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Research article

Awareness of antibiotic use and antibiotic resistance among stakeholders in the pig value chain: A preliminary report

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Abstract

A growing threat to global health is antibiotic resistance, which is caused by the inappropriate use of antibiotics. This study was designed to assess the level of awareness of pig farmers and other stakeholders in the pig production value chain with regards to knowledge, attitude, and practices on antibiotic use and resistance in Jos metropolis and Kanke LGA of Plateau State. A qualitative approach using a pretested 80-point structured questionnaire shared by sending a web-link through social media (WhatsApp), email, and via interview of farm owners (single farm visit) was employed. The findings from the assessment revealed a mixed understanding among pig farmers regarding the prudent use of antibiotics, with areas of both good knowledge and potential misconceptions observed. The farmers used antibiotics therapeutically and oxytetracycline (31%), sulfadimidine (17%), and gentamicin (12%) were the most commonly used antibiotics. Knowledge on antibiotic residue and withdrawal period was generally poor. Farmers (61.5%) reported not keeping track of the antibiotics used on their farmers, and many farms do not have effective farm biosecurity measures in place. Overall, the farmers had general awareness on the concepts of antibiotic resistance and antibiotic use, however, they are not aware of the local agency (NAFDAC) regulating the use of drugs in food animals and which antibiotics have been banned for use in humans and animals. It was concluded that there is a need to improve access to government veterinary services for pig farmers on the Plateau, while addressing the identified awareness gaps on antibiotics and encouraging rational use.

Keywords: Awareness, Antibiotics use, Antibiotic resistance, Pigs value chain.

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INTRODUCTION

The Nigerian pig farming industry, despite being a significant investment with considerable economic potential, remains comparatively underdeveloped when compared with the thriving cattle and poultry sectors (Adebowale et al., 2020). Investing in pig farming presents a substantial opportunity to align with Sustainable Development Goal 2 (SDG 2), which aims to address hunger, achieve food security, improve nutrition, and promote sustainable agriculture (Uddin and Osasogie, 2016). Pigs offer advantages over other livestock due to traits like their reproductive efficiency, rapid growth, and efficient feed conversion (Igbokwe and Maduka, 2018). However, these advantages are accompanied by challenges such as inadequate strategies for disease prevention and control, susceptibility to diseases, high mortality rates, poor management practices, and deficient veterinary care systems within many pig farming communities. Additionally, various factors negatively impact the pig production value chain, including price fluctuations, market instability, cultural and religious restrictions on pork consumption, low demand in certain regions, high feed costs, and inadequate veterinary services (Fasina et al., 2012; Abiola et al., 2015; Igbokwe and Maduka, 2018).

Consequently, pig farmers may resort to the indiscriminate and excessive use of antibiotics without proper guidance from veterinary and veterinary paraprofessionals, leading to the emergence and spread of antibiotic resistance (Sawadogo et al., 2023). This phenomenon poses significant threats to global health, food security, and development, particularly in developing countries like Nigeria, where there is a high demand for animal protein and weak regulatory oversight on livestock production (Dyar et al., 2020; Nohrborg et al., 2022; Sawadogo et al., 2023). In Ogun State, Adebowale et al. (2020) reported farmers previous experiences, cost or lack of access to veterinary services, economic benefits, ease of access to over-the-counter drugs, poor farm management skills, and practices and poor biosecurity measures as key drivers of indiscriminate antibiotics use in the pig production value chain.

Furthermore, due to the dominance of small-scale pig farming in Nigeria and the lack of awareness among farmers regarding the implications and impact of antibiotic resistance, efforts to curb indiscriminate antibiotic use have been largely less successful (Sadiq et al., 2018; Ting et al., 2022). Addressing these issues require a bottom-up approach that educate pig farmers on reducing over reliance on antibiotics and adopting practices that promotes prudent use of antibiotic drugs (Robinson et al., 2017; Zellweger et al., 2017). These include improvement in knowledge and awareness levels among stakeholders, and enhanced access to veterinary advice and medications (Adesokan et al., 2015; Caudell et al., 2020).

It was hypothesised that pig farmers on the Plateau have better knowledge, demonstrated better attitudes and imbibed the best practices with regards to use of antibiotic drug. Therefore, this study aimed to assess the awareness levels regarding antibiotic use and resistance among stakeholders in the pig production value chain, with the goal of informing targeted interventions that promotes responsible antibiotic use and preventing the risks associated with antibiotic resistance.

MATERIALS AND METHODS

Study Design

A cross-section survey was conducted among stakeholders involved in pig production systems in selected farming communities in Jos metropolis and Dawaki, in Kanke LGA, Plateau State (9°10' N, 9°45' E). The study adopted a qualitative approach using a pretested 80-point structured questionnaire shared by sending a web-link (https://forms.gle/L8SVK9xwbbwMkFry6) through social media

(WhatsApp), email, and via interview of farm owners (single farm visit). Pretested questionnaires were designed to evaluate the knowledge, attitudes and practices of pig farmers towards antibiotic use and antibiotic resistance. The study targeted pig farmers and other stakeholders because pigs were usually owned by small farmer households and have high socio-economic importance in Nigeria (Adedeji et al., 2022). Population of interest was limited to selected pig farmers on the Plateau. The eligibility criteria for farmer inclusion in the study were; they had to be small-scale farmers, have been engaged in pig farming for at least one year, and be actively involved in making management decisions for their pigs.

Sample Size

The sample size required was estimated using Epi Info version 7.2.6.0 sample size calculator for estimating prevalence. The assumptions were as follows: estimated prevalence of 50% (Because there was no available estimate on the prevalence of antibiotic knowledge among pig farmers in the study area), 8% desired precision at 95% confidence interval. Based on these assumptions, a total sample size of 150 pig farms/farmers was required. The participants involved in this study offered a diverse range of data, reflecting various production contexts and demographic characteristics (Table 1).

Questionnaire Design and Data Collection

Based on information gathered from literature review on knowledge, attitudes and practices of pig farmers and expert's opinion, a set of closed-ended questions were designed to ensure data collection and improve response rates for the cross-sectional survey. The questionnaire was divided into 8 sections; 1 & 2 - Pig farm and farmers' demographics (20 questions); 3-Knowledge of antibiotic use (21 questions); 4 -Knowledge of antibiotic resistance (7 questions); 5 -Knowledge of acts and regulation controlling the use of antibiotics in Nigeria (6 questions); 6 - Pig farmers' attitude towards antibiotic use (6 questions); 7 -Farmers' practices as it relates to antibiotic use and antibiotic resistance (8 questions); and 8 -Farmers' practices as relates to farm biosecurity (12 questions).

Data analysis

Data cleaning was done using the z-value comparison for the identification of outliers and subsequent removal. Percentages of the frequency of responses was determined using Microsoft excel (2019) and data collected with the questionnaire which include sociodemographic distribution of respondents as well as responses to the questions were analysed statistically using Chi-square in JMP version 17 and P-value < 0.05 was considered statistically significant.

RESULTS

Sociodemographic Characteristics of Pig Farmers

The results presented in Table 1 provided insight into the sociodemographic characteristics of the pig farmers surveyed in this study. Majority of the respondents were male, accounting for 73.7% of the total sample, while 26.3% were female. The age of the pig farmers varied, with the range spanning from less than 25 to 55 years. Notably, nearly half of the respondents (50%) fell within the 41 to 55 age range. Additionally, the highest level of education among the surveyed pig farmers was predominantly university education, with 77% of respondents having attained this level. Secondary education was the next most common education level, with 16.9% of farmers, and primary education, which accounted for 5.1% of respondents.

Regarding experience in pig farming, the data revealed that 32.2% of farmers had reared pigs for about six to ten years, 22.9% had less than five years' experience, and 39.8% had over ten years' experience. A significant majority of pig

farmers (72.6%) reported middle-class or higher incomes, while 27.1% reported lower income status. More than half of the surveyed pig farmers (53%) identified pig production as their primary source of livelihood.

Table 1 Socio-demographic characteristics of pig farmers in Jos and Kanke Local Government Area

Variable	Frequency (n = 118)	Percentage (%)	χ^2	P-value
Age (Years)				
< 25	3	2.5	74.26	<.0001
25-40	48	40.7		
41-55	53	44.9		
>55	14	11.9		
Sex				
Female	31	26.3	27.68	<.0001
Male	87	73.7		
Level of Education				
Primary	6	5.1	106.73	<.0001
Secondary	20	16.9		
Tertiary	92	77.9		
Primary Occupation				
Small scale livestock owner	52	44.1	6.83	0.0329
Other type of farming	66	55.9		
Experience in Pig farming (Years)				
<5	33	27.9	7.87	0.0489
6-10	38	32.2		
11-15	29	24.6		
>16	18	15.3		
Household Economic Status				
Low income	32	27.2	25.66	<.0001
Middle and above	86	72.9		
Contribution of livestock farming to household income (Percentage)				
<50%	56	47.5	0.31	0.5806
>50 %	62	52.5		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable

Characteristics of the Surveyed Pig Farms

Table 2 summarized the key attributes of the pig farms. Majority of farmers reared fewer than 14 pigs on their farms, with 51.7% in this category. However, a significant portion (48.7%) reared more than 14 pigs. The most common pig breeds found on the farms were Landrace (28%), Large White (19.5%), and Nigerian indigenous breeds (14.4%). Other breeds reared included Duroc, Yorkshire, Hampshire, and crosses. In terms of farm management system, majority of the farms (49.2%) utilized semi-intensive management systems, and intensive management systems (43.2%). Additionally, a small percentage (7.6%) operated as free-range farms. The farms typically reared both piglets and sows, with the animals reared either for slaughter or immediate sale after being weaned. A vast majority of farmers (81%) utilized compounded feed on their farms, approximately half of the farmers obtained their water from boreholes (49%) or well water (50%). Many of these farms were situated at varying distances from veterinary care facilities, with most located between 6 to 9.9 kilometres away.

Farmers reported a range of illnesses and symptoms commonly observed on the farms, included pig diarrhoea, respiratory disorders, coccidiosis, parasitism, exudative dermatitis, anaemia, African swine fever, mastitis, foot-and-mouth disease, porcine parvovirus, mange, and inappetence (Figure 1).

Table 2 Characteristics of the surveyed pig farms in Jos and Kanke Local Government Area

Variable	Frequency	Percentage (%)	χ^2	P-value
Number of pigs in farms				
< 14 pigs	61	51.7	0.14	0.7127
>14 pigs	57	48.3		
Production system				
Free range	09	7.6	44.99	<.0001
Intensive	51	43.2		
Semi-intensive	58	49.2		
Breeds				
Duroc	11	9.3	93.3152	<.0001
Landrace	28	23.7		
Large white	45	38.1		
Nigerian Indigenous Breeds	24	20.3		
Hamshire	02	1.7		
Yorkshire	05	4.2		
Mixed breeds	3	2.5		
Age of Pigs (Months)				
<= 5years	83	70.3	107.38	<.0001
<=12 months	32	27.1		
All age range	1	0.85		
Feed source				
Commercial	15	12.7	172.04	<.0001
Compounded	95	80.5		
Others	08	6.8		
Water Source				
Borehole	58	49.2	85.55	<.0001
Tap water	01	0.8		
Well water	59	50.0		
Average distance of farm from a Veterinary store (km)				
<2.9	20	16.9	51.29	<.0001
3-5.9	21	17.8		
6-9.9	65	55.1		
>10	12	10.2		
Distance of pig farms to water bodies (meters)				
<10	07	5.9	75.96	<.0001
100	08	6.8		
100-200	59	50.0		
>200	44	37.3		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable

Awareness of Antibiotic Use

Twenty-one questions were used in the assessment process to gauge participants' understanding on prudent antibiotics use (Table 3 and 4). All participants (100%) recognized that antibiotics are used to treat infections in both humans and animals. Majority of the farmers (66%) correctly identified that antibiotics cannot be used to treat infections caused by fungi and viruses. The farmers sourced veterinary medications, including antibiotics, from Agro-veterinary shops (59.3%), drug vendors (17.8%) and veterinarians (6.8%). Majority of the farmers (88.1%) reported using antibiotics for therapeutic purposes –a small percentage used them for prophylaxis (1.8%) or for growth promotion (10.2%). The outcome of the study also revealed oxytetracycline (31%), sulfadimidine (17%), gentamicin (12%), enrofloxacin (10%), and penstrept (8%) (Procaine penicillin G: 200,000IU and Dihydrostreptomycin: 200mg combination), and tylosin (8%) as the most commonly used antibiotics in pig production in the study area (Figure 2). Other drugs used by farmers included, amprolium (anticoccidial agents) and ivermectin (antiparasitic).

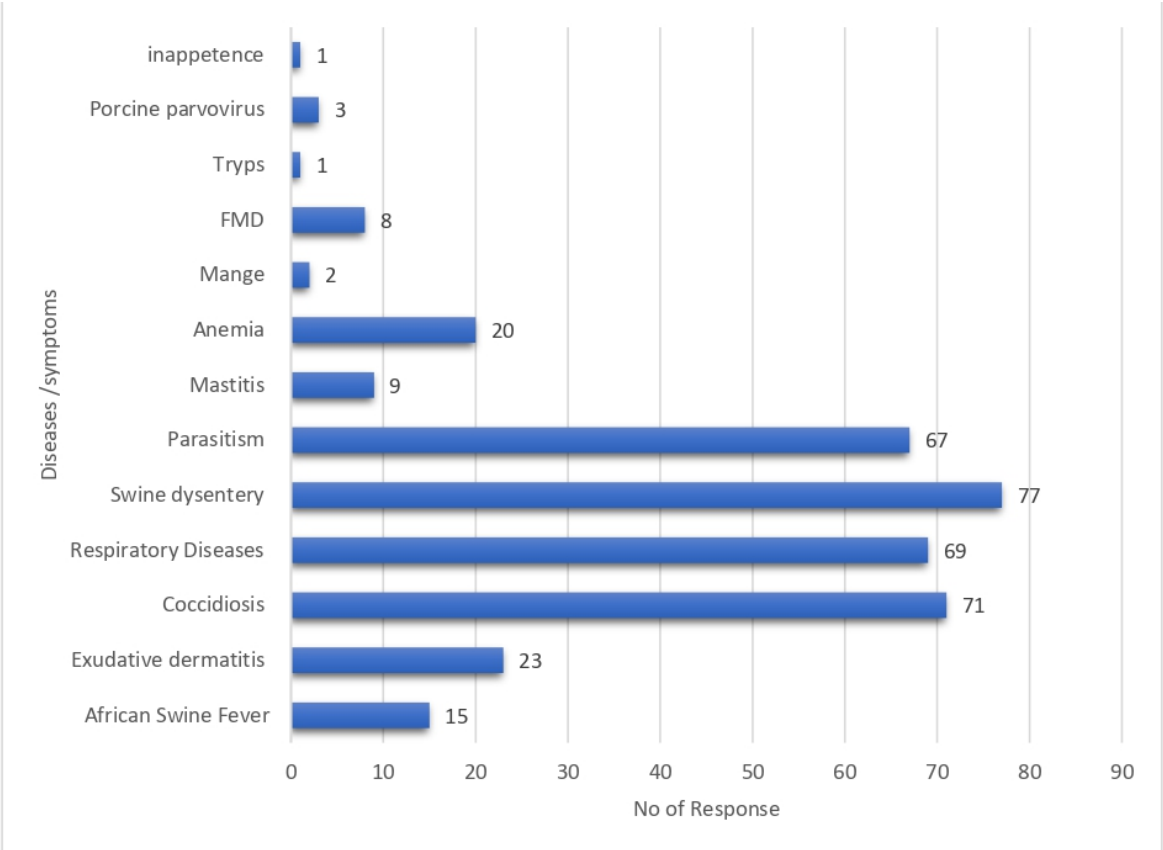

Figure 1 Diseases/symptoms encountered by pig farmers in the study area

A significant percentage of the farmers (61.9%) reported not keeping track of antibiotics used on their farms. And when pigs are unwell, most farmers (74.6%) reported seeking veterinary assistance, while others consulted animal pharmacies (13.6%) or drug vendors (11.7%). Despite recognizing the necessity of antibiotics for animal health, a significant portion of farmers (60.2% and 45.8%) believed that antibiotics could enhance animal growth and reduce inflammation. Conversely, many farmers (93.2%) acknowledged the importance of securely storing antibiotics according to manufacturer recommendations.

A significant percentage of these farmers (85.6%) were aware of the potential risks associated with the use of multiple antibiotics, such as drug interactions and decreased effectiveness. Additionally, the farmers (91.5%) recognized the importance of adhering to antibiotic withdrawal periods to ensure food safety. Furthermore, most farmers (86.4%) agreed that treating the entire flock when only a few pigs exhibited clinical symptoms of illness is necessary, and 55.2% believed that providing antibiotics to pigs could have unfavourable effects.

Table 3 Awareness of antibiotic use.

Questions	Category	Percentage	χ^2	P-value
Antimicrobial drugs are compounds which are used for bacterial treatment and control.	No	0(0.00)	NA	NA
	Yes	118(100.00)		
Virus and fungi are microorganisms that antibiotics cannot cure.	No	28(23.73)	34.27	<.0001
	Yes	90(76.27)		
Do you know who is legally responsible for prescription of antimicrobials for use in your farm?	No	21(17.80)	53.07	<.0001
	Yes	97(82.20)		
Do you think it is easy to get access to antimicrobials?	No	69(58.47)	3.41	0.0649
	Yes	49(41.53)		
Where do you purchase your antibiotics (Select all that applies)	Agro-Vet shop	70(59.32)	202.89	<.0001
	Drug vendors	7(5.93)		
	Veterinarian	2(1.69)		
	Agro-vet shop	1(0.85)		
	Agro-vet shop, Veterinarian	6(5.08)		
	Drug vendors	21(17.80)		
	From other farmers	1(0.85)		
	Traditional practitioner	2(1.69)		
	Veterinarian	8(6.78)		
Do you keep records of antimicrobials used in your farm?	No	45(38.14)	6.71	0.0096
	Yes	73(61.86)		
Who do you consult when your animals are sick?	Animal Pharmacy	16(13.56)	84.02	<.0001
	Drug vendor	14(11.86)		
	Veterinarian	88(74.58)		
Are antimicrobials needed to keep animals healthy?	No	7(5.93)	110.46	<.0001
	Yes	111(94.07)		
Will the use of antimicrobials result in better growth of animals?	No	8(6.78)	105.08	<.0001
	Yes	110(93.22)		
Do you think antimicrobials are efficient for the treatment of both bacterial and viral infections?	No	47(39.83)	4.92	0.0266
	Yes	71(60.17)		
Antimicrobial drugs are the same as drug for relief of inflammation.	No	64(54.24)	0.85	0.357
	Yes	54(45.76)		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable

Table 4 Awareness of antibiotic use.

	Category	Percentage	χ^2	P-value
Antimicrobial drugs should be stored in a secure place and in accordance with the manufacturers' recommendation.	No	8(6.78)	105.08	<.0001
	Yes	110(93.22)		
Interaction among multi-antimicrobial drugs used at the same time can reduce the efficacy of other antimicrobial drugs for bacterial treatment and control.	No	17(14.41)	66.28	<.0001
	Yes	101(85.59)		
Antimicrobial drug's efficacy could not be reduced when administered in sub-recommended dosages.	No	73(61.86)	6.71	0.0096
	Yes	45(38.14)		
Drug withdrawal periods should be adhered to as per the prescription to avoid drug residues in meat or animal products.	No	10(8.47)	95.09	<.0001
	Yes	108(91.53)		
Do you think the treatment is needed for the whole herd if one/few pigs showing any symptoms?	No	16(13.56)	69.92	<.0001
	Yes	102(86.44)		
Do you think giving antimicrobials to animals may result in any negative consequences?	No	53(44.92)	1.23	0.2689
	Yes	65(55.08)		
For what purpose do you use antibiotics?	Growth Promotion	2(1.69)	161.83	<.0001
	Prophylaxis	12(10.17)		
	Treatment	104(88.14)		
Do you feel you have received enough information on how antimicrobials should be used in animals?	No	93(78.81)	41.70	<.0001
	Yes	25(21.19)		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable

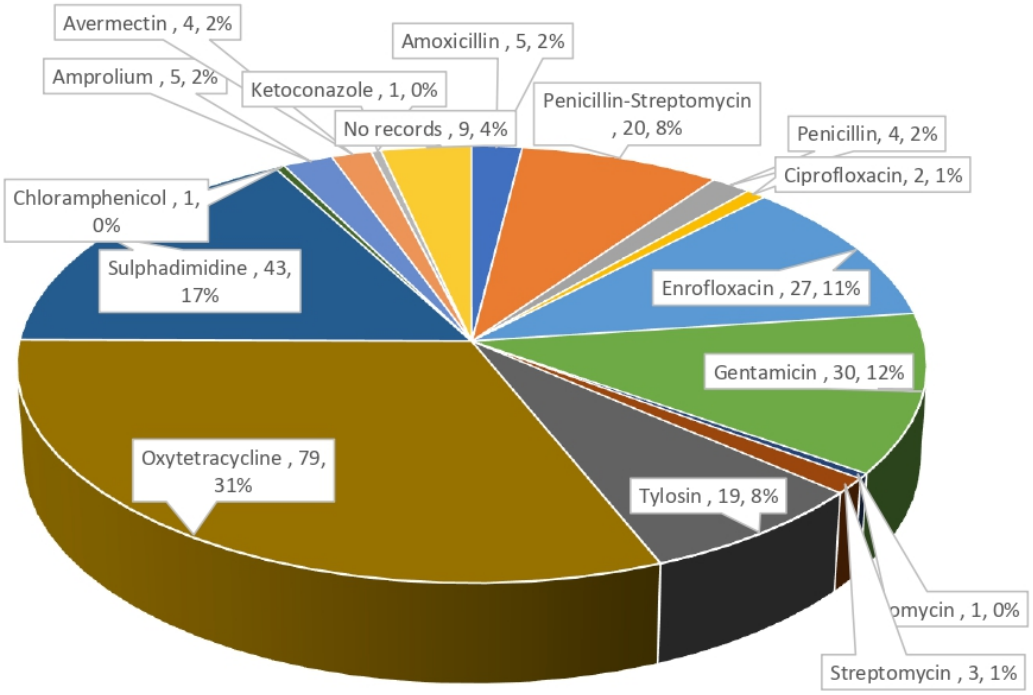

Figure 2 Antimicrobials commonly used in pig farmers in Jos Plateau State

Awareness of Antibiotic Resistance and Acts Regulating the Use of Antibiotics in Nigeria

Pig farmers (80.5% and 75.4%, respectively) demonstrated awareness or familiarity with the concepts of antibiotic resistance and antibiotic residues. A substantial portion of farmers (77.1%) recognized the potential risks to human health associated with consuming pork contaminated with antibiotic-resistant bacteria or residues. The farmers further expressed familiarity with the concept that non-therapeutic or indiscriminate antibiotic use (79.7%) can contribute to the development of antibiotic resistance. These farmers (82.2%) also recognized the importance of using antibiotics sparingly to prevent resistance (Table 5 and 6). While a significant proportion (77.1%) reported being fairly knowledgeable about laws governing antibiotic use in humans, animals, and the environment. However, over half of the farmers (56.8%) were unaware of the prohibition of antimicrobial medication use for non-therapeutic purposes in food animals in Nigeria. Many of these farmers (58.5%) were not aware of specific regulations enforced by the National Agency for Food and Drug Administration and Control (NAFDAC) and other agencies guiding the rational use of antimicrobials and related products in food animals.

Practices towards Antibiotic Use

Majority of pig the farmers (78.8%) reported consulting a veterinarian when their pigs were ill or showing signs of illness. These farmers (72%) reported to have administered antibiotics to all pigs, even those without symptoms of illness, as a preventive measure. However, a sizeable minority (21.2%) reserved antibiotic use for sick pigs, while a small percentage (4.2%) utilized antibiotics as feed additives for disease prevention and for growth promotion.

Table 5 Farm biosecurity practices of pig farms visited.

Questions	Category	Frequency	X-value	P-value
1. Is your farm fenced?	Fenced	59(50.00)	13.9153	0.001
	Not Fenced	29(24.58)		
	Partly Fenced	30(25.42)		
2. Do you have hand washing facilities at farm entrances?	No	57(48.31)	0.1356	0.7127
	Yes	61(51.69)		
3. Do you have vehicular, foot dips at farm and pen entrances?	No	71(60.17)	4.9156	0.0266
	Yes	47(39.83)		
4. Are the pig pens netted?	No	63(53.39)	0.5428	0.4613
	Yes	55(46.61)		
5. What is your source of drinking water?	Borehole	58(49.15)	149.4305	<.0001
	Borehole, Well water	8(6.78)		
	Purchase from water vendors, tap water	1(0.85)		
	Well water	50(42.37)		
	Well water, Purchase from water vendors	1(0.85)		
6. Do you sanitize your drinking water?	No	57(48.31)	0.1356	0.7127
	Yes	61(51.69)		
7. If your answer to question 6 is yes, specify the water sanitizer.	Alum (Aluminium sulphate)	2(3.39)	97.2803	<.0001
	AquaSep (®)	2(3.39)		
	Boiling	1(1.69)		
	Byy	1(1.69)		
	Chlorine	30(50.85)		
	Chlorine or Aquazix (®)	1(1.69)		
	Discol (®)	1(1.69)		
	Iodastery (®)	1(1.69)		
	Isoclor (®)	8(13.56)		
	Ultra-D (®)	1(1.69)		
	water guard (®)	2(3.39)		
	Water sanitizer (®)	9(15.25)		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable. *These sanitizers are mostly trade names and active ingredients vary according to manufacturers instructions.*

Parenteral treatment (injection) was the most common method of antibiotic administration, preferred by 78.8% of farmers, followed by oral administration through feed or water (18.6%) (Due to weak regulations, these farmers had access to antibiotics and as such it was quite worrisome that they administered these antibiotics without prescriptions and or guidance from Veterinarians). A significant portion of the farmers (56.8%) admitted to have used antibiotics intended for human use on their pig farms. While many farmers (61.0%) reported following treatment plans rigorously, a sizeable percent (39%) admitted to stopping treatment once they observed improvement in their pigs' health.

Farmers' responses regarding the disposal of leftover antibiotics varied, with some opting for improper methods such as burning, burying, or discarding in ponds or the environment (The ideal situation was to submit these antibiotics to NAFDAC who will then dispose it off properly, however, looking at the complexity of systems in Nigeria, it may not be feasible. Also, due to knowledge gap, the farmers had poor knowledge of the regulators responsible for the regulation of Food, drugs and other products). With regards to withdrawal periods, while 50% of the farmers reported observing withdrawal periods before selling or slaughtering their pigs, a notable proportion (30.6%), do not observe these withdrawal periods and were unaware of the concept. The farmers (81.4%) also admitted to have purchased and administered antibiotics to their pigs without consulting a veterinarian and farmers reported to have administered antibiotics to all pigs regardless of their health status.

Practices on Farm Biosecurity

Table 5 and 6 presents an evaluation on the knowledge farm biosecurity. Half of the pig farms had perimeter fencing around the farms. However, a significant portion (49.6%) either had partial fencing or no fencing at all. While about half of the farms had hand washing stations at the entrances (51.7%), a considerable percentage (48.3%) lacked this basic hygiene facility. About 60.2% of the farms did not have vehicular or foot dips at the farm and pen entrances, and borehole and well water (49.2% and 42.3%, respectively), were the major sources of water on the farms -with a smaller percent reported to source water from vendors (6.8%). However, practices for water sanitation varied, with only about half of the farmers (51.7%) employing methods such as boiling or using sanitizers to ensure water quality. A significant fraction of pig farmers reported various practices for managing pig litters, including selling to vegetable growers (46.6%), used on crop farms (29.7%), or disposed in landfills and bodies of water. While a majority of farmers (46.6%) cleaned their pig pens once a day, others (34.2%) reported less frequent cleaning intervals, while some (10.2%) admitted to not cleaning their pig enclosures at all.

Table 6 Farm biosecurity practices of pig farms visited.

Questions	Category	Frequency	X-value	P-value
8. Do you quarantine sick or newly purchased pigs?	No	59(50.00)	0	1
	Yes	59(50.00)		
9. Do your workers use protective clothing while on farm?	No	70(59.32)	4.1258	0.0422
	Yes	48(40.68)		
10. Do you have a facility where you store faecal material?	No	35(29.66)	20.1031	<.0001
	Yes	83(70.34)		
11. How do you dispose your faecal material	Dispose in the environment	4(3.39)	157.28	<.0001
	Dump site	4(3.39)		
	Sell to vegetable farmers	13(11.02)		
	sell to vegetable farmers and use to grow vegetables	55(46.61)		
	Sell to vegetables farmers, use it to grow vegetables and sources of energy	1(0.85)		
	use it to grow vegetables	35(29.66)		
	use it to grow vegetables, dispose in nearby water bodies	2(1.69)		
	water bodies	3(2.54)		
12. How often do you wash the pen house?	Daily	55(46.61)	65.2532	<.0001
	Fortnightly	5(4.24)		
	Monthly	16(13.56)		
	Not at all	12(10.17)		
	Once a week	13(11.02)		
	twice a week	17(14.41)		

P < 0.01=highly significant; P<0.05=Significant; P>0.05= Not significant; NA; Not Applicable

DISCUSSION

Sociodemographic Characteristics of Pig Farmers

The demographic findings provided valuable understanding into the sociodemographic characteristics of pig farmers in the study population, highlighting key aspects such as gender distribution, age demography, educational background, experience in pig farming, income levels, and livelihood dependence on pig production. These findings are essential for understanding the profiles of pig

farmers and can inform targeted interventions and policies aimed at supporting and improving pig farming practices and livelihoods.

The gender distribution observed in this study suggested that pig farming is predominantly undertaken by men and this was in tandem with previous reports in southern Nigeria, where it was observed that pig production was predominantly a man's endeavour (Nwanta et al., 2011; Uneze and Onugu, 2012; Abiola et al., 2015; Omowon et al., 2019). This may be due to the perception that management of pigs is quite laborious, requiring physical strength and may not be an enterprise that is woman friendly. Interestingly, while other studies believed it was male dominated, Bawa et al. (2004) reported the high involvement of women (61.7%) in semi-intensive management of pigs than men (32.24%). The difference in gender disparity could be due to cultural and religious beliefs, as many cultures prohibited the consumption and handling of pigs and pork by women.

With respect to age distribution, a significant proportion of pig farmers were older individuals, rather than younger individuals which corresponded to the findings of Omowon et al. (2019), the pig farmers were reported to be above 54 years of age. Hence a need for government and stakeholders' involvement through provision of incentives to attract young and middle-age farmers into pig production in Nigeria. The enterprise is lucrative (because pigs constituted about 4% of the non-ruminant livestock in Nigeria) and in some countries like China, pig production is a major source of foreign exchange earnings (Obayelu et al., 2017; Bai et al., 2023).

The distribution in terms of level of education is in agreement with the findings of Osundu et al. (2014) which suggested an increased interest in pig production involving individuals with varied educational levels otherwise evidenced by the involvement of many retired civil servants as their post-retirement vocation. The findings are also important, in that whenever, government and relevant stakeholders consider introducing and adopting new technologies or the use of artificial intelligence in pig value chain to increase productivity, and it will gain acceptability. Regardless, efforts should be put in place to encourage the involvement of young people into livestock production to boost the agricultural economy of Nigeria. Similarly, the distribution with respect to experience indicated a diverse range of experience levels among the surveyed farmers. Our findings agreed with work of Nwachukwu and Udegbunam (2020) who also reported pig farmers with more than 20 years' experience. If this trajectory continues, in the next decades, significant improvement will be recorded in the Nigerian pig production value chain, farmers will record an increase in production, reduction in the occurrence of diseases, and alternatives sources of income.

The financial status of surveyed farmers indicated that a considerable portion of pig farmers in Nigeria have relatively stable or higher financial statuses and with the enterprise serving as a primary source of livelihood for over half the population, indicates the importance of pig farming as a means of sustenance for a significant portion of the population. This underscored the prospect of the livestock sub-sector as an important contributor to the agro-economic development of farmers, and by extension the agricultural sector of Nigeria.

Characteristics of the Surveyed Pig Farms

The observation of various pig breeds, population of pigs and management practices reflected the diversity in breed preferences among farmers, variability in farm sizes among the surveyed population highlighted the range of management practices employed by pig farmers in Plateau State. Also, the purposes for the endeavour indicated a focus on both breeding and the commercial aspects of pig farming. To improve the pig production value chain in Nigeria, government and relevant stakeholders need to invest in improved breeds with high disease resistance index.

The high reliance on formulated diets for pig nutrition suggested the use of locally found materials among pig farmers. However, the risk of feeding the animals with contaminated feed cannot be down played as the standardization of the formulation used cannot be ascertained. The water sources (borehole and well water) are considered relatively safe emphasizing the need for access to clean water sources in pig farming operations. The proximity of pig farms to veterinary settings suggested that while veterinary services are accessible, there may be logistical challenges associated with reaching these facilities in a timely manner. This may compound the problems associated with indiscriminate use of antibiotics in pig production, because lack of access to veterinary services may spur farmers to procure antibiotics from drug vendors and administer without prescription.

Various disease conditions outlined by the surveyed farmers highlighted the prevalence of various health challenges faced by pigs and underscored the importance of disease management and prevention practices in pig farming. Which is in tandem with the findings of Nwanta et al. (2011) and Asambe at al. (2019) where they reported that diseases and poor management practices constituted major impediments to the growth of the pig production value chain in Nigeria, with African swine fever (ASF) being the most predominant disease. However, in this study the major diseases reported by farmers included parasitism, respiratory diseases, swine dysentery and coccidiosis. This could be attributed to management practices and changes in the climate conditions of Plateau State. The State is cold and dry during the cold months of the years and humid and warm during rainy season, which may favour the onset and spread of some of the aetiologic agents of the diseases mentioned (Shehu et al., 2018).

Awareness of Antibiotic Use

A basic understanding of antibiotic usage and its role in controlling bacterial infection was demonstrated among the farmers surveyed in this study. Although there is still need for better awareness on antibiotic therapy since almost half the population are still conflicted with using antibiotics in fungal and viral based conditions. Various antibiotic drugs were highlighted to be used by pig farmers for various reason. This is in agreement with Adebowale et al. (2020) where he reported tetracycline, gentamicin and tylosin as the most used antibiotic drugs amongst pig farmers in Ogun State, South-western Nigeria. The use of various classes of antibiotics by farmers could suggests resistance to antibiotic therapy especially since a good number suggested the source of these drugs as Agro-veterinary shops.

However, the keeping track of antibiotic used on the farm reported by a sizeable portion of the farmers indicated a level of accountability in antibiotic administration. Understanding rational use of antibiotics is central to curbing the menace of antibiotic resistance. When farmers and critical stakeholders in the livestock value chain are properly informed on the dangers and economic losses associated with AMR, the country is on track to eliminating indiscriminate antibiotic use. The indiscriminate use of antibiotics in animal production represents a significant cause for concern due to the potential of antibiotic resistance (Adebowale et al., 2020). This has significant impact on humans due to the increased chance of transmission of antibiotic-resistant pathogenic bacteria from animals to humans, increase in the cost of treatment and prolonged hospital admission.

The use of antibiotics as growth promoters reported by a percentage of farmers suggests a need for more awareness campaign on the mechanism of drug resistance development among farmers. Perceptions of using antibiotics as growth promoters facilitates the indiscriminate use of antibiotics in animals, and going by the number of farmers that alluded to such knowledge, and the lack of adequate regulations with regards to the use of antibiotics in livestock, the fight against antibiotic resistance is far from over.

On the other hand, practices such as storing antibiotics according to manufacturer's instructions, awareness to the dangers associated with the use of multiple antibiotics such as drug reactions and decreased effectiveness and adhering to antibiotic withdrawal period shows a promise in the fight against antibiotic resistance. Also, the herd health principle of treating the whole flock and not only those with clinical symptoms indicated a common practice in disease management, which contradicted their response to the awareness of antibiotic use in animals.

Overall, the findings from the assessment revealed a mixed understanding among pig farmers regarding the prudent use of antibiotics, with areas of both good knowledge and potential misconceptions being highlighted. These insights can inform targeted educational initiatives aimed at promoting responsible antibiotic use practices among farmers. The disparity in the potential misconceptions could be associated with the level of education as previous studies showed that level of education is linked to rational use of antibiotics (Eltayp et al., 2012; Adebowale et al., 2020).

Awareness of Antibiotic Resistance and Acts Regulating the Use of Antibiotics in Nigeria

The basic understanding of the potential risks associated with antibiotic use in both animal and human health was demonstrated by the farmers which highlighted an understanding of the link between antibiotic use in pigs and public health concerns. The need for using antibiotics only sparingly indicated a level of understanding of responsible antibiotic use in practices as indiscriminate/non-therapeutic use could result in resistance.

Although a good percent of farmers showed a good knowledge on antibiotic use and governing regulations, there were gaps in awareness regarding specific regulations such as the prohibition of combining nitrofurans and chloramphenicol in animal feed. This suggested a need for increased awareness and education regarding regulatory requirements for antibiotic use in pig farming and enforcement of such regulations to ensure strict compliance. Despite gaps in awareness of regulatory frameworks, farmers demonstrated understanding of who is legally authorized to prescribe antibiotics for animal health and the requirement for NAFDAC approval for antibiotic medications and feed supplements.

The findings indicated a mixed level of awareness among pig farmers regarding antibiotic resistance, residues, and regulatory frameworks governing antibiotic use. While many farmers had basic knowledge of these concepts, there are opportunities for further education and awareness-building efforts to enhance understanding of responsible antibiotic-use practices and compliance with regulatory requirements.

Practices Towards Antibiotic Use

The recognition of the importance of professional veterinary care in managing pig health by the farmers suggests the role of the veterinarian in creating awareness and their strategic location in the fight against drug resistance. The use of antimicrobials as growth promoters although a low practice among the surveyed farmers negates the globally accepted use that is either for prophylaxis or therapeutic purposes suggesting still yet a need for more awareness. It is a well-known fact that growth promoters are sometimes used to denote antimicrobials used for prophylactic purposes and administered to animals in low doses.

Prolonged use of these antimicrobials at sub-optimal doses may lead to resistance development. The European Union has banned the use of antimicrobials as growth promoters however, such practices are still being utilized in China and United States of America (Viola and DeVincent, 2006; Vondruskova et al., 2010; Dang et al., 2013; Adebowale et al., 2020). This is particularly worrisome, because

in Nigeria regulations regarding the use of antimicrobials in human and animal health are weak.

With most antibiotics administered parenterally as reported by most farmers, such administration requires the services of a trained personal or long period of experience which could be the case in this instance as is demonstrated in the demography. The use of antibiotic intended for humans for their pigs further highlighted a practice of self-medication by the farmers which has a potential for misuse of antibiotics and the need for proper veterinary oversight on antibiotic use and consumption. Stopping treatment once improvement in pig health is observed and the improper disposal of leftover antibiotics indicated a potential risk of incomplete treatment and need for education on proper disposal practices to prevent environmental contamination that can result in antibiotic resistance.

The poor knowledge on the withdrawal guidelines suggested a high risk of exposure to residual antibiotics in pork being sold that can result in resistance suggesting a need for increased awareness and adherence to withdrawal guidelines. With farmers practicing self-medication, a potential misuse of antibiotics is evident. This is the result of lack of awareness on antimicrobial stewardship, and poor implementation of the guidelines for proper use of antibiotics. Since veterinarians and veterinary paraprofessionals are at the centre of advocating for animal health and welfare and in creating awareness on the rational use of antibiotics, these roles must be taken with all sense of responsibility because livestock farmers depended on their advice on animal health, and choices of antibiotics. This finding also underscored the need for innovative educational interventions on antimicrobial use amongst livestock producers (Visschers et al., 2015; Adebowale et al., 2020).

Practices on Farm Biosecurity

Most farm had a basic level of physical barrier for biosecurity which indicated a good understanding of disease transmission and prevention between humans and animals. However, the lack of foot dips and a wash station before accessing the farm suggests a limitation on the knowledge thereof. As such creates a potential risk of introducing pathogens onto the farm premises via contaminated footwear or vehicles. Knowledge on water treatment is also limited as only few carried out practices such as boiling which could be responsible for the varying diseases experienced by the farmers. The poor waste management practices by farmers such as dumping litters in water bodies, landfills and selling to vegetable growers suggests a possibility of zoonoses and environmental contamination by these litters and a need for awareness on the risks of such practices and a standardized waste management practice. Inadequate cleaning practices posed a risk of disease transmission and poor farm hygiene. Addressing gaps in biosecurity measures, such as lack of hand washing facilities, water sanitation, and waste management, is essential to enhancing disease prevention and control on pig farms and promote overall farm hygiene and productivity.

The potential limitation of this research could be the extrapolation of the findings. Because the study is preliminary, the focus was on pig farmers on the Plateau, the findings are not representative of other regions of the country with different pig farming practices, cultural attitudes towards antibiotic use, or levels of awareness about antibiotic resistance. Additionally, the sample size and diversity of stakeholders included in the study may impact the ability to generalize the results. Moreover, the self-report nature of data collection methods, such as surveys or interviews, may introduce response bias or social desirability bias, where participants may provide answers that they perceive as socially acceptable rather than reflecting their true beliefs or behaviours. Finally, as with any preliminary report, the limitations could be related to the scope of the study, such as the depth of analysis or the range of variables considered, which could be addressed in future research to provide a more comprehensive understanding of the topic.

CONCLUSIONS

The findings of this study revealed a variable level of awareness with regards to antibiotic use, antibiotic resistance, and practices on farm biosecurity. While a significant proportion of the farmers indicated positive knowledge gain, there still exist gaps especially as it relates to the use, and proper disposal of antibiotics. Farmers believed that antibiotics are efficient supplements in the promotion of livestock growth. This underscores the importance of investment in training efforts to all livestock farmers in Nigeria. Additionally, the government should ensure the implementation of regulations on antibiotic use in whatever form in the livestock industry.

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AUTHOR CONTRIBUTIONS

Asinamai Athliamai Bitrus: Developing and sharing of questionnaire, data collation from questionnaire and discussion of findings.
Dishon Hurdison Charibu: Development of Methods for Statistical Analysis of data, analysis of data and proof reading of manuscript.
Oludayo Michael Akinsola: Development of study design, Statistical Analysis of data and proof reading of manuscript.
Oludotun Olubusola Oladele: Development of questionnaire and data collection via interview of farmers as well as farm visits and proof reading of questionnaire.
Adanu Williams Adanu: Development of Study design and sample size determination using Epi info 7 as well as proof reading of manuscript.
Essienifiok Saturday Unanam: Development of questionnaire, farm visit for data collection by interview and proof reading of manuscript.
Omoniwa David Oludare: Development of questionnaire, farm visit for data collection by interview, and proof reading of manuscript.

CONFLICT OF INTEREST

There is no conflict of interest by the authors with respect to this research work as all authors proof read and accepted the content of this manuscript. This research work did not receive any funding.

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