ensuring food safety.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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