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Article

Antimicrobial Use and Resistance: Knowledge, Attitudes, and Practices of Broiler Farmers in Mzimba, Malawi

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Abstract

Background: There is wide use of antimicrobials in chicken production worldwide. However, little is known about the factors that motivate poultry farmers towards antimicrobial use (AMU), and awareness of antimicrobial resistance (AMR), and how such factors can lead to AMR in bacterial poultry pathogens, particularly those isolated from chicken meat. **Objective:** To evaluate knowledge, attitudes, and practices about the use of antimicrobials among chicken farmers in the Mzimba district, Malawi. **Materials and methods:** A cross-sectional study was conducted involving 89 chicken farmers in Mzimba to assess their knowledge, attitudes, and practices (KAP) related to AMU and AMR. Data analysis was performed using STATA version 15, applying linear regression and Pearson correlations analysis for KAP scores. **Results:** Among the chicken farmers, 46.1%, 43.8%, and 42.7% demonstrated good knowledge, attitudes, and practices, respectively. Training on AMU and AMR was significantly associated with knowledge ($p = 0.002$) and practices ($p = 0.02$). There was a weak relationship among knowledge, attitudes, and practices scores with p -values of 0.2, 0.07, and -0.05. Gaps existed in coordination between veterinarians and farmers and all farmers (100%) were accessing antimicrobials from veterinary shops without consulting veterinarians. Farmers were not aware of policies related to AMR and AMU. **Conclusion:** chicken farmers exhibited low KAP levels on AMU and AMR. This situation constitutes an emergency of AMR and therefore underscores for policy development targeted enforce regulations, and improve KAP through trainings programs on AMU, AMR, and importance of consulting veterinarians in chicken production.

Keywords: antimicrobial resistance; antimicrobial use; awareness; chickens; antimicrobials; Malawi

1. Introduction

The poultry industry is increasing rapidly worldwide, with significant contributions from countries like the United States, China, and Brazil [1,2]. Globally, chickens account for 91% of the world's total poultry population and contribute to around 89% and 92% of poultry meat and egg production, respectively [3]. The increase in chicken meat production worldwide has a potential to improve human nutrition and health [2,4]. In Africa, South Africa stands out as the largest producer of poultry, generating 1.9 million metric tons of chicken per year [5]. Other significant poultry producers in this region include Nigeria, Egypt, Uganda, Tanzania, Morocco, Kenya, and Algeria.

Despite a surge in poultry production in Africa, Africans consume 3.3 kg of poultry meat per year, which is below the global average consumption of 14 kg [6]. However, there is still hope due to an increase in poultry consumption in Sub-Saharan Africa (SSA) with an annual average of 5.4%. Malawi, a SSA country, has made tremendous progress in poultry industry, with a lot of exports primarily to Mozambique and Tanzania [7]. Poultry production in Malawi is a major source of animal protein, and its demand has risen steadily since the mid-2000s due to economic growth and urbanization. Consumption is projected to reach about 110 thousand tons of chicken meat by 2030 [8,9].

Considering this rising demand, meat production improvement demands through increased feed conversion, growth rate promotion, and increased antimicrobial use to fight bacterial infections are widely employed. However, when the antibiotics are used in the absence of proper prescription and regulations, a selective pressure causes the bacteria to develop resistance to the antibiotics [10]. This poses a serious threat to both human and animal health, given the interconnected 'One Health' nature of antimicrobial resistance across these interfaces [11].

Several studies have shown that in Low- and Middle-Income Countries (LMIC) like Malawi, most farmers have limited awareness, knowledge, attitude and practices (KAP) on antimicrobials and use antibiotics without prescriptions from trained veterinary staff. In most cases, they rely on information from veterinary shop staff who are usually unqualified or inadequately trained to sell antimicrobials [12,13]. This training gap coupled with provision of wrong prescriptions to farmers by such individuals contributes to AMR in Malawi.

The majority of chicken farmers in Malawi lack proper training in poultry husbandry, including biosecurity and antimicrobial use, and there are currently no recommendations regarding the wise use of antibiotics in poultry and food animals. The presence of limited awareness and KAP levels regarding antimicrobial use among the majority of poultry farmers leads to inappropriate use on antimicrobials. Mzimba being a rural district, majority of chicken farmers produce chickens are at small scale and the veterinary drug market is not well established with presence of limited veterinary service provision among chicken and other livestock farmers.

Besides using synthetic drugs in poultry farming, anecdotal evidence has shown that some farmers use herbal remedies to treat infections in chickens although little is known about their efficacy and effectiveness. These factors, complexed with a surge in chicken meat consumption, low literacy and poverty levels could be contributing factors to high levels of AMR in Malawi to antibiotics commonly used in human infections such as tetracycline and co-trimoxazole which presents a critical public health and food safety challenge [14,15].

Recently, in Malawi, high prevalence of antimicrobial-resistant bacteria in food animals have been reported due to the misuse or overuse of antimicrobials [14]. Consumption of chicken meat contaminated with resistant bacteria such as *Escherichia coli* (*E. coli*), *Salmonella* spp., and *Enterobacter* spp. can lead to infections that are difficult to treat and manage. This results in increased morbidity, mortality, and healthcare costs [16]. Additionally, high levels of antibiotic use led to the accumulation of antibiotics in animal tissues to toxic levels, such as in chicken, that can be passed on to consumers. These antibiotic residues in chicken tissues pose significant risks to vulnerable consumers such as toxic allergic reactions and disruption of gut microbiota [18]. In regions with strict food safety standards, the presence of AMR bacteria in chicken can hinder market access for meat products which

can potentially contribute to malnutrition among the populations. Despite these challenges the burden of AMR in Malawi is still ill-defined.

Therefore, the burden of AMR in Malawi can be decreased by establishing surveillance programs, appropriate guidelines for the prudent use of antibiotics in food animals, in and biosecurity training programs for livestock farmers, technicians, veterinarians, and the general public on the rational use of antimicrobial drugs [17,18]. Training programs that emphasize the rationale use of antibiotics and effective management practices can benefit greatly from KAP about antibiotic use and resistance. This research aimed at assessing knowledge, attitudes and practices among farmer on antimicrobial use and resistance which are important for responsible use of antimicrobials while preventing antibiotic resistance. Consequently, this research findings have the potential to guide policy development and targeted interventions to curb the unregulated use of antimicrobials and spread of AMR in chicken farming.

2. Methodology

2.1. Study Area

The study was conducted in Mzimba North, targeting households of farmers keeping chickens and informal markets from February to May 2025. Located at Latitude: 11° 54' 0" S and Longitude: 33° 36' 0" E. Mzimba North is found in the northern region of Malawi, within the Mzimba district. This district covers an area of 10,430 km² and has a human population of approximately 610,944. Mzimba North includes areas such as Mzuzu, Ezondweni, Vwaza Wildlife Reserve, Ekwendeni, Mpherembe, and Mtwalo and Kapingo Sibande, which are notable for having a large population of people keeping chickens for both food and income (Figure 1).

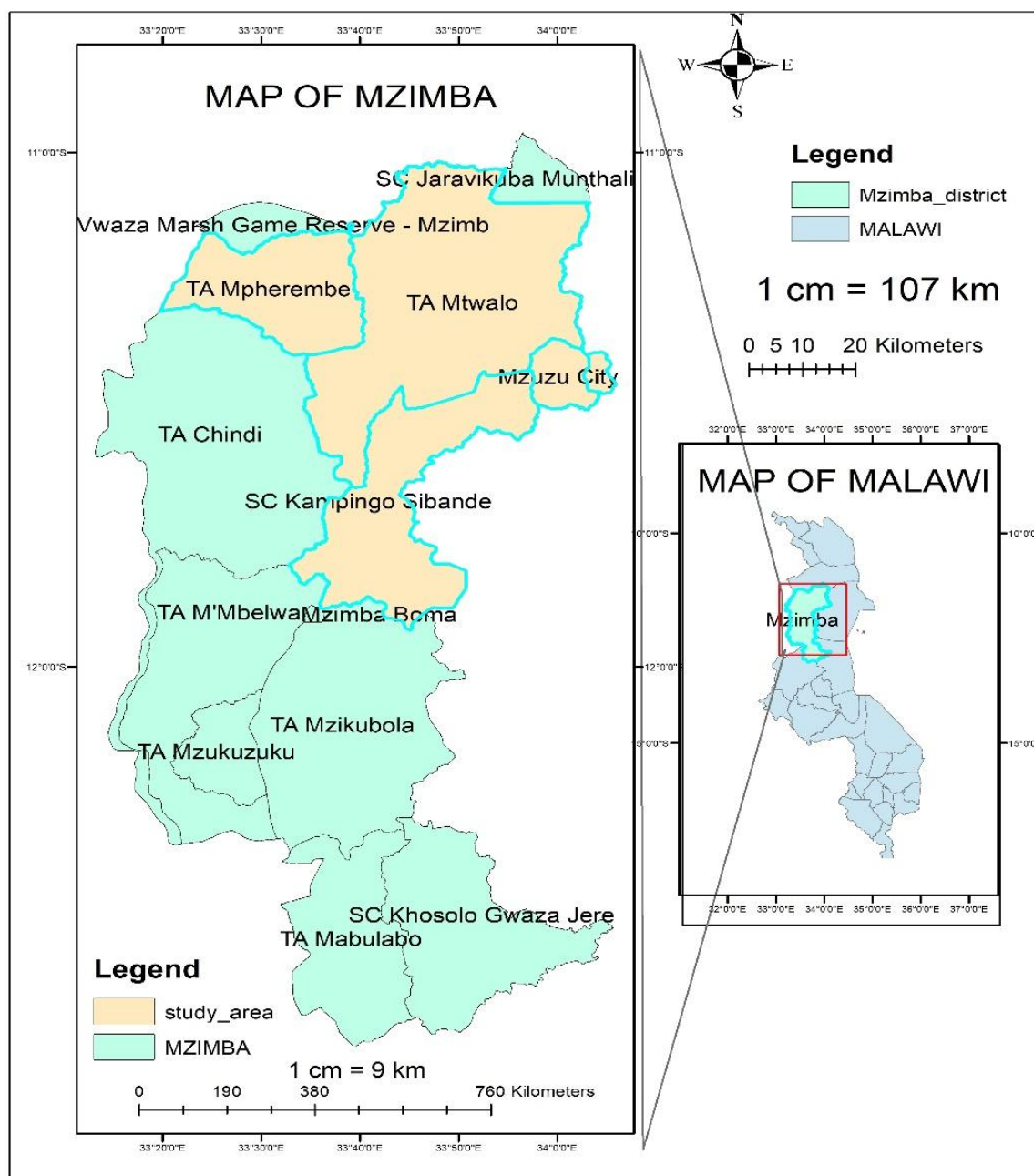


Figure 1. Study area: Map of Malawi showing the location of Mzimba district (highlighted in green rectangle on the right, where yellow colour areas represents study areas). The map was drawn using ArcGIS Vision 15 Software, (Esril California, USA).

2.2. Sample Size Determination and Sampling Techniques

The sample size was calculated using OpenEpi software, version 3 (www.openEPI.com), a tool designed for epidemiology statistics. Sample size was calculated using the formula: $n = [DEFF * Np(1-p)] / [(d^2 / Z^{2(1-\alpha/2)} * (N-1) + p * (1-p)]$, where

DEFF is Design effect: 1.0, N: is population size: (the total number of household farmers keeping broilers in Mzimba North), d: confidence limits as % of 100 (absolute +/- %: 5%), p: hypothesized % frequency outcome in a population: 50% +/- 5, and $\alpha = 0.05$, $Z = 1.96$.

The total sample size for the study was 89, while the study population (total number of broiler farmers in the area) was 114 according to the 2024 livestock data from Mzimba North. Potential participants were identified with the help of veterinary assistants, and a purposive and stratified sampling method was used to enroll chicken farmers in the study.

2.3. Inclusion and Exclusion Criteria

2.3.1. Inclusion Criteria

The study enrolled farmers residing in the aforementioned area, who were actively rearing chickens for meat during the time of the study and had provided consent. Those farmers with multiple animal types were also considered in this study, as long as they reared broiler chickens for commercial purposes.

2.3.2. Exclusion Criteria

The study excluded all farmers who were only keeping other animals other than chickens. Individuals who were less than 18 years, declined to participate and did not provide consent were excluded from the study.

2.4. Study Research Design

This study used a cross-sectional design to assess farmers' KAP regarding antimicrobial use. Broiler farmers were surveyed using a structured questionnaire to gather data on their KAP and understanding of antibiotic use.

2.5. Knowledge, Attitudes, and Practices Survey Development

The questionnaires were designed to cover a range of topics, including demographic information, an assessment of AMU conditions, and an evaluation of KAP connected with AMU and AMR among farmers. Most questions in the questionnaire were multiple-choice. Demographic information included age, gender, educational level, training in AMR, training AMU and years of experience in chicken farming. AMU-related questions addressed various aspects of poultry management, such as the types of antimicrobials used, their sources, storage practices, and overall farm management, including flock size, bird health, the specific antimicrobial used by farmers, and the recurrence of illness. Knowledge-related questions centered on AMU, antibiotic withdrawal periods, AMR transmission, and government regulations concerning AMU. Regarding perceptions of AMU and AMR, the attitude section investigated factors such as the use of prescribed antimicrobials and instances of overdosing. Finally, the practice-related questions aimed to gather information on sensitivity testing, adherence to full courses of antimicrobials, and whether farmers consult veterinarians.

2.6. Sample Collection

2.6.1. Semi-Structured Interviews (SSI)

Data collection was done using a self-administered structured questionnaire facilitated by the Kobo Collect tool. A pilot study involving 9 farmers was carried out to pretest the questionnaire for face and content validity, but the findings from the pilot study were not included in the analysis of the main study. The farmer was interviewed voluntarily after being fully informed about the survey's objectives, and their verbal consent was obtained before they could participate. Each consenting poultry farmer received a structured questionnaire designed to assess their KAP regarding AMU and AMR. The questionnaire was developed in English and then translated into Tumbuka, ensuring that all respondents were comfortable with the language used. Each interview lasted 20 to 30 minutes for each respondent.

2.7. Data Management and Analysis

The questionnaire was stored online on KoboToolbox (<https://www.kobotoolbox.org>). The data were then exported into Microsoft Excel worksheet-2016 for cleaning and management, and thereafter posted into STATA version 15 software, where all statistical analyses were done.

Descriptive statistical analysis of the responses captured using questionnaires was performed using Microsoft Excel worksheet-2016. STATA was used to compute correlation coefficients of the independent variables such as age, sex, marital status, education level, years in practice, formal training in AMU, and formal training in AMR against their dependent variables such as knowledge, attitude, and practices scores. Data coding was done for the variables, for instance, variables like knowledge, attitudes, and practice, each correct response was given a score of 1, while a wrong or doubtful response was scored as 0.

The study used the mean values as a cut-off point because there was no cut-off point to assess poor and better /good knowledge, attitudes, and practices. Scores above and equal to the mean were regarded as better knowledge, practice, and a positive attitude, while scores below the mean were considered as low knowledge, practice, and a positive attitude. Pearson's correlation test, T-test and linear regression analysis were used to compare the means of the knowledge, attitudes, and practices levels. In all the analyses, alpha was set at $P \leq 0.05$. Sensitivity analysis was used in the data management to deal with confounding variables.

2.8. Ethical Approval

Ethical approval was obtained from the Department of Animal Health and Livestock (DAHLD) in Malawi (Ref: NO DAHLD/AHS/01/2025/02). Informed oral consent was obtained from every chicken farmer before the interview. Before the interviews, the study objectives, interview process, and the usage of the data were fully understood by the participants.

3. Results

3.1. KAP Survey Results

3.1.1. Demographic Information

The study conducted a total of 89 farmer interviews. The interview results showed that the majority of smallholders were males (51%) with ages ranging from 31 to 40 years (30.3%). In addition, 70% (n = 62) of the chicken farmers had completed high school, at least 74% had never received formal training specifically in AMR or antibiotic use, and 32% (n = 32) of the breeders had less than 5 years of experience raising broilers Table 1.

Table 1. Demographic characteristics(n=89).

Variable	Categories	Frequency (%)
Gender	Male	51 (57%)
	Female	38 (43%)
Age group	20-30	13 (14.6%)
	31-40	27 (30.3%)
	41-50	21 (23.6%)
	Above 50	28 (31.5%)
Marital status	Single	15 (17%)
	Married	74 (83%)
Education level	No formal education	2 (2%)
	Primary	11 (12%)
	Secondary	62 (70%)
	Tertiary	14 (16%)
	0-1	10 (11%)

Number of years in poultry practice	1-4	29 (32%)
	4-10	21 (24%)
	More than 10	29 (32%)
Formal training of AMR	No	86 (97%)
	Yes	3 (3%)
Formal training of AMU	No	69 (78%)
	Yes	20 (22%)

3.1.2. AMU Situation Analysis Among Chicken Farmers

Most farmers relied on veterinary shop owners for advice on antimicrobial use, accounting for 58% of respondents. In contrast, 28% were relying on their own knowledge, only 11% were seeking advice from veterinarians. When it comes to sourcing antimicrobials, 89% were purchasing from agro vets unlike from veterinarians and the chief animal development officer Figure 1.

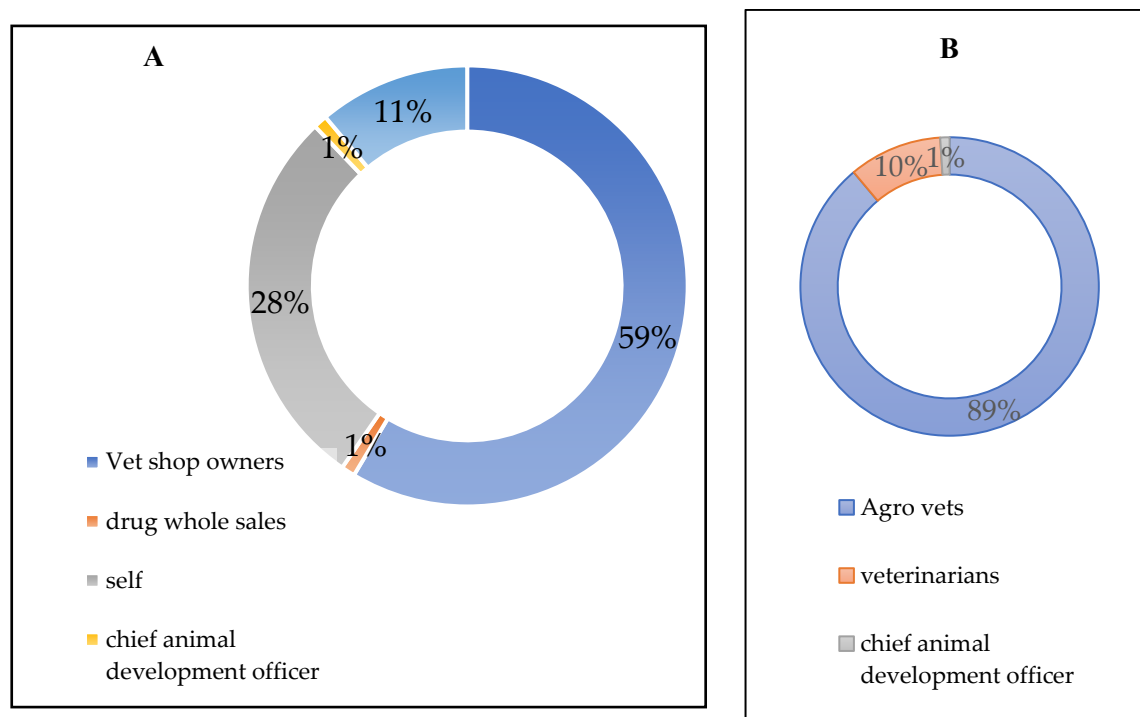


Figure 1. Source of antimicrobials(A), and advice among chicken farmers(B).

When it comes to selecting antimicrobials, the majority of the farmers (49%) indicated that they consulted shop owners, while a small proportion sought guidance from veterinarians and community health workers. For determining dosages, 52% (n=46) relied on their own judgment, 38% (n=34) consulted shop owners, and 7% (n=6) sought advice from Animal Vaccinators (AVOs) Figure 2. Selection(A) and dosage(B) determination of antimicrobials by farmers..

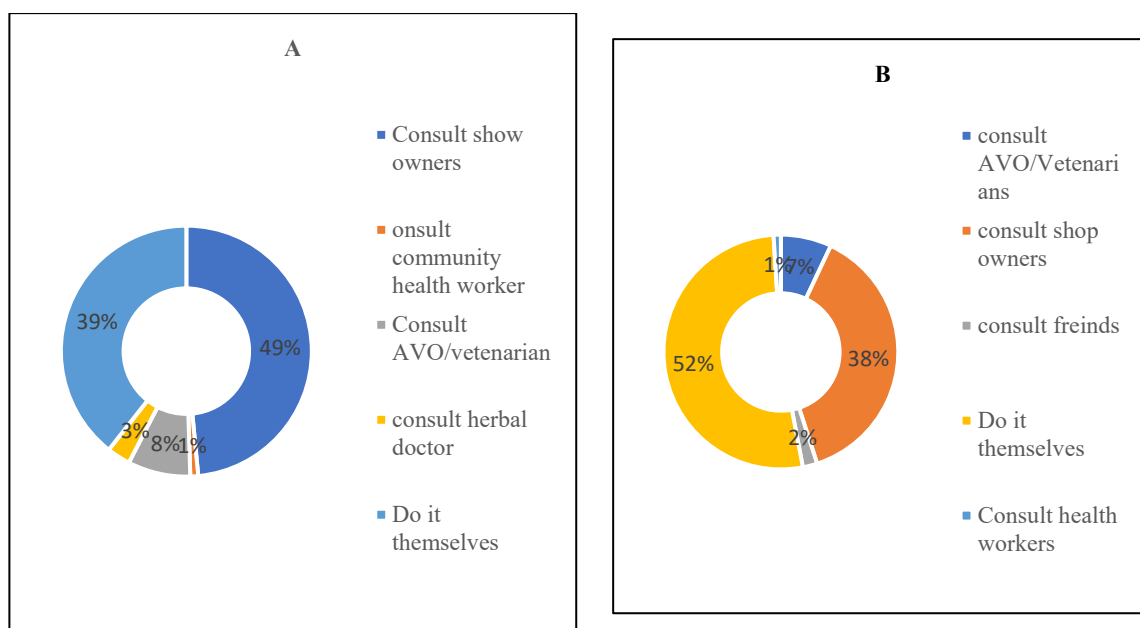


Figure 2. Selection(A) and dosage(B) determination of antimicrobials by farmers.

3.1.3. Information of Antimicrobial Prescription and Use

Seventy-six percent of farmers were aware that veterinarians have the authority to write prescriptions. However, 90% of respondents reported that veterinarians do not actually write prescriptions. Additionally, 97% of respondents indicated that veterinary shops do not require prescriptions Table 2. In terms of accessing antibiotics, 92% (n=82) purchased them from shops without prescriptions while 6% (n=5) from shops with prescriptions, 2% (n=2) sourced antibiotics from other shops, and 5% from shops that required prescriptions.

Table 2. Prescription of antimicrobials information.

Variable	Category	Frequency (%)
Who has the authority to write a prescription	Registered veterinarian	68 (76%)
	Not sure	9 (10%)
	Vet shop owners	6 (7%)
	Anyone	6 (7%)
Are prescriptions written	No	80 (90%)
	Yes	9 (10%)
Do the Veterinary medicine stores request for prescriptions for some antimicrobials like antibiotics	No	87 (97%)
	Yes	2 (2%)

To evaluate how AMU is monitored in chicken production, farmers were asked to identify the responsible individuals overseeing AMU on their farms. According to the responses, 93.3% of the farmers indicated that the Department of Animal Health and Livestock Development (DAHLD) is responsible for monitoring AMU. Additionally, 31% reported that agrovets shops play a role in checking AMU on farms, while 20% indicated that the Malawi Pharmacy and Medicines Regulatory Authority is responsible. Furthermore, 11% mentioned the Malawi Bureau of Standards, and 6.7% reported that the Poison and Medicine Board is mandated for this oversight.

3.1.4. Challenges Faced by Farmers to Continue the Use of Antimicrobials in Chicken Farming

A high prevalence of chicken diseases was reported by 84.2% (n=75) of respondents as the primary challenge forcing them to use antimicrobials. Additionally, 2.3% cited the limited availability of vaccines as a reason for antimicrobial use. Furthermore, 12.4% (n=11) indicated that they use antimicrobials to maintain productivity and profitability, while 1% reported using antibiotics due to difficulties in accessing veterinary professionals. Some of the diseases reported infecting chickens include Gumboro disease, bacterial infections, worm infestations, viral diseases, and other unidentified illnesses Figure 3.

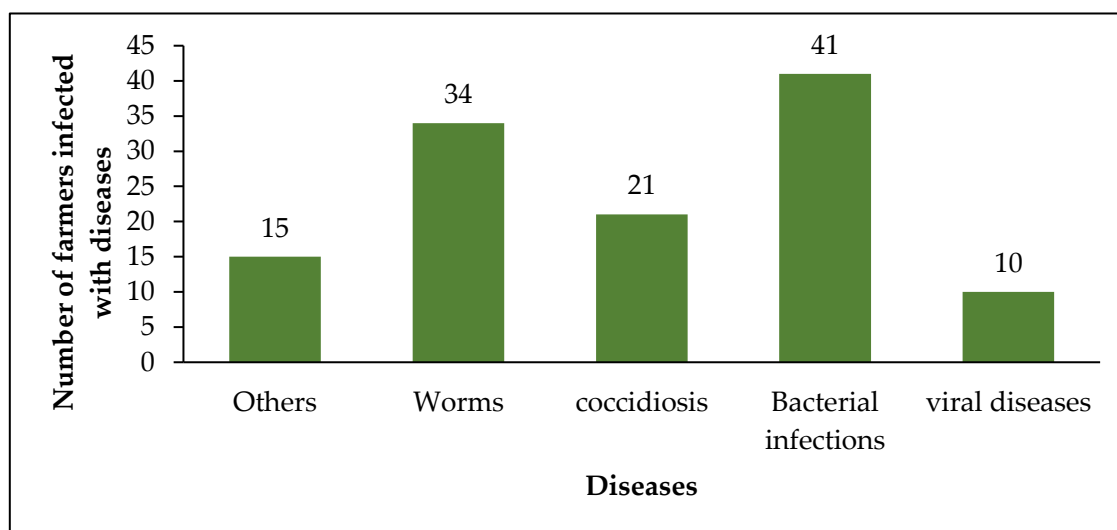


Figure 3. Diseases infecting chickens mentioned by farmers.

In terms of antibiotics commonly used by farmers, most farmers reported tetracycline (63%), sulfonamides (22.5%), and quinolone (16.8%) Table 3. Apart from conventional or modern antibiotics, 11.2% of the farmers (n=10) were using natural herbal medicine to treat chicken infections. The following were some of the herbal antibiotics used by farmers that were reported: Guava extracts (*Psidium guajava*), Moringa, majick powder, Alouvela (*Aloe barbadensis miller*), avocado (*Persea americana*), eucalyptus, duhat (Java plum, *Syzygium cumini*), tamarind (*Tamarind indica*), and natural antibiotics (plant-derived compounds). Apart from herbal medicine, 6.7% farmers (n=6) were using diaglow (a pesticide) as an antibiotic.

Table 3. Classes of antibiotics used by farmers in the study area.

Class of antibiotics	Antibiotics mentioned by farmers that they use in poultry farming	Number of farmers (%)
Tetracycline	Alamycine, Trimovate, oxyfarm, Trimo farm, egocin, oxysol, tetracycline, limoxin,	56 (63%)
Quinolone	Arysel, interflox, livita, enflolaxin, limox.	15 (16.8%)
Trimethoprim and /sulphamethzole	Intertrim, Vitamed, Trisulmycine, Bactrim, co-trimoxazole	20 (22.5%)
Penicillin	Contrivet (amoxicillin), democycline, piperacillin,	5 (5.6%)
Aminoglycosides	Neomycin, biosole	3 (3.4%)

cephalosporin's	Vetox	1 (1%)
Tylosin	Dawa tyloodoxy, Batylocin	2 (2.2%)

3.1.5. Knowledge About National Policies Related to the Use of Antimicrobials and AMR

To assess knowledge of farmers about national policies related to antimicrobial use in chicken farming, 93.2% (n= 83) of the farmers were not aware of national polices, while 6.8% (n=6) farmers were aware of national policies. These farmers, who were aware of national policies, had attended secondary schools and tertiary institutions. The farmers who reported that they knew national policies mentioned that they do not follow such policies. While the farmers who reported that they don't know national policies stated that most of them don't know such regulations, others reported that people don't follow laws, and others said the government is not implementing such laws related to AMU. Farmers who reported that they know National policies related to the use of drugs and AMR provided the following recommendations: providing increased access to antimicrobials, and increasing farmers' training and awareness.

3.1.6. Knowledge of Chicken Farmers About AMU and AMR

Mean total score of respondents of total of 11 questions designed to assess the knowledge of respondents toward AMU and AMR Table 4 was 9.4 ± 0.49 . Using the mean score as a cut-off point, only 46.1% of respondents demonstrated proficiency by providing correct answers above the mean of the questions, while the remaining 53.9% yielded responses falling below the mean.

Of the 89 farmers, 25% (n=22 respondents) recognized AMR as a serious public health problem, while 75% (n=67 respondents) did not. About 95% had heard about AMU and 98% had never heard anything about AMR. In regards to the knowledge of antimicrobial transfer via chicken products, 96% (n=85 respondents) knew that antimicrobials can be transferred to the humans via chicken products, and 91% of them knew that inappropriate use of antimicrobials can lead to the development of AMR. Among 89 farmers, 97% reported that it is wrong to sell chicken meat before the withdrawal period, and 94% reported that antimicrobial residues could be serious to public health; however, 27% were aware that use of antimicrobials in feed formulation is inappropriate. Notably, 63% were aware of the institutions that control sales of the antimicrobials, and 70% were aware that the lack of control over the sales of antimicrobials can lead to AMR Table 4.

Table 4. Knowledge of chicken farmers on AMU and AMR.

Variable	yes	No
Knowledge		
Do you know that antimicrobial resistance is a serious public health problem?	22 (25%)	67 (75%)
Does the Government of Malawi have a policy/framework for antimicrobial use in animals?	32 (36)	57 (64%)
Heard of AMR	84 (94%)	5 (6%)
Heard of AMU	87 (98%)	2 (2%)
Do you know that antimicrobials can be passed on to humans through the consumption of chicken products?	85 (96%)	4 (4%)
Do you know that inappropriate use of antimicrobials can lead to the development of the AMR?	81 (91)	8 (9%)

Do you know that it is wrong to sell your animal products (meat) before the withdrawal period is over after administering?	86 (97%)	3 (3%)
Do you know that antimicrobial residues in poultry animals could be hazardous for public health?	84 (94%)	5 (6%)
Do you know that the use of antimicrobials in feed formulation is inappropriate?	24 (27%)	65 (73%)
Do you know who controls the sale of antimicrobials?	56 (63%)	33 (37%)
Do you know that lack of control in the sales of antimicrobials contributes to AMR?	62 (70%)	27 (30%)

The coefficient analysis revealed significant relationships between gender, education level, training in AMR and AMU with farmers' knowledge scores Table 5. In contrast, age, marital status, and years of poultry farming experience showed no significant associations.

Table 5. Correlation of independent variables with knowledge scores.

Variable	T-test	significance
Age range group	-0.04	0.969
Gender	2.65	0.010
Marital status	0.42	0.678
Years in poultry farming	0.03	0.978
Education level	54.64	0.000
AMU training	2.59	0.011
AMR training	3.27	0.002

3.1.7. Attitudes of Chicken Farmers on AMU and AMR

Mean total scores of respondents for total of 14 questions designed to assess the attitudes of respondents toward AMU and AMR was 30.47±49. Using this as a cut-off point, only 43.8% of respondents demonstrated proficiency by providing correct answers to over 30% of the questions, while the remaining 56.2% yielded responses falling below the mean. On safety, 98% (n=87) of the respondents strongly agree that antimicrobials are safe for humans and animals, and 91% (n=81 respondents) strongly agree that antimicrobials are needed for any animal illness. About 93.26% (n=83) of the respondents strongly agree that broad-spectrum antimicrobials are capable of curing any infection.

Out of 89 farmers, 82% (n=73) strongly agreed that antimicrobials are needed to prevent serious illnesses, but only 35% (n=34) strongly disagreed with adding antimicrobials in feed. 94% of respondents strongly agree that non-prescribed antimicrobial sales should be prohibited, 57% of the respondents strongly agree that antimicrobials are needed during weather/season changes, and 63% strongly agreed that they are needed for fever/cold.

In regards to disease symptoms, 79% (n=70) strongly agreed that stopping antimicrobials after symptoms disappear is safe to preserve them for the future, and 96% (n=85) strongly agreed that missing doses contribute to AMR. In terms of overdosing of antimicrobials, only 33% (n=29) strongly agreed that overdosing could lead to AMR, with 39.3% (n=35) strongly disagreeing, 62% (n=55) strongly agreed that vaccination can reduce antimicrobial use. Seventy-nine percent (n=70) of the respondents strongly disagreed that it is not good to use expired drugs in treating chicken diseases,

and 78% (n=69) of the respondents strongly disagreed that it is safe to eat animals that die during the course of treatment Table 6.

Table 6. Attitudes of farmers on AMU and AMR.

Variable	category	Frequency (%)
Antimicrobials are safe, so they are commonly used in human and animals.	Strongly agree	87 (98%)
	Strongly disagree	1 (1%)
	Neutral	1 (1%)
Antimicrobials are needed for the treatment of any type of illness in animals.	Strongly agree	81 (91%)
	Neutral	3 (3%)
	Agree	2 (2%)
	Disagree	2 (2%)
	Strongly disagree	1 (1%)
It is better to make sure that animals are cured by broad-spectrum antimicrobials?	Strongly agree	83 (93%)
	Neutral	3 (3%)
	Agree	2 (2%)
	Disagree	1 (1%)
Antimicrobials are needed to prevent only serious illness?	Strongly agree	73 (82%)
	Neutral	10 (11%)
	Agree	2 (2%)
	Disagree	2 (2%)
	Strongly disagree	2 (2%)
non-prescribed antimicrobial sales should be prohibited?	Strongly agree	84 (94%)
	Agree	3 (3%)
	Strongly disagree	2 (2%)
	disagree	
When weather/seasons change, antimicrobials are needed for animals?	Strongly agree	51 (57%)
	Agree	4 (4%)
	Neutral	26 (29%)
	Disagree	2 (2%)
	Strongly disagree	6 (6%)

When animals have a fever/cold, antimicrobials are needed?	Strongly agree	56 (62)
	Agree	19 (21%)
	Neutral	6 (7%)
	Disagree	4 (4%)
	Strongly disagree	4 (4%)
Once the animals are cured, it's important to stop the dosage so that they are kept safe in case the animals get sick again in the future and can be re-used?	Strongly agree	70 (79%)
	Agree	6 (7%)
	Neutral	10 (11%)
	Strong	3 (3%)
	disagree	
It's safe to eat an animal if it dies in the course of treatment	Strongly agree	2 (2%)
	Neutral	4 (4%)
	Disagree	14 (16%)
	Strongly disagree	69 (78%)
	disagree	
Overdosing can lead to AMR	Strongly agree	29 (33%)
	Agree	2 (2%)
	Neutral	11 (12%)
	Disagree	12 (13%)
	Strongly disagree	35 (39%)
Missing a dose of antimicrobials may contribute to antimicrobial resistance?	Strongly agree	85 (96.5%)
	Agree	1 (1%)
	Neutral	1 (1%)
	Disagree	1 (1%)
	Strongly disagree	2 (2%)
Vaccination can reduce the use of antimicrobials in animal farms?	Strongly agree	55 (62%)
	Agree	2 (2%)
	Neutral	25 (28)
	Disagree	1 (1%)

	Strongly disagree	6 (7%)
Antimicrobials should be added to feed at any time to prevent animals from becoming sick.	Strongly agree	17 (19%)
	Agree	3 (3%)
	Neutral	22 (25%)
	Disagree	16 (18%)
	Strongly disagree	31 ((35%)
Expired antimicrobial can be given to animals when they are sick rather than waste/dispose it?	Agree	5 (6%)
	Disagree	14 (16%)
	Strongly disagree	70 (79%)

Coefficients analysis revealed that all the independent variables were not significantly correlated with the farmers' attitudes on AMU and AMR Table 7.

Table 7. Correlation of independent variables with attitudes scores.

Variable	T-test	Significance
Age range group	1.14	0.257
Gender	-0.55	0.585
Marital status	-0.67	0.508
Years in practice	-0.95	0.345
Education level	-0.65	0.519
Training AMU	1.00	0.319
Training AMR	0.95	0.346

3.1.8. Practices of Chicken Farmers About the Use of Antimicrobials

The mean score of a total of 9 practices questions administered to poultry farmers regarding their practices on AMU was 4.4 ± 0.18 . Using total mean score as cut off point, 47.5% demonstrated proficiency by correctly answering the questions above the mean score of 4.4, while 59.3% exhibited responses that fell below this mean score.

Notably, 94% (n=84) of the respondents reported that they treated animals without conducting antimicrobial sensitivity tests, while 6% provided treatment after laboratory tests. It was also found that 51% mentioned that they do not consult anyone when chickens are sick. Apart from the consultation, 63% (n=56) of the respondents selected antibiotics themselves, and 68% (n=61) decided dosage themselves.

Despite the farmers administering drugs themselves, 91% (n=81) reported that they allow their chickens to complete the full course of antimicrobial treatment when treated by veterinarians. Again, 84 % (n=75) reported that they check expiry dates. It was also discovered that 92% (n=82) stop administering antibiotics when symptoms disappear. In terms of disposing off drugs, 92% (n=82) mentioned that they burn or bury expired drugs, 64% (n=57) reported that they throw them away, 6% (n=5) put them in animal feed, 2% reported that they return them to the veterinary laboratory. Most farmers dispose of expired drugs appropriately, but a small proportion misuse them. It was also found that 80% of farmers increase dose/frequency when clinical symptoms persist Table 8.

Table 8. Practices of chicken Farmers on AMU and AMR.

Variable	category	Frequency (%)
What do you do when animals sick	Treat without sensitivity tests	84 (94%)
	Treat after carrying out sensitivity tests at the laboratory	5 (6%)
Whom do you consult when animals are sick?	No body	46 (51%)
	Assistant veterinarian	25 (28%)
	Farmer technician	10 (11%)
	Veterinarian	8 (8.99%)
Whom do you consult for selection of antimicrobials and its dosage?	No body	56 (63%)
	Assistant veterinarian	23 (26%)
	Farmer technician	6 (7%)
	Veterinarian	4 (4%)
Whom do you consult for the preparation and administration of antibiotics	No body	61 (69%)
	Assistant veterinary	17 (19%)
	Farmer technician	7 (8%)
	Veterinary	4 (4%)
Do you allow your animals to complete the entire course of antimicrobials as prescribed by the veterinarian?	No	8 (9%)
	Yes	81 (91%)
Do you check the expiry date of the antimicrobials before administering them/selling them	No	14 (16%)
	Yes	75 (84%)
Do you continue issuing antibiotics when the symptoms disappear	No	82 (92%)
	Yes	7 (8%)
What do you do when you realize that the antimicrobials have expired?	Burn/bury them	82 (92%)
	Throw them	57 (64%)
	Put them in animal feed	5 (6%)
	Return to veterinary labs	2 (2.2%)
	Use them	2 (2.2%)
Do you increase the dose and frequency of antimicrobials when there are clinical symptoms?	No	17 (19%)
	Yes	72 (80%)
Bad	51 (59.3%)	
Good	38 (42.7)	

Coefficients analysis between the independent variables (age, gender, marital status, years in practice, and education levels) were tested against the dependent variable (practices) using STATA.

The findings revealed that only AMR training was significantly correlated with the practices ($p = 0.024$) Table 9.

Table 9. Correlation of independent variables with practices scores.

Variable	T-test	Significance
Age range group	-0.44	0.659
Gender	0.87	0.388
Marital status	-0.54	0.591
Years in practice	-0.53	0.596
Education level	0.24	0.809
AMU training	1.32	0.191
AMR training	2.29	0.024

A correlation test between knowledge against attitude, and practices was further conducted by using Pearson's correlation test. As per the criteria by Said et al.(2020), the correlations were ranked as $0 - 0.25 =$ weak correlation, $0.25 - 0.5 =$ fair correlation, above $0.5 =$ Good correlation. Therefore, the correlation analysis between knowledge and attitude score indicated there was a weak positive relationship between knowledge and attitude among participants in the study (0.22). This means that the attitude of the poultry farmers towards AMU and AMR were influenced by their knowledge. At the same time, knowledge about AMU and AMR influenced respondents' attitudes Table 10.

The correlation analysis between knowledge and practice score indicated that there was no linear relationship between knowledge and practice among participants in the study (0.07), suggesting that the practices of the poultry farmers towards AMU and AMR do not influence their knowledge. In contrast, the correlation analysis between practices and attitude score indicated there is a negative relationship between practice and attitude among participants (-0.0539). This means that their knowledge influenced the attitude of the poultry farmers towards AMU and AMR. At the same time, attitudes about AMU and AMR influenced their practices Table 10.

Table 10. Correction of KAP of farmers on AMU and AMR.

Variables	Coefficient	P-value
Knowledge and attitudes	0.2097	0.0486
Knowledge and practices	0.0732	0.4957
Attitudes and practices	-0.0539	0.6162

4. Discussion

4.1. AMU Situation Analysis

According to the authors, this is the first study to assess KAP in relation to AMU and AMR in Malawi's Mzimba district. The study revealed that the majority of the poultry farmers in Malawi obtain antimicrobials from agrovets and rely on veterinary shop owners for advice related to antimicrobial sources and selection of antimicrobials that are used in broiler chicken production. This is a similar scenario in other settings, such as in Bangladesh, Nigeria, and Fiji, where the majority of the poultry farmers obtain antimicrobials from feed sellers, and they also do not consult veterinarians for proper prescriptions [20–23]. This is largely due to economic reasons and dissatisfaction with the previous services offered by the government's veterinary officers, which exacerbates AMR [20,21].

The most commonly used antimicrobials from this study were comparable with the studies conducted in Malawi and other global settings [19,26,27,31]). For instance, tetracycline, sulphonamides, oxytetracycline, and quinolones have been reported previously in Malawi, Bangladesh, Ethiopia, and Nigeria. However, quinolone use was not rampant in the present study compared to other settings. These differences suggests variation in geographical location, disease burden, management systems, economic related matters and distribution of the antibiotics. Interestingly, most of these antibiotics are mostly dispersed by veterinary shop owner as reported by the present study and others [19,26,27,31] . This implies that distribution of these antibiotics is not satisfactory and the regulatory bodies must tighten access to such antibiotics because these are similar antibiotics used in treatment of human infections. The overuse of tetracyclines and other antibiotics in the poultry and other animal production increases the risk of AMR [30,32,33, 34,37].

According to the World Organization for Animal Health, all of these antibiotics apart from polypeptides are considered to be very important antibiotics in veterinary use [24]. Tetracyclines are classified as highly important antibiotics used in humans, while aminoglycoside, macrolides, polypeptides, and sulfonamides have been listed as important antibiotics [25]. It is inappropriate to utilize critically important antimicrobials for controlling the spread of clinically diagnosed infectious diseases within livestock or treating livestock with clinically confirmed transmissible diseases.

WHO recommends that medically important antibiotics should not be used in animals which is not the case in Malawi where most of the farmers use Bactrim and amoxicillin to treat infections in chickens [26]. These antibiotics are supposed to be reserved for the treatment of infections in humans. However, poverty drives the famers to be using such antibiotics in chicken production with the aim to increase productivity of their enterprises. For instance, farmers reported that they are unable to buy recommended antibiotics to treat chickens because of financial problems. Others reported that they use bactrim and amoxicillin because they get them for free from government hospitals. After failing to complete the dosage they use the remaining antibiotics to treat infections in chickens rather than letting them to get being expired. AMR is fueled by this type of antibiotic misuse and overuse. When antibiotics are used in broiler chicken treatment and not follow the antibiotic withdrawal period, their residues are consumed together with the meat by humans. This promotes the development of bacterial antibiotic resistance (AMR) due to the inadequate concentration of antibiotics [27].

Although World Animal Protection bans routine antibiotic feeding to farm animals, limits antibiotic usage to sick individual animals, and outlaws reimbursement for low-welfare practices [28]. In this study, most farmers reported using Egocine as growth promoter as well as antibiotic. Egocine contains oxy-tetracycline hydrochloride as a main antibiotic and water- and fat-soluble vitamins which is used as routine growth promoters in chickens. This practice is not only unacceptable but also is against action plan implemented by FAO which prohibits the use of antibiotics as feed additives for livestock and poultry growth aimed at combating AMR [29]. Some nations have outlawed the use of antibiotics as growth promoters in livestock production, but Malawi is an exception.

The reliance on farmer's judgment based on selection and determination of dosage for antibiotic use as evidenced in this study can lead to unintended misapplication, including incorrect dosages, inappropriate treatment durations, and unnecessary use, ultimately contributing to antibiotic resistance, and posing risks to public health [30]. The popularity of certain types of antibiotics, like tetracycline's and aminoglycosides, reflects global trends and highlights the importance of using antibiotics carefully [31]. Farmer's must follow internationally recognized guidelines, such as those set by the World Organization for Animal Health, to ensure responsible use of antibiotics and prevent potential public health and food safety implications.

It was discovered in this investigation that some farmers were using herbal remedies. The majority of farmers who acknowledged using these remedies said they don't use synthetic antibiotics. Although they are not sure of their dosage and withdrawal period because the pharmacokinetics and pharmacodynamics of the majority of these herbal medications are still unknown. Even so, results

revealed that most farmers using herbal remedies to their chickens do not face bacterial infections. Although this is a promising solution, further research should be done to assess the efficacy and safety of the herbal medicines used by poultry farmers so that they can be a substitute for synthetic antibiotics. Most bacteria are susceptible to natural remedies such as aloe vera and moringa, but more should be done to standardize the dosage and assess the residues in meat [32,33].

Understanding the use of antibiotics was one of the main problems portrayed in this study and elsewhere [34,35]. Farmers struggled to identify chicken diseases, although they were able to identify associated systems. This limits the possibility of providing appropriate antibiotics to their chickens. But they indicated that they provide treatment based on the symptoms presented by chickens. Furthermore, symptom-based treatment alone is highly likely to result in misuse and overuse of antibiotics, which contributes to the development of AMR. The lack of knowledge regarding the specific indications and improper administration of antibiotics due to a lack of training in AMU increases the risk of antibiotic misuse and contributes to the development of MR in broiler chickens.

4.2. Knowledge, Attitudes, and Practices of Farmers Related to AMU and AMR

This study found a low knowledge of AMU and AMR, a negative attitude and poor practices towards AMU and AMR. The low level of knowledge could be associated with a lack of training in AMU and AMR. In this study, only a small proportion of the farmers were trained in AMU and AMR. This lack of appropriate training among poultry farmers is similar to the studies done by [23,27,36]. The majority of poultry producers lack sufficient expertise, as evidenced by the poor knowledge scores in this study. These farmers are unaware of the potential negative effects of improper use of antimicrobials which can lead to the irrational use of these medications. Poultry producers who are ignorant about AMU and AMR run the risk of using antibiotics improperly, which exacerbates AMR [37]. Hence, there is a need for these poultry farmers to be sensitized regarding correct AMU and AMR.

The farmers low level of knowledge in AMR is concerning. Especially when the majority indicated that they were not aware that AMR which is a public health concern and that antibiotics could be used to treat any disease. To these farmers, antibiotics can be used for any illness, including anti-parasitic, anti-protozoa, and viral infections. The low awareness of AMR among poultry farmers calls for improved educational interventions and the strengthening of antimicrobial stewardship programs [38].

Although most farmers reported that they have heard about AMR and AMU in chicken. A significant relationship was found between the knowledge level and the level of education. Most poultry farmers who attained a tertiary education generally had high knowledge scores. This could be attributed to the fact that participants of the tertiary level and some from the secondary level may have learned about AMU and AMR or may have read about the same. Previous studies done in Sudan and Ethiopia had similar findings that attributed the lack of knowledge to the low level of education of the participants [39,40].

In this study a serious gap was revealed in agricultural systems in Mzimba, Malawi, where there is shortage of veterinarians, leading to the administration of antibiotics by farmers without prescriptions and consultation. In some places, government veterinarians stopped visiting the farmers to assess the health status of their chickens. In areas where veterinarians are available, farmer's lack of money to call veterinarians and loss of trust prevent them from accessing required services. Others reported that they have been doing chicken farming for years and claimed to have good experience in chicken farming that does not require the services of experts. Another fact that may be related to the failure to consult veterinarians is the ease of purchasing medications without a prescription. Farmers easily access antibiotics in Malawi in veterinary shops [12,17].

A study in Kenya by Laxminarayan *et al.* (2013), also reported that the majority of antimicrobials were buying over the counter or from animal health assistants, without consulting a veterinarian, as they were easily accessible, the same situation in Tanzania, Serbia, Ghana and other LMICs [51–54]. Normally, the procedure was supposed to be that the farmers should report disease cases to

veterinarians, who would then diagnose the animals, purchase the drugs, and administer the recommended drugs to the animals [45]. Normally, veterinary shops are supposed to sell drugs on the basis of a prescription to registered veterinarians, rather than directly to farmers.

Farmers who lack expertise in chicken production and the usage of antibiotics may not be aware of the appropriate use of antibiotics, including the correct dosage, duration, and withdrawal periods. Notably, Phares *et al.* (2020), found similar results in Ghana. The lack of understanding among farmers, as evidenced by the use of antibiotics for various animal diseases without proper knowledge, raises immediate concerns for animal health and public health. Using antibiotics without understanding how to use them properly, and not considering other ways to treat illnesses can be risky and could lead to AMR. The indiscriminate use of antibiotics without adequate knowledge can lead to ineffective treatments, prolonged illnesses, and economic losses. It is crucial to improve farmer's understanding of antibiotic use and resistance to ensure responsible antibiotic usage and effective disease management practices in animals.

Interestingly, the majority of the farmers believed that the sale of non-prescription antibiotics should be outlawed because they frequently purchase expired medications, and some claim that antibiotics couldn't cure their chicken's illnesses. Due to high cost of the antibiotics some farmers stop the dosage after the animal is cured and the antibiotics are reserved to be used in the future. The tendency to purchase non potent and expired antibiotics could negatively affect the attitudes of farmers towards the use of drugs. The sale of non-potent and expired antibiotics is attributed to a lack of proper regulation of antibiotic use in Malawi. This increases the likelihood of substandard or counterfeit antibiotics entering the market, posing further risks to public health. Although farmers in the study reported obtaining antibiotics from registered shops, the absence of regulatory oversight in antibiotic acquisition contributes to unmonitored and possibly inappropriate use.

Poor practices regarding AMU and AMR reported in this study is another stumbling block to the efforts put in place by Ministry of Agriculture in Malawi, WHO and other international organizations aimed at controlling AMR[47]. This is similar to the practices of farmers in Cambodia regarding AMU and AMR [48]. Treating chickens without antimicrobial sensitivity testing and consultations with veterinarians is one of the common practices that influences AMR. This is commonly due to the lack of diagnostic tools, shortage of veterinarians, and high cost of sensitivity testing in Malawi, which hinders evidence-based treatment of bacterial infections in chickens. This might also be because most farmers are not trained on antibiotic usage and AMR. There was a weak relationship between attitudes, practices, and knowledge. This shows that a lack of training in AMU and AMR might be a contributing factor to low KAP.

This study had a number of limitations. Firstly, only broiler farmers and one district were included in the study. The current study's conclusions might not be representative of the whole Malawi and all livestock animals. Nonetheless, the results of this study may offer a baseline comparison with the other districts of Malawi. The study didn't find any differences interms of AMU and AMR between rural and urban. Therefore other studies must be conducted to assess KAP among other livestock farmer on AMU and AMR, accessibility of antimicrobials, and consultation of veterenarians on use of antimicrobials.

5. Conclusions and Recommendations

It is concluded that chicken farmers had low KAP about AMU and AMR in chicken production. There was an unregulated antibiotic supply chain among farmers and veterinary shop owners in Mzimba district, Malawi.

Factors such as easy access to medications, poor guidance from veterinary professionals on proper administration and antibiotic selection, lack of knowledge about AMU and AMR from a health perspective and national policies, and poor government oversight of medication acquisition and use constitute the main risk factors for the emergence of AMR in chicken production.

Therefore, it is crucial to support the development of policies that encourage the responsible use of antibiotics through regular farmer training programs to improve their KAP on AMU and AMR,

strengthen regulatory frameworks, and enable appropriate veterinary medicine distribution and retailing. Additionally, farmers need to consult veterinary professionals about the use of antimicrobials in any event in their production. Promote farm management practices through the use of alternative treatments such as vaccines, probiotics, and prebiotics to reduce the reliance on antibiotics in chicken production and farmers need to follow regulations in related to antimicrobial use and antimicrobial resistance.

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