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Awareness of Antimicrobial Usage and Antimicrobial Resistance (AMR) among Livestock Farmers in Katsina State, Nigeria

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ABSTRACT: *Awareness of antimicrobial usage and emergence of antimicrobial resistance (AMR) among livestock farmers is of paramount importance in overcoming the challenges of AMR in agriculture and public health. A survey was conducted among 100 livestock farmers in ten randomly selected Local Government Areas (LGAs) in Katsina State, Nigeria using a structured questionnaire to explore awareness of livestock farmers towards antimicrobial usage and Antimicrobial Resistance. Descriptive statistics were conducted to obtain frequencies and proportions of the outputs. A Mann-Whitney test was performed to get the difference in attitude of participants to antimicrobial use and AMR. Fifty-four (54%) of livestock farmers were shown to have poor knowledge of and 35 (35%) were shown to be misusers of antimicrobials and AMR. On the practices in the use of antimicrobial, the study revealed that, the most common antimicrobials used by the participants were oxytetracycline (59%), penicillin (10%), and gentamicin (2%). There was no significant association between participants' level of knowledge, attitude and practices and the usage of Antimicrobials and AMR among livestock farmers in Katsina State (p= 0 .219). Therefore, in line with the recommendations of World Health Organization (WHO) for creating Awareness, and improving KAP of antimicrobials and AMR emergence, the results of the survey underpin the need for concerted efforts to overcome the threat of AMR through tailored programmes, research and policy direction.*

Keywords: *Antimicrobials, Attitude, Katsina, Knowledge, Nigeria, Practices, Resistance*

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INTRODUCTION

According to World Health Organisation (WHO 2019) report on the rising public health challenge of antimicrobial resistance (AMR), no fewer than 700,000 people lose their lives annually to AMR-related illnesses across the globe; and that by 2050, 10 million additional people may die and about 24 million more are predicted to suffer from extreme poverty (WHO, 2019). Further, a report by European Centre for Diseases Control (ECDC), shows that, by the year 2014, the average antimicrobial consumption (AMC) in food-producing animals (152mg/Kg) was significantly higher than in humans (124mg/Kg) (ECDC, 2017). This was disproportionately found to occur in many of the

European countries (ECDC, 2017). It is pertinent to ask a question here as to why the use of antimicrobials in food animals is still high, even among, high-income countries. Olatoye & Ehinmowo. (2011) argued that, the intensive system of production is responsible for the increase, while other authors believe it occurs as a result of the need to prevent infections and improve wellbeing of the livestock to reach market weight earlier than normal, as this increases the income of the farmers (Hollis and Maybarduk, 2015).

Conversely, in low-, to middle-income countries like Nigeria, the antimicrobial use in food animals was found to be driven by inadequate, as well as slow-implementation of regulations guiding the use of the drugs. For example, Adebowale *et al*. (2020); Alhaji *et al*. (2018); Alhaji *et al.* (2019) further found that, farmers use antimicrobials to, prevent and treat diseases and promote growth of their animals even when not prescribed by relevant animal healthcare professionals. Similarly, over-prescribing by health personnel, compromising their use by people, agricultural and environmental factors as well as inadequate implementation of government policies, are reported to be among the main drivers of AMR (Holmes *et al.*, 2016; WHO, 2019). To underscore the importance of threat of AMR, the WHO developed an action plan in 2015 with five targets. The first target is: "improving Awareness and understanding of antimicrobial resistance and strengthening knowledge through surveillance and research" (WHO, 2015b; 2019). Others are: "reducing the incidence of infection; optimizing the use of antimicrobial agents; and developing the economic case for sustainable investment that takes account of the needs of all countries, and increase investment in new medicines, diagnostic tools, vaccines and other interventions" (WHO, 2015b; 2019).

In line with the first target of WHO's action plan on AMR, and to obtain primary data about KAP of antimicrobials and AMR among public, the World Health Organisation (WHO) conducted a multi-country survey, involving ten countries randomly selected across many regions of the world in 2015 (WHO, 2015a). Similarly, various levels of KAP were found among people who use antimicrobials with low-levels, and high-levels, recorded in low-income and high-income countries, respectively (Caudell *et al.*, 2020; Gebeyehu *et al.*, 2020; WHO, 2015a). As described by Lawal-Adebowale. (2012), there are three systems of livestock production in Nigeria: intensive (commercial), semi-intensive (agro-pastoral) and extensive (pastoral). While the intensive or commercial contributes barely 1 percent, semi-intensive or agro-pastoral 17 percent of the production, the extensive or pastoral system contributes the remaining 82 percent (Lawal-Adebowale, 2012). The intensive system of production is mostly practiced by private individuals who build farms in rural areas to serve as sources of animal and animal products to the urban population in the country (FAO, 2019).

Frequently, indiscriminate use of antimicrobials were reported across the systems of production (Adebowale *et al*., 2020; Adekanye *et al*., 2020; Al-Mustapha *et al*., 2020).

Therefore, as an important public health threat with its impacts on socio-economic and health life of people, it is imperative that research be carried out to know the KAP of the livestock farmers about antimicrobials and AMR in Katsina state. This is because, according to 2011 National Agricultural Survey, Nigeria has 13.9 million cattle with 70% of them in Northern Nigeria, and Katsina state is among the top five with abundant meat, milk and other livestock products that is contributing to the country's Gross Domestic Products (GDP) (Katsina State Government, 2021; Lawal-Adebowale, 2012).

Furthermore, as encouraged by WHO on the need to conduct similar or related research at sub-country levels to know the baseline data for implementing the action plan (WHO, 2015b); and to adhere to the WHO's recommendation in Nigeria, many research studies were carried-out among diverse groups of people and sectors across the country including among university students (Abimbola, 2013); poultry farmers (Alhaji *et al*., 2018) and pig farmers (Adebowale *et al.*, 2020). A significant gap, indicating myriad of perception, knowledge, and attitude of these groups to antimicrobials and AMR was found (Adebowale *et al*., 2020; Alhaji *et al*., 2018; Abimbola, 2013). However, based on the available literature, very few of such research were conducted among livestock farmers in Nigeria generally and even less so in Katsina state specifically. The aims of the study were to collect data about knowledge, attitude, and practices (KAP) of livestock farmers in Katsina State, Nigeria towards antimicrobial use and antimicrobial resistance. Specifically, the aims were to determine the knowledge of antimicrobials and AMR among livestock farmers in Katsina State, Nigeria; investigate the attitude to the use of antimicrobial drugs among livestock farmers in Katsina State, Nigeria; collect data about the practices on use of antimicrobials among livestock farmers in Katsina State, Nigeria; and to make recommendations, based on the findings, for how to improve livestock farmers' awareness, knowledge and attitudes towards antimicrobial use and AMR.

MATERIALS AND METHODS

Study area

Katsina is a state in Northern Nigeria situated on Latitude between 110 07' 49N' 130 22 57" and Longitude 6052' 03E and 9 90 02'E", and an estimated population of 5,792,578 people, based on 2006 census (Katsina State Government, 2021). It borders Kaduna State to the South, Jigawa and Kano States to the East, Zamfara State to the West and the Niger Republic to the North. The State occupies an area of about 23,938sq kilometres with 34

local government areas (LGAs). The major tribes and languages spoken are Hausa and Fulani, and Islam is the predominant religion (Katsina State Government, 2021).
The climate of the State extends from the tropical grassland, known as the Savannah in the south, to the Arid Zone to the North. Agriculture and animal husbandry is the main occupation of the people of the State. According to 2011 National Agricultural Survey, Nigeria has 13.9 million s cattle with 70% of them in Northern Nigeria, and Katsina state is among the top five (Lawal-Adebowale, 2012). This is why the State has abundant meat and milk, and therefore important to address KAP of livestock farmers regarding AMR in Katsina State.

Sample and sampling procedure

Katsina state has three geo-political zones: Katsina Central, Katsina South and Katsina North each with 11, 11, and 12 LGAs, respectively (Figure 1). One hundred local livestock farmers were recruited from ten LGAs in the state. Funtua, Kafur, and Malumfashi LGAs were randomly selected from Katsina South Zone; Dutsinma, Katsina and Batagarawa from Katsina Central Zone; and Baure, Daura, Kankiya, and Maiadua from Katsina North Zone, because it has the highest number of LGAs (12) (Katsina State Government, 2021) and the highest livestock population in the state (Katsina State Government, 2021; Lawal-Adebowale, 2012). Within each LGA one livestock farming community (village) was purposively selected based on information about areas with high cattle density, and the ten questionnaires administered based on the eligibility criteria of participants.

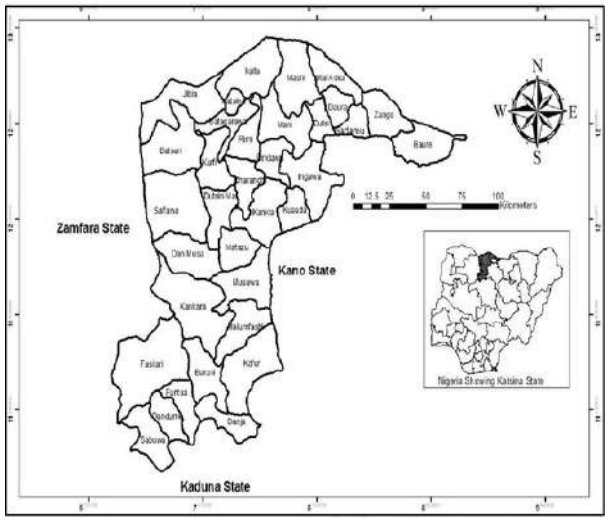

Figure 1: The Map of Katsina State Showing Local Government Areas (Source: Katsina State Government, 2010).

Target populations for this study were predominantly agro-pastoralists, and a few pastoralists who keep local breeds of cattle for livelihood, through sales of animal, milk, and milk products, and who represent 95% of livestock farmers in the study area. Eligibility for participation was male or female (because both can own a herd) and aged >20 years- as it was believed that people above 20 years have some level of knowledge of animal production and/or have witnessed disease management using antimicrobials.

Since this project involved travel to farming communities, there was a practical limitation in how many participants were accessible during the period of the study. It was estimated that 100 was a pragmatic number that could be achieved. Using a sample size of 100 people it was estimated that there would be a 10% acceptable error rate). If, for example, 70% of the respondents are aware of the dangers of AMR, the actual proportion of that belief would probably lie somewhere between 60% and 80%. A larger sample would have resulted in a smaller error, but this was not feasible within the resources available for this study.

Instrument for data collection

The material used for data collection was a printed, structured questionnaire with majority close-ended questions that was designed based on two sources: A survey of antimicrobial usage in local dairy cows in North-Central Nigeria (Alhaji *et al.*, 2019) and a WHO validated questionnaire (WHO, 2015a) and used in a research on knowledge and practices towards antibiotic usage. The Alhaji's questionnaire was chosen as the North-Central region shares nearly similar demography and setting as Katsina state (Katsina State Government, 2021). Moreover, the questionnaire was well-designed in a simple, unambiguous language and was administered to 384 households across the North-Central zone of Nigeria (comprising of six states) (Alhaji *et al*., 2019). The whole validated questionnaire used by World Health Organisation (WHO) in a multi-country public awareness survey on antibiotic resistance (WHO, 2015a) was considered for use in its entirety, because it has been widely used and adapted in other studies (Adekanye *et al*., 2020; Kamata *et al*., 2018).

Data collection

Contacting the community leaders and local animal health workers, who serve as gate-keepers, ahead of time helped identify participants who were willing to participate in advance. This made establishing contacts much easier. Community leaders were contacted by telephone to make a suggestion as to the best time for me to visit. After arrival on the appointed day, the community leaders introduced the research team to the suitable participants. In the Northern Nigerian rural culture, it is not always suitable to send written materials ahead of time, and therefore all arrangements are made verbally through gate-keepers.

The questionnaire was low-risk and non-sensitive, and did not involve questions about participants' health or sensitive topics. Participants were asked to consent to voluntarily participate by signature, thumb print on the consent form or verbally before filling the questionnaire. Verbal consent was accepted because of low-formal education or choice. The date that consent was taken was recorded. These methods were suited to the culture of rural Nigeria: culturally, livestock farmers in Nigeria are likely to co-operate with the recommendation of their community leaders or people they trust. The settings are quite different from urban settings.

Data management and handling

The paper questionnaires were coded without the person's name, separate to the consent forms, which have people's names in them. They were always locked up when not being used. A portable safe box was borrowed for locking the questionnaires up. When participants were handed a questionnaire or interviewed, the portable safe was opened and the respective number of questionnaires was picked. Immediately after filling, the questionnaires were taken back into the safe. In transporting the completed questionnaires, the safe was always kept adjacent to the researcher to avoid any loss, theft, or access by a third person. And after arriving home, they were stored in office cabinet under lock and key and accessible to researchers only. Therefore, the security of the data was ensured. The electronic data was fully anonymised and stored electronically.

Statistical analysis

Responses obtained from the participants on the paper questionnaires were entered into SPSS software version 26 (IBM SPSS Statistics, Armonk, New York) and converted into SPSS file by creating columns for each variable and rows for each participant. Descriptive statistics for all variables (frequencies, proportions etc.) were conducted. Differences and Chi-square tests between variables, where appropriate, were tested and analysed in accordance with a predefined analysis plan (Dohoo *et al*., 2009). The participants' level of knowledge was determined according to scoring for the knowledge questions. Each of the fifteen knowledge questions of the questionnaire was assigned 1 mark and converted to 100%. Participants who scored ≥8 marks (≥50%) were considered to have satisfactory knowledge of antimicrobials and AMR. On the other hand, participants who scored ≤7 (≤49%) marks were deemed to have poor knowledge of antimicrobials and AMR. The attitude of participants to antimicrobial use and AMR was also derived. Because the attitude questions were in Likert Scale, they were added together to obtain a total score, with the highest score being a positive (healthy) attitude and lowest being negative (unhealthy) attitude. A reverse-coding was also conducted where highest scores were reversed to lowest (5 reverse to 1) and *vice-versa*. The total score was used for analysis of the survey data. For practices of livestock farmers about antimicrobial use, participants were classified as 'Misusers' and 'Not-Misusers' (Non-misusers) of antimicrobials based on their answers to practices questions and scored accordingly. A misuser is someone who gave antibiotic without animal health practitioner's prescription, determine dosage arbitrarily, frequently administer antimicrobials in feeds prevent infections, and does not observe withdrawal period for antimicrobials. A non-misuser is someone who does not engage in any of the above. The independent variables from socio-demographic characteristic were created and the dependent variables (i.e. knowledge, attitudes, and practices) were also identified. To find the differences and association between explanatory and outcome variables, Mann-Whitney and Chi-square tests was conducted as described (Dohoo *et al.*, 2009).

RESULTS

Socio-demographic characteristics of participants

The socio-demographic characteristics of livestock farmers in Katsina State, Nigeria who participated in this survey were summarised. The results showed that, the level of response from the participants in the survey was 100% as all the 100 pieces of print questionnaires submitted were returned, fully completed. Refusal rate was very few, except in Mai'adua LGA where few participants declined to consent to take part, based on their perception that others will answer the questions better. Distribution and location of participants cut across the three zones of the state comprising ten (10%) participants from each of the ten local government areas, randomly selected for the survey. Looking at the age groups of the participants, more than one-third, and 39 (39%), were within the range of 31-34 years of age, forming the bulk of the respondents. Younger respondents of 21-30 years age range also contributed a little under a quarter 23 (23%) of the population; while 41-50 years, and 51-50 years contributed 18 (18%), and 17 (17%) participants, respectively; only 3 (3%) participants fall within the age range of 61-70 years (Figure 2).

Moreover, a disproportionate majority of the respondents were found to be males 79 (79%), while only 21 (21%) were females (Figure 3). On marital status of the respondents, 83 (83%) of them referred to themselves as being married while 13 (13%) were singles; however, only 4 (4%) identified themselves as widows. On the highest level of education attained by each participant, more than one-third 38 (38%) of the participants indicated that, they do not have any formal education as against 8 (8%), 19 (19%), and 36 (36%) who pointed to having attained

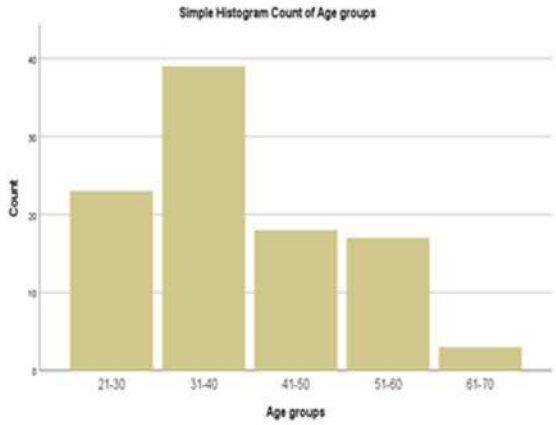

Figure 2: Distribution of age group of livestock farmers surveyed for the research in Katsina State, Nigeria.

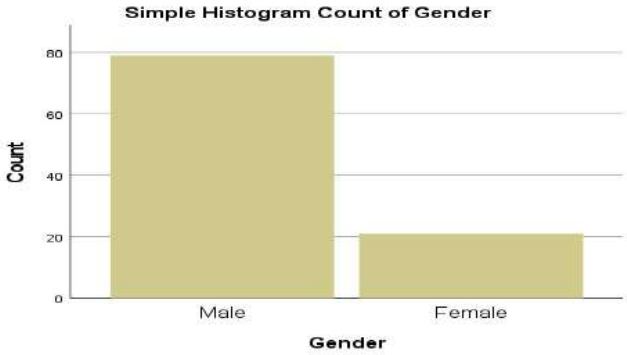

Figure 3: Distribution of gender of livestock farmers surveyed in Katsina State, Nigeria.

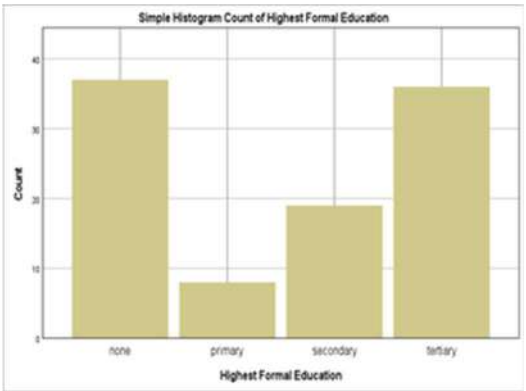

Figure 4: Distribution of highest formal education attained by livestock farmers surveyed for the research in Katsina State, Nigeria.

primary, secondary, and tertiary education, respectively (Figure 4).

Knowledge of antimicrobials and amr among livestock farmers in Katsina state, Nigeria

From Table 1 on knowledge of antimicrobials and AMR; half, (50, 50%), of all the participants were found to be aware of the use of antimicrobials for treatment of mastitis, a mammary gland infection, in cows. However, 19 (19%) of the respondents marked using antimicrobials for prevention of mastitis in lactating cows, and 8 (8%) confirmed use of antimicrobials to promote milk yield in their cows. Nearly one-third, 29 (29%), pointed that they know antimicrobials to be used for all of the above purposes. On the respondents' knowledge about misuse of antimicrobials in lactating cows, 48 (48%) of them affirmed that they also knew antimicrobial misuse occurs

Table 1: Livestock Farmers' Knowledge about Antimicrobials and AMR in Katsina State, Nigeria.

Variable	Frequency (n)	Proportion (%)	Confidence Interval (CI)
Know antimicrobials to be used			
To treat mastitis in lactating cows	50	50	39.83, 60.17
To prevent mastitis in lactating cows	19	19	11.84, 28.07
To promote milk yield in lactating cows	8	8	3.52, 15.16
All of the above	29	29	20.36, 38.93
Antimicrobials misuse in lactating cows is when			
Administered under-dose	32	32	23.03, 42.08
Administered over-dose	64	64	53.79, 73.36
Administered in normal dose	17	17	10.23, 25.82
Don't know	21	21	13.49, 30.29
Effects of antimicrobials misuse on lactating cows			
Non response to bacterial infection treatment	48	48	37.90, 57.79
Extra costs on treatment of bacterial infection	34	34	24.82, 44.15
Don't know	25	25	16.88, 34.66
Antimicrobials misuse in lactating cows can predispose to resistance emergence			
Agree	65	65	54.82, 74.27
Disagree	5	5	1.64, 11.28
Don't know	29	29	20.36, 38.93
Antimicrobial resistance can be passed from lactating cows to humans through			
Drinking raw milk	63	63	52.76, 72.**44**
Drinking fermented milk (*nono*)	28	28	f19.48, 37.87

when the drugs are administered as under-dose, while more than two-third (64, 64%) of respondents believed misuse occurs when antimicrobials are administered as overdose in lactating cows. On the contrary, 17 (17%) participants marked antimicrobial misuse to be when the drugs are given at normal doses. And 21 (21%) of the livestock farmers answered that they don't know what antimicrobial misuse entails. However, on respondents' knowledge about whether misuse of antimicrobials in lactating cows can lead to emergence of resistance, 65 (65%) of the livestock farmers agreed, while only 5 (5%) disagree with the statement. A quarter (25, 25%) responded that they do not know whether misuse of antimicrobials could predispose to emergence of antimicrobial resistance in lactating cows or not. A varied response on the livestock farmers' knowledge about effects of antimicrobial misuse in lactating cows was also observed. Almost half (48, 48%) of respondents knew that, the effects of antimicrobial misuse in lactating cows could appear as non-response to treatment of diseases caused bacteria. Moreover, while 34 (34%) were of the view that, the effect is extra cost on treatment of infections; only a quarter (25, 25%) of the participants responded that they don't know what the effects are. Livestock farmers' responses on whether AMR can be passed from cows to humans also differ. Majority of the participants (63, 63%) knew that AMR could be passed from lactating cows to humans through drinking of row (fresh) milk. However, 28 (28%), 10 (10%), and only 7 (7%) of respondents knew that, consumption of fermented milk, eating of raw cheese, and direct milking of cows could result in passing of AMR from lactating cows to humans, respectively. On the contrary, 27 (27%) of respondents did not know whether AMR could be passed from lactating cows to humans or not. Additionally, difference in level of knowledge of livestock farmers on effects of AMR in humans was also revealed. One-third (33, 33%) of participants knew non-response to treatment of bacterial infection as an effect in humans; 22 (22%) believed the effect to be extra cost on treatment of bacterial infection; while 27 (27%) indicated that AMR could lead to longer duration of treatment of bacterial infection in humans. But despite that, 22 (22%) of livestock farmers still do not know of any effects of AMR on humans.

Practice of usage of antimicrobials in lactating cows among livestock farmers in Katsina State, Nigeria

Livestock farmers' practices with regard to antimicrobial usage in lactating cows vary significantly. Responses from participants in the survey indicated that approximately one-third (32, 32%) of the livestock farmers obtained their antimicrobials after prescription by animal health officials, followed by prescription or suggestion from friends and relations (23, 23%); and only 9 (9%) of livestock farmers disclosed resorting to self-prescription of antimicrobials for their animals. On where the farmers purchase antimicrobials, 27 (27%), 8 (8%), and disproportionately, 61 (61%) of participants, indicated purchasing from veterinary drug shops, human drug shops, and animal hawkers respectively. Also, 26 (26%) of farmers engaged in self-administration of antimicrobials while the majority (61, 61%), pointed that they employ the services of animal health officials. On frequency of use of antimicrobial drugs

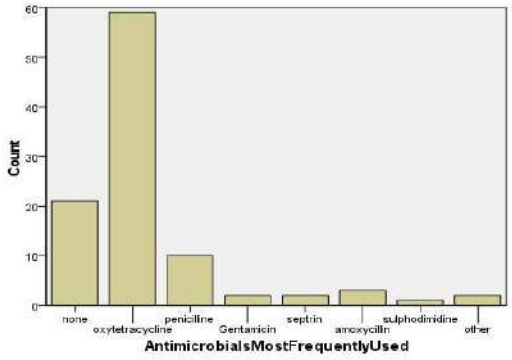

Figure 5: Antimicrobials most frequently used by livestock farmers surveyed in Katsina State, Nigeria.

in lactating cows with mastitis infection, just under half (46, 46%) of participants indicated that, they use the drugs as prescribed by animal health officials. However, 18 (18%), and 35 (35%) respondents indicated using them only once for the entire period of infection, and once daily until animals recover, respectively. However, very few (5, 5%) of the participants pointed out that, they usually engaged in the use of the drugs twice daily until animal recover.

Furthermore, on how dosages of antimicrobials are determined, a quarter (25, 25%) of the participants pointed to determining dosages of antimicrobials arbitrarily against the remaining three-quarter (75, 75%) who determine dosages from instructions on label. The routes of administration of antimicrobials frequently used by the livestock farmers were also revealed. The most common routes of administration of antimicrobials were through injection, mouth, and feed with each practiced by 64 (64%), 21 (21%), and 11 (11%) of the participants, respectively. However, 23 (23%) of respondents indicated that, they frequently engaged in the use of all the three routes above. Finally, while 53 (53%) of livestock farmers indicated observing withdrawal period of antimicrobial drugs in their practices, 44 (44%) did not. On the purpose of using antimicrobials on lactating cows, 56 (56%) of the livestock farmers disclosed that, they used them to treat mastitis. However, 11 (11%) of them answered that they utilise them for prevention of mastitis, while use of antimicrobials for promotion of milk yield was practiced by only 6 (6%) participants. Notwithstanding, more than one-third, (36, 36%) participants pointed that they employ the use antimicrobials for all of the above purposes. The antimicrobial drugs most frequently used by livestock farmers in Katsina state Nigeria, were oxytetracycline (59%), penicillin (10%), gentamicin (2%), septrin (2%), amoxycillin (3%), sulphonamides (1%), and others (2%) (Figure 5). However, 21% of the livestock farmers did not indicate using any antimicrobials more frequently than others.

Livestock farmers' attitude in relation to antimicrobials knowledge and practices among livestock farmers in Katsina State Nigeria

To understand the distribution of attitude in relation to knowledge and practices, and to find difference between the various variables among livestock farmers in Katsina Sate, Nigeria to antimicrobials and AMR, a non-parametric difference (Mann-Whitney) test was conducted. Figure 6 shows a significant variation in distribution of attitude to the use of antimicrobials among livestock farmers with poor knowledge (≤49%), and those with satisfactory knowledge (≥50%) was observed (p= 0.012). The participants with poor knowledge show a lower median attitude (median score= 35) while those with satisfactory knowledge display a higher median attitude (median score= 40). On the other hand, (Figure 7) shows no significant difference in the distribution of attitude among misusers (median score: 40) and not-misusers (median score: 38) of antimicrobials (p= 0.864).

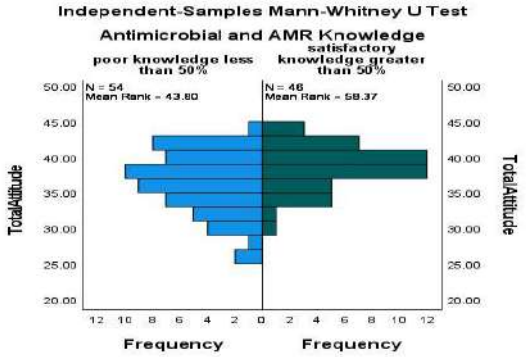

Figure 6: Distribution of attitude of livestock farmers in relation to poor knowledge and satisfactory knowledge of antimicrobials.

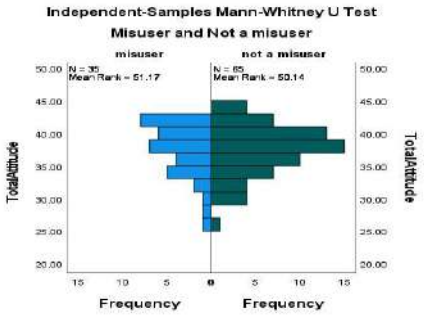

Figure 7: Distribution of attitude of livestock farmers in relation to misusers or not-misusers of antimicrobials.

DISCUSSION

From our knowledge, this is the first study that explores the KAP about the use of antimicrobials, and AMR among

Table 2: Practices of antimicrobial usage on livestock (lactating cow) among livestock farmers in Katsina state Nigeria

Practices	Frequency	Proportion	Confidence Interval
Personnel that prescribe antimicrobials for usage in lactating cows			
Animal health officials	32	32	23.02, 42.08
Self-prescription	9	9	4.20, 16.40
Friends and relations	23	23	15.17, 32.49
Purchasing places of antimicrobials			
Veterinary drug shops	27	27	67.51, 84.83
Human drug shops	8	8	3.52, 15.16
Animal drug hawkers	22	22	14.33, 31.39
Who administer antimicrobials on cows?			
Self-administered	26	26	17.74, 35.73
Animal health officials	61	61	50.73, 70.60
Frequency of antimicrobial usage on lactating cows with mastitis			
As prescribed	46	46	35.98, 56.26
Only once	18	18	11.03, 26.95
Once daily until recovered	35	35	25.73, 45.18
Twice daily until recovered	5	5	1.64, 11.28
Dosage determination before antimicrobials use			
From instructions on the label	75	75	65.34, 83.12
Arbitrary	25	25	16.88, 34.66
Frequently used route of administration			
Injection	64	64	53.79, 73.36
Mouth (POS)	21	21	13.49, 30.29
Through feed	11	11	5.62, 18.83
All of the above	23	23	15.17, 32.49
Observe about withdrawal periods			
Yes	53	53	42.76, 65.92
No	47	47	36.94, 57.24
Purpose for antimicrobial usage			
Treatment of mastitis in lactating cows	56	56	45.72, 65.92
Prevention of mastitis in lactating cows	11	11	5.62, 18.83
Promotion of milk yield in lactating cows	6	6	2.23, 12.60
All of the above	36	36	26.64, 46.21

livestock farmers in Katsina State, Nigeria. Generally, the results of the survey revealed that a significant number (35, 35%) of livestock farmers are misusers of antimicrobials; 54 (54%) have poor knowledge of antimicrobials and AMR; and that the attitude of the livestock farmers to antimicrobial use and AMR differ slightly, where livestock farmers with higher level education show a fairly better attitude than those with lower, or without, formal education. Disproportionately, the results indicate that 54% of livestock farmers in the study have poor knowledge of antimicrobials and AMR against only 46% who have satisfactory knowledge of antimicrobial usage among the respondents. Therefore, in line with the aim and objectives of this research, the survey has disproportionately revealed a dearth of necessary knowledge of antimicrobials and AMR among 54% of livestock farmers. This will, significantly, pose a public health challenge to the sector. Livestock farmers' lack of knowledge could predispose to inappropriate use of antimicrobials which could consequently lead to development of resistance that will ultimately increase the risk of passing AMR from animals, through animal products such as milk and meat, to humans. Related studies indicated a unsatisfactory knowledge among participants from Nigeria (WHO, 2015a), leading inappropriate use that lead to detection of antimicrobial residue in animal products (Olatoye and Ehinmowo, 2011; Olatoye *et al*., 2016). On the respondents' knowledge about misuse of antimicrobials in lactating cows, only 48% of livestock farmers affirmed they knew that antimicrobial misuse occurs when the drugs are administered as under-dose. The knowledge of misuse of antimicrobials is of significant importance in relation to the aims and objectives of the survey. Livestock farmers who are aware of what 'misuse' indicate, are more likely to engage in rationale use of antimicrobials than those who do not. Adekanye *et al*. (2020) and Adebowale *et al*. (2020) found a similar habit of misuse among veterinarians, and pig farmers, respectively, as posing serious implications for the livestock sector, and the drive towards antimicrobial stewardship in Nigeria. However, the 50% knowledge of misuse obtained in this survey could not have been reached if a larger sample that covers broader locations of livestock farmers were used. Similarly, livestock farmers' knowledge on whether AMR can be passed from animal products to humans varies. Although, 63% of the participants knew that resistance could be passed to humans, more than a quarter (27%) did not. Passing of resistance from animals to humans could lead to the same effects observed in animals. The threat of effects of passing of resistant bacteria to humans, and emergence of resistance is well established (Hollis and Maybarduk,

2015; Hu *et al*., 2020; Olatoye *et al*., 2016). However, while, the action against the threat is being developed and implemented globally (WHO, 2015b), and in Nigeria (NCDC, 2017), there is still a significant challenge of overcoming the passage of resistance to humans through one-health initiative, and operationalization of the action plan (Achi *et al*., 2021). With reference to the aim and objectives of the study, the revelations in this survey indicate that, 63% of livestock farmers knew the possibility of passing AMR to humans, could be due to small number of, and the educational level of, participants where more than half (63%) indicated having attained primary, secondary or tertiary education. Moreover, majority indicated getting knowledge of antimicrobials and AMR from animal health officials close to them. The practices of livestock farmers in this survey further indicate a divergent response (Table 2). On personnel who prescribe antimicrobials before they are used on lactating cows, only 32 (32%) participants get their prescription from professionals, in this case, animal health officials. Further, although only one-tenth of participants reported resorting to self-prescription of antimicrobials, another 23% pointed to using antimicrobials prescribed to, or given by, friends and relations. The practices of using antimicrobials through self-prescription, and suggestions, by friends and relations, is against the recommendations of World Health Organization (WHO), and best practice for antimicrobial use (Michael *et al*., 2014; WHO, 2019). While only 32% participants practiced the appropriate method of obtaining antimicrobials, the remaining 68% who resort to other methods in this survey, pose a challenge to public health in the state, and Nigeria at large. The findings are also in consonance with other survey where antimicrobial misuse in prescription was reported to be high in pigs (Adebowale *et al*., 2020). Moreover, the survey is in line with others where misuse was high (61.7%) among respondents in cows (Alhaji *et al*., 2019), and poultry (Alhaji *et al*., 2018). Frequently, places where antimicrobials are obtained also play a vital role in promotion of bad practices in use of antimicrobials and emergence of AMR. The survey further revealed that, 27%, 8%, and 22% engaged in practices of purchasing their drugs from veterinary drug shops, human drug shops, and animal drug hawkers, respectively. Although, obtaining drugs from veterinary drug shops could be considered a good practice as most of the times, they are provided by qualified veterinarians or animal health workers in the outlets; purchasing drugs from human drug shops and animal drug hawkers could potentially promote bad practices that could lead to misuse, and consequently, emergence of resistance. In line with the objective of the research, the prevalence of purchase of antimicrobials from human drug shops, and animal drug hawkers by 8% and 22% of participants, respectively, pose a significant threat. Especially, in poultry and pig production, such practices are very common (Adebowale *et al*., 2020; Alhaji *et al*., 2018). However, because participants of this survey were mostly located in rural areas, high cost of, and access to veterinary shops, could be difficult, thus necessitating the purchase of drugs from animal drug hawkers in rural areas and weekly markets. This could be the reason behind the significantly high responses of purchasing drugs from animal drug hawkers among the livestock farmers. Notwithstanding, the purpose of, and the route of, administration of antimicrobials, employed by livestock farmers are also vital to understanding the extent of misuse of, and development of resistance to antimicrobials (Caudell *et al*., 2020). In this survey, the results showed that 36% of livestock farmers utilized antimicrobials for the purpose of both treatment, and prevention of mastitis, as well as promotion of milk yield. Moreover, even though only 11 (11%) participants reported administering antimicrobials through feeds, forty seven (47%) participants do not usually observe withdrawal period. Using antimicrobials for the purpose of prevention of diseases, or promoting milk yield, as well as not observing withdrawal period for antimicrobials, has been implicated in causing antibiotic residues in meat (Olatoye and Ehinmowo, 2011), and milk in Nigeria (Olatoye *et al*., 2016). Furthermore, similar practices were reported in Ethiopia (Gebeyehu *et al*., 2021), and Ghana (Akansale *et al*., 2019) both of which are developing countries like Nigeria. Averting the bad practices of antimicrobial administration in animal feeds and prevention, rather than, treatment purposes, has been captured in WHO's action plan against AMR (WHO, 2015b), and the Nigeria's antimicrobial stewardship and action plan, too (NCDC, 2017) Moreover, the results further showed that, the antimicrobials frequently used by livestock farmers in the surveys as oxytetracycline (59%), penicillin (10%), gentamicin (2%), septrin (2%), amoxycillin (3%), sulphonamides (1%), and others (2%); while 21% of the livestock farmers did not indicate using any antimicrobials more frequently than others. Other studies have consistently shown oxytetracycline to be the most common antibiotic used by food animal producers for the purpose of prevention of diseases and promotion of health (Adesokan *et al*., 2015; Alhaji *et al*., 2018; Njoga *et al*., 2018). The prevalence of frequent oxytetracyline use by livestock farmers has been linked to its being cheap, and availability in the market (Clement *et al*., 2020). However, other studies trace its popularity among livestock farmers to previous decades when it was recommended for addition in animal feeds at small doses to subjugate non-beneficial bacteria in animal gut thus promoting the activity of beneficial ones (Akansale *et al*., 2019; Olatoye and Ehinmowo, 2011). In line with the aim of the survey, the findings on frequent and indiscriminate use of antimicrobials by farmers, calls for more concerted effort to overcome the threat pose by the practices. Similarly, the general attitude and perception of livestock farmers about risk pathways for AMR dissemination from milk and other

product to humans in this survey showed a significant variation in distribution. Consumption of raw milk and milk products (raw milk, fermented, and raw cheese) as a risk pathway was disproportionately considered as low risk, moderate risk and high risk by livestock farmers (Chi-square: 20.41; P<0.001). Similarly, direct or indirect contacts with contaminated udder and meat, was also perceived by participants to have a significant variation is risk (Chi-square: 28.68; P<0.001); and the environment also, showed a similar pattern (Chi-square: 18.14; P=0.001). However, the risk associated with these pathways have been described as high risk in the dissemination of resistance (Gaze and Depledge, 2017; Hu *et al*., 2020; WHO, 2017). Other studies also established the risk pathways as medium for dissemination leading to detection of residues in meat, milk and environment (Olatoye and Ehinmowo, 2011; Olatoye *et al*., 2016; Stanton *et al*., 2020). Even though, the survey covered only a few participants in the study area, the distribution in the perception of livestock farmers to dissemination of AMR affirmed to the need for further broad study to know the exact perception which, in majority of the time, translate to attitude. The Mann-Whitney test results show a significant variation in distribution of attitude to the use of antimicrobials among livestock farmers with poor knowledge (≤49%), and those with satisfactory knowledge (≥50%) (p= 0.012). The participants with poor knowledge show a lower median attitude (median score: 35) while those with satisfactory knowledge display a higher median attitude (median score: 40). This indicates that participants with poor knowledge of antimicrobials were more likely to have bad attitude towards antimicrobial use when compared to those with satisfactory knowledge, who are less-likely to indulge in such attitude though, insignificant. A study by Adebowale *et al*. (2020) also revealed a similar finding where farmers with satisfactory knowledge of antimicrobials were more likely to engage in good use of antimicrobials; and have high tendency to seek the services of animal health providers and observe biosecurity measures in their farms. However, Adekanye *et al*. (2020) found different attitude among veterinarians where a significant number of participants believed antimicrobials could be used if biosecurity of farms is at stake. Based on the research aim, and objectives, the results have shown that, livestock farmers with poor knowledge have bad attitude, and calls for creation of Awareness to mitigate the bad practices towards antimicrobials and AMR. Conversely, Figure 7 shows no significant difference in the distribution of attitude of misusers and non-misusers of antimicrobials, among livestock farmers in this study. Both misusers and non-misusers show nearly same broad distribution of attitude. In another survey, Oyebanji. (2018) revealed similar findings where majority of participants, including educated and uneducated, shown a similar attitude towards antimicrobial use. On the contrary, a survey among pastoralists in North-Central Nigeria indicated that, respondents with poor knowledge were more likely to have bad attitude towards antimicrobial use, when compared to those satisfactory knowledge (Alhaji et al., 2019).

Strength and limitations

The survey is limited by many factors including small number of villages, and participants per local government area who participated; narrow scope against similar studies such as had large scope and covered 241 participants (Adekanye *et al.*, 2020) and 384 participants (Alhaji *et al*., 2019). Similarly, despite the support received in the study area, access to remote villages was somewhat difficult owing to the terrain in some, and inadequate access roads in others. The sampling method employed in selecting farming community, was purposive, which could potentially lead to bias, against a systematic random sampling that would have produced a better outcome. Although, the questionnaire used in the survey was developed based on previous study by Alhaji *et al.* (2019),- which has good content in relation to the study area but no rigorous testing, and the WHO (2015a) validated instrument; questions of validity and appropriateness, in relation to the study area, still arise; and since majority of livestock farmers did not have satisfactory level of education, and needed assistance in filling some of the questionnaires, difference in responses to research assistants across the communities, could have occurred which has the potential to affect results. However, robust sampling method was employed among the LGAs, and distribution of the socio-demographic characteristics of the participants showed that majority were males (79, 79%), aged 31-40, and married (83, 83%) which is common in research, shows the strength of the survey.

Conclusion

The empirical findings of the study have revealed different outcomes in relation to the three research questions that the survey intends to answer. The study has shown that majority of livestock farmers in Katsina State, Nigeria who participated in the survey had poor knowledge of, had insignificant difference in distribution of attitude to, and had poor practices (misuse) towards, antimicrobial use and AMR. However, knowledge and attitudes were not related to whether or not antimicrobials were misused. Moreover, there were no significant relationships observed between the socio-demographic characteristics of livestock farmers and KAP. Those with high knowledge had a better attitude towards antimicrobials and AMR, than participants with poor knowledge. Therefore, the survey has revealed a significant gap in the knowledge, attitude and practices of livestock farmers who participated in the study.

Recommendations

Broader research and extensive surveys on areas of procurement and distribution of antimicrobials among drugs retailers, prescription behavior of animal health workers, misuse in farms and herds, and surveillance and detection of antimicrobials in animal products meant for human consumption using standardized tools could reveal an overall data on antimicrobial use and AMR emergence in the entire value chains and sectors of the state, and the country. Review level research to obtain and harmonize detail data about the extent of the problems among both urban, and especially local population, and across various sub-sectors and sub-groups need to be explored, and implementation, monitoring and evaluation of operationalization of policy programmes aimed at reducing the challenge of antimicrobial misuse and AMR emergence for efficient outcome, as recommended by WHO. Moreover, beyond simple Awareness and education, improving the socio-economic conditions that influence people to engage in misuse of antimicrobials could go a long way in reducing the threat of misuse of antimicrobials and emergence of AMR.

Ethical clearance

Ethical approval for the research was obtained from the Ethics Committee of the Department of Livestock and Grazing Reserves, Katsina State, Nigeria through a Permission Letter with reference number: DLGR/VET/DRA/MISC/VOLII/45.

Conflict of interest

The authors declare no competing interests regarding publication of this paper.

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APPENDICES

Appendix I: Livestock farmers and research assistants.

Appendix II: Participants filling the questionnaires.

Appendix III: Group pictures of participants, community leaders and researchers.