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REGULAR ARTICLES

Antimicrobials in animal production: usage and practices among livestock farmers in Oyo and Kaduna States of Nigeria

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Abstract Antimicrobials have proven to be important for sustainable livestock production by their use as growth promoters and in the control of animal infections. However, injudicious use of antimicrobials could accelerate the emergence and spread of resistant bacterial strains with attendant socioeconomic and public health issues. This work assessed antimicrobial usage in animal production with emphasis on usage and practices by livestock producers in Oyo and Kaduna States of Nigeria. Data on antimicrobial usage were collected through interviews, questionnaire and focus group discussions. Four hundred and fifty-four farmers in 11 communities within 11 Local Government Areas of Oyo and Kaduna States of Nigeria were sampled in a multi-stage sampling procedure. The study showed that antimicrobial agents were widely distributed, readily accessible and commonly used in animal production. Fluoroquinolones and other critically important antimicrobials for human medicine were widely used in animals as prophylactics. Potentially harmful antimicrobials including furazolidones and chloramphenicol already banned for use in humans and animals were freely marketed and used in livestock production. Most of the respondents believed that veterinarians should be responsible for the administration of antimicrobials to animals, but in practice, they buy and administer antimicrobials without consulting veterinary professionals. It was observed that the ready availability of antimicrobial agents promoted the use of antimicrobials in livestock production and may encourage non-adherence to hygienic principles and management laxity in farm operations. The non-involvement of veterinary professionals and laboratory investigations in disease diagnosis prior to antimicrobial use could lead to improper usage that contribute to the development of antimicrobial resistance in bacterial strains. Responsible antimicrobial stewardship and strict regulations are vital to prolonging the benefits derivable from the use of antimicrobials.

Keywords Antimicrobial usage · Food animals · Practices · Farmers · Nigeria

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Introduction

Antimicrobial agents are used extensively in medical and veterinary practices for the treatment, control and prevention of bacterial infections (Phillips et al. 2004). Usage of antimicrobial agents is an integral component of most commercial livestock production. Antimicrobials have proven to be important for sustainable livestock production and for the control of animal infections that could be transmitted to humans through the food chain (Casewell et al. 2003; Phillips et al. 2004). Usage of antimicrobials contributes significantly to improved productivity and increased profitability by minimizing losses associated with morbidity and mortality from bacterial diseases (Hao et al. 2014). Antimicrobials also help in improving feed conversion efficiency and are thus used routinely by

livestock producers as growth promoters (Onu et al. 2004). This has helped a great deal in boosting animal protein availability for food security as an antidote to hunger and malnutrition especially in the developing countries. However, exposure to antimicrobial agents is a major factor contributing to the emergence and spread of antimicrobial resistance in bacteria. This development constitutes a substantive threat to the efficacy of therapeutic antimicrobial usage in human and veterinary medicine (Levy and Marshall 2004). Resistant bacterial strains can be transmitted from animals to humans through consumption of contaminated animal products. Transmission can also occur by direct and indirect contact with carrier animals and their environment (Marshall and Levy 2011).

One of the major factors driving the emergence of antimicrobial resistance in bacterial strains is the high level of dependence on antimicrobial agents in animal production. A larger percentage of antimicrobial agents are used in animals than in humans, and this may account for the high level of reservoirs of resistant bacteria of animal origin (Chantziaras et al. 2014; ECDC/EFSA/EMA 2015). The increase in antibiotic resistance has been attributed to a combination of microbial characteristics, the selective pressure of antibiotic use as well as environmental and social changes that enhance the emergence, survival and dissemination of resistant organisms (Levy and Marshall 2004; Džidić et al. 2008). In order to preserve the therapeutic efficacy of antimicrobials and prevent the continuous emergence of antimicrobial resistance among bacteria, many countries have formulated policies to restrict the use of antimicrobial agents in animals (Maron et al. 2013). Emphasis is now placed on the judicious antimicrobial usage in animals so as to maximize the benefits derivable from their use.

In Nigeria, high rates of antimicrobial resistance are increasingly been reported among bacteria of animal origins, but there are no information on practices relating to antimicrobial usage in animals. While it is generally believed that antimicrobial agents are widely used in animal production system, documented evidence of antimicrobial usage in animal are limited (Alo and Ojo 2007; Oluwasile et al. 2014). Moreover, factors contributing to the use of antimicrobial agents in animals in Nigeria are yet to be documented. Information on the knowledge, attitude and practices of farmers on antimicrobials and their application in animals will help in formulating strategies to maximize and preserve the potential benefits of antimicrobial usage in livestock production with minimal jeopardy to public health. This work assessed the range of available antimicrobial agents and level of usage in animal production in Oyo and Kaduna States of Nigeria. It also evaluated the practices of livestock producers in relation to antimicrobial usage.

Materials and methods

This study is a survey targeted at gathering information relating to antimicrobial usage in animal production from producers of various animals (chicken, turkey, guinea fowl, geese, duck, horse, cattle sheep, goat, dog, rabbit and quails). The survey was conducted in Oyo and Kaduna States, Nigeria. The selection of the states was purposive and was based on existence of local producers of livestock in many of the suburbs of the selected states and the availability of large market for antimicrobial agents. The geographical location of Oyo and Kaduna States is shown in Fig. 1.

Oyo State is an inland State in South-western Nigeria, with its capital at Ibadan, the third largest metropolitan city in Nigeria. Oyo State covers approximately an area of 28, 454 km^2 and is ranked 14th by size in Nigeria (http://en.wikipedia.org/wiki/Oyo_State, accessed 11th June 2014). Oyo State has 33 local government areas (LGA); the state is homogenous, mainly inhabited by the Yoruba ethnic group who are primarily agrarian but have a predilection for living in high-density urban centres. The indigenes mainly comprise the Oyos, the Oke-Oguns, the Ibadans and the Ibarapas, all belonging to the Yoruba family. The tropical climate and the derived savannah vegetation in the state favours the production of crops and livestock.

Kaduna State is a state in the North-central region of Nigeria with a total area of 46,053 km^2 and 23 LGA. Its capital is Kaduna, an ancient city, a trade centre and a major transportation hub for the surrounding agricultural areas with its rail and road junctions. Kaduna State is mostly populated by Hausa, Gbagyi, Adara, Gong, Atyap, Bajjuu, Koro, Zango, Kataf and Agworok ethnic communities (http://en.wikipedia.org/wiki/Kaduna_State, accessed 11th June 2014). The climate and vegetation also favour the production of various animals and serve as a major commercial centre in the northern region of the country.

Sampling of respondents

Multi-stage sampling procedure was adopted for this study. LGAs were selected purposively based on information obtained from local key informants on locations with high level of livestock activities in each of the states. From each Senatorial zone of the states, one LGA was selected purposively. However, in Kaduna, due to the identification of more useful locations with high concentration of livestock activities, more LGAs were selected. Table 1 shows the LGAs, communities and number of producers selected in each of the states. In all, 11 LGAs, 11 communities and 454 producers were sampled for the study.

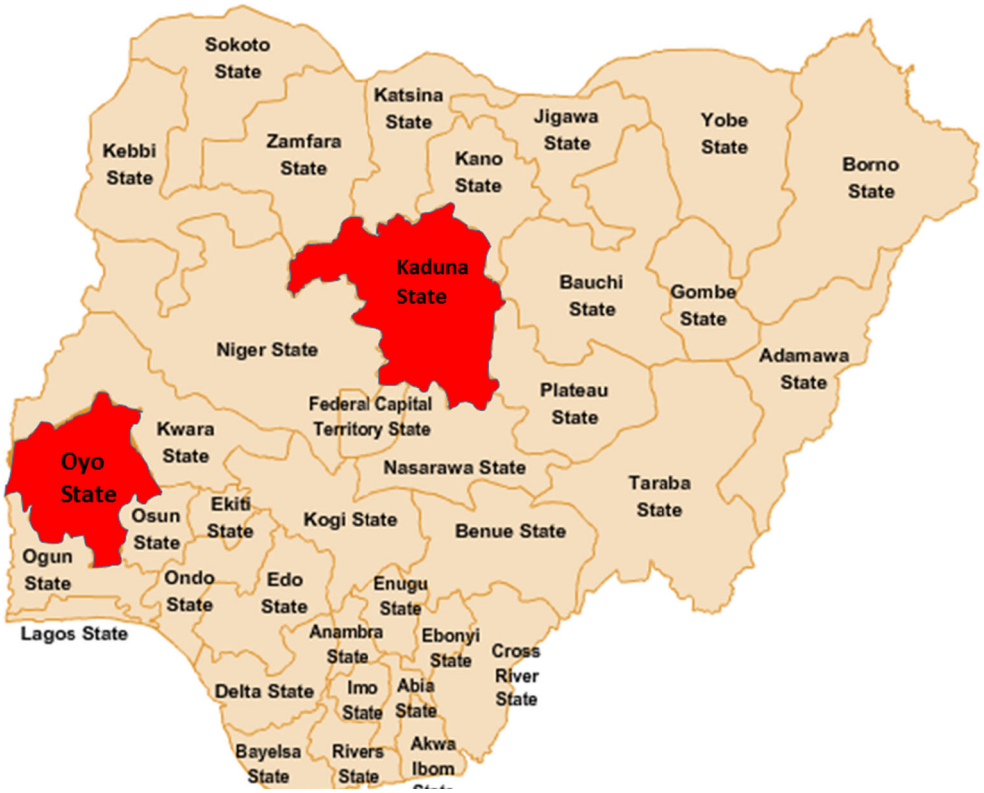

Fig. 1 Map of Nigeria showing the various states. Oyo and Kaduna States are highlighted *red*

Data collection and analysis

Data were collected using interviews, questionnaires and focus group discussions (FGD). Questionnaire was developed and faced validated by experts in the field. The questionnaires focused on providing answers to the research questions of the study. Data collected included demographic data: production data, knowledge, attitude and practices related to antimicrobial usage in the states and antimicrobial usage patterns. One FGD was conducted in each of the states at the beginning of the fieldwork. Participants at the FGD included representatives of investigating team and identified stakeholders. The types of antimicrobial agents, quantity and frequency of usage were determined based on data obtained from responses of farmers to questionnaires, interviews and available farm records. Descriptive statistics such frequency and percentages of distribution were determined to generate summarized results in Tables and Figures.

Table 1 Sampling locations and sample size

	Oyo State	Kaduna State	Total
LGA selected	Egbeda Atiba Saki West Atisbo	Zango Kataf Jema Soba Zaria Birni Gwari Kaduna North Lere	11
Communities selected	Ibadan Oyo Township Saki Ago-Are	Zonkwa Kafanchan Maigana Zaria Birnin Gwari Kaduna S/Naka	11
Number of producers selected	216	238	454

Results

This study showed that chicken production was the predominant activity among the respondents in the two states, but other animals including sheep and goat, turkey, pigs and cattle were also produced at an appreciable level (Table 2). Antimicrobial usage was a very common practice among livestock producers in both states. All the respondents (100 %) in Kaduna State and nearly all (98.1 %) in Oyo State used antimicrobials in livestock production (Table 3). More farmers in Oyo State (70.4 %) than in Kaduna (37.4 %) kept regular record of antimicrobial usage on the farm. Farmers used 28 different types of antimicrobial agents in livestock production. Some antimicrobials with at least 30 % usage in either or both of the states include tetracyclines, tylosin, ciprofloxacin, gentamycin, chloramphenicol, colistin, erythromycin, enrofloxacin, furazolidone, sufonamides, streptomycin, penicillin and neomycin (Table 4, Fig. 2). Antimicrobial agents were widely marketed for animal use in the two study

Table 2 Level of involvement in production of animal types by farmers in Oyo and Kaduna State of Nigeria

Animal types	Percentage of involvement among animal producers	
	Oyo State	Kaduna State
Camels	0	0.4
Cats	1.4	0.8
Cattle	13.9	29.8
Chickens	80.6	39.1
Dogs	6.5	7.1
Donkeys	0	0
Ducks	6.5	2.5
Fish	2.3	2.1
Geese	0.9	3.4
Guinea fowls	2.8	3.4
Horses	0	0.4
Pigs	22.2	17.2
Quail	0.5	0.8
Rabbits	6.5	2.5
Sheep and goats	34.7	38.7
Turkeys	30.6	9.7

locations. In Oyo State, as many as 125 brands of antimicrobial agents were available over the counter for livestock producers. In Kaduna State, there were 159 different antimicrobial labels. Out of the total 246 antimicrobial trade names, only 38 were common to both states. Eighty two (33.3 %) of the 246 antimicrobial brands contained more than one active antimicrobial agent. Some very popular brands (neoceryl plus®, alfacery®, keproceryl®, ceryl SP®) contained a combination five active components (erythromycin, neomycin, streptomycin, colistin and oxytetracycline). A particular brand (embaceryl®) also contained tylosin and sulphonamide in addition to the five aforementioned antimicrobials.

Treatment of sick animals (94.9 % in Oyo and 98.8 % in Kaduna), disease prevention (95.5 % in Oyo and 87.9 % in Kaduna) and growth promotion (78.7 % in Oyo and 56.6 % in Kaduna) were considered important factors influencing the decision for use and choice of antimicrobial agents in animals. Other factors important considerations are outcome of laboratory analysis (50.5 % in Oyo and 49.5 % in Kaduna), experience of farmers (87.5 % in Oyo and 71.8 % in Kaduna), financial status (71.3 % in Oyo and 52.5 % in Kaduna), price of antimicrobial agents (56 % in Oyo and 66.4 % in Kaduna),

Table 3 Usage of antimicrobial drugs (AMDs) in animal production

	Oyo (n=216)		Kaduna (n=238)		Total (n=454)	
	Frequency	%	Frequency	%	Frequency	%
Use AMDs for animals						
Yes	212	98.1	238	100	450	99.1
No	4	1.9	0	0	4	0.9
Keep regular records						
Yes	152	70.4	89	37.4	241	53.1
No	64	29.6	149	62.6	213	46.9
Records shown						
Shown	113	74.3	67	75.3	180	74.7
Not shown	39	25.7	22	24.7	61	25.3

Table 4 Classes of antibiotics commercially available for use in animals in Oyo and Kaduna States, Nigeria

Classes of antibiotics	Number of available commercial preparation(s)/tradename(s)
Beta-lactams	
Amoxicillin	3
Penicillin	10
Aminoglycosides	
Gentamycin	12
Neomycin	24
Streptomycin	20
Fluoroquinolones	
Ciprofloxacin	4
Enrofloxacin	13
Flumequine	3
Norfloxacin	2
Pefloxacin	1
Macrolides	
Azithromycin	1
Erythromycin	25
Tylosin	25
Nitrofuran	18
Furazolidone	
Tetracyclines	
Chlortetracyline	3
Tetracycline	2
Oxytetracycline	102
Doxycycline	20
Phenicol	9
Chloramphenicol	
Phosphonic	
Fosfomycin	1
Polypeptides	
Polymyxin B	1
Colistin	20
Sulphonamides	
Sulphadiazine	6
Sulphamethoxazole	4
Sulphadimidine	11
Sulphasalazine	1
Sulphaquinoxaline	3
Trimethoprim	7

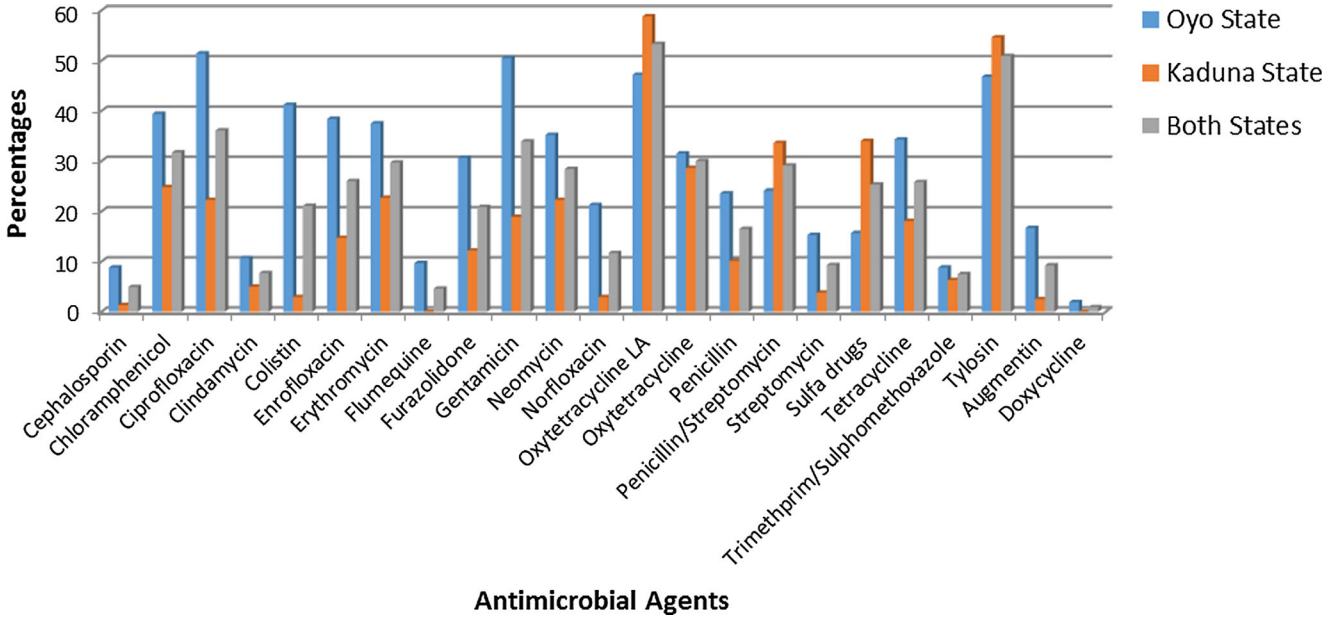

Fig. 2 Comparative distribution of antimicrobial usage among producers in Kaduna and Oyo States of Nigeria

level of awareness about animal diseases and antimicrobial agents (82.6 % in Oyo and 69.3 % in Kaduna), ready access to antimicrobial agents (66.7 % in Oyo and 75.2 % in Kaduna), exposure to pathogens due to poor hygiene (78.6 % in Oyo and 69.3 % in Kaduna), route of drug administration (53.3 % in Oyo and 73.5 % in Kaduna), duration of antimicrobial therapy/dosage regimen (68.6 % in Oyo and 62.6 % in Kaduna) and influence of advertisement (37.9 % in Oyo and 12.2 % in Kaduna).

Antimicrobial agents were used mainly for prophylactic and therapeutic reasons but rarely for growth promotion (Tables 5 and 6). It appeared that livestock producers in Oyo State used antimicrobials more for prophylaxis while those in Kaduna used antimicrobials more for therapeutic purposes. However, the use of antimicrobials as a growth promoter was reported more in Kaduna State than in Oyo State. In Kaduna State, cephalosporin, ciprofloxacin, clindamycin, enrofloxacin, erythromycin, gentamycin, neomycin and trimethoprim/sulphamethoxazole were reportedly used as growth promoter while in Oyo State, only gentamycin was reportedly used as growth promoter.

Livestock producers have divergent opinions on who should administer antimicrobial agents to animals. Many (67.6 %) of the respondents believed that veterinarians or animal health workers should be responsible for the administration of antimicrobials to animals. However, in practice, farmers (44.9 %) or farm attendants (5.5 %) administered antimicrobials to the animals, and veterinarians were involved only in 36.7 % of cases. Farmers could administer any of the antimicrobial agents through the oral and intramuscular routes. The oral administration was more commonly practiced than intramuscular. Drugs with high levels (50 % and above) of intramuscular administration included long acting oxytetracycline, penicillin, penicillin/streptomycin, streptomycin and tylosin. The most preferred route of antimicrobial administration in Oyo State was oral (71.7 %) while in Kaduna, the most preferred route was intramuscular injection (53.8 %). Veterinarians were more involved in administration of antimicrobials in Kaduna State (42.0 %) than in Oyo State (30.6 %). In Oyo State, 75.9 % of farmers as against 92.0 % in Kaduna State sought veterinary advice before antimicrobial administration. About 92 % of farmers in both states claimed to regularly adhere to recommended dosage of antimicrobials. Over 85 % of producers based their decisions for antimicrobial usage on past experiences. Sometimes, farmers tend to administer above the recommended dosage. Reasons given for administering above recommended dosage included past experience of the farmers on the particular antimicrobial, need for urgent outcomes, severity of cases and assumption of low active ingredients in some brands of drugs. Less than 5 % of the producers believed that recommended dosages are usually not effective. Only 24.5 % of producers in Oyo State and 13.0 % in Kaduna State submit samples to the laboratory for microbiological analysis and drug sensitivity testing before antimicrobial administration. In Oyo State, 13.9 % of persons responsible for antimicrobial administration on the farm and 21.4 % in Kaduna State had no form of training on antimicrobial usage and administration. Few farmers (1.4 % in Oyo and 3.4 % in Kaduna) would not check manufacturers' instruction, drug dosages and expiry dates before antimicrobial usage. Moreover, some farmers (37.0 % in Oyo and 43.3 % in Kaduna) indicated to have particular preference for certain drug manufacturers or antimicrobial labels due to personal experience of the effectiveness of such brands or

Table 5 Reasons and frequency of antimicrobial usage in Oyo State, Nigeria

Antimicrobial agents	Number of farmers using antimicrobial	Reason for usage (%)			Frequency of usage (%)	
		Growth promotion	Prophylaxis	Treatment	Regularly	Rarely
Cephalosporins	19	0	5 (26.3)	14 (73.7)	11 (57.9)	8 (42.1)
Chloramphenicol	85	0	36 (42.4)	49 (57.6)	55 (64.7)	30 (35.3)
Ciprofloxacin	111	0	29 (26.1)	82 (73.9)	70 (63.1)	41 (36.9)
Clindamycin	23	0	11 (47.8)	12 (52.2)	17 (73.9)	6 (26.1)
Colistin	89	0	38 (42.7)	51 (57.3)	72 (80.9)	17 (19.1)
Enrofloxacin	83	0	48 (57.8)	35 (42.2)	62 (74.7)	21 (25.3)
Erythromycin	81	0	54 (66.7)	27 (33.3)	61 (75.3)	20 (24.7)
Flumequine	21	0	15 (71.4)	6 (28.6)	14 (66.7)	7 (33.3)
Furazolidone	66	0	29 (43.9)	37 (56.1)	52 (78.8)	14 (21.2)
Gentamicin	109	1 (0.9)	55 (50.5)	53 (48.6)	70 (64.2)	39 (35.8)
Neomycin	76	0	37 (48.7)	39 (51.3)	55 (72.4)	21 (27.6)
Norfloxacin	46	0	21 (45.7)	25 (54.3)	32 (69.6)	14 (30.4)
Oxytetracycline LA	102	0	56 (54.9)	46 (45.1)	61 (59.8)	41 (40.2)
Oxytetracycline	68	0	42 (61.8)	26 (38.2)	50 (73.5)	18 (26.5)
Penicillin	51	0	13 (25.5)	38 (74.5)	29 (56.9)	22 (43.1)
Penicillin/streptomycin	52	0	22 (42.3)	30 (57.7)	36 (69.2)	16 (30.8)
Streptomycin	33	0	19 (57.6)	14 (42.4)	16 (48.5)	17 (51.5)
Sulfa drugs	34	0	16 (47.1)	18 (52.9)	26 (76.5)	8 (23.5)
Tetracycline	74	0	36 (48.6)	38 (51.4)	50 (67.6)	24 (32.4)
Trimethoprim/sulphamethxazole	19	0	13 (68.4)	6 (31.6)	15 (78.9)	4 (21.1)
Tylosin	101	0	32 (31.7)	69 (68.3)	59 (58.4)	42 (41.6)
Amoxicillin/clavulanic acid	36	0	17 (47.2)	19 (52.8)	18 (50.0)	18 (50.0)
Doxycycline	4	0	3 (75.0)	1 (25.0)	2 (50.0)	2 (50.0)

recommendation by a veterinarian. Some however based their decision on drug popularity and price of the drug. Some farmers (17.1 % in Oyo State and 2.5 % in Kaduna State) did not think that the services of veterinarians are necessary for the prescription and usage of antimicrobial agents. Livestock producers (97.2 % in Oyo State and 98.7 % in Kaduna State) indicated that improved hygiene could reduce the need for antimicrobial usage in animal.

Regarding therapeutic failure following antimicrobial usage, 72.2 % of livestock producers in Oyo State and 60.9 % in Kaduna State indicated that they have experienced antimicrobial failure at one point or the other. In addition, 47.7 % of producers in Oyo State and 37.0 % in Kaduna State have experienced adverse effects of antimicrobial usage in animals. Some of the undesired effects resulting from antimicrobial failure and side effects are high mortality (45.4 % in Oyo and 23.9 % in Kaduna), decreased production (28.2 % in Oyo and 59.2 % in Kaduna), income loss/increased expenditure (26.0 % in Oyo and 8.4 % in Kaduna), disease persistence (13.0 % in Oyo and 20.2 % in Kaduna) and weakness (12.5 % in Oyo and 16.8 % in Kaduna). Other reported consequences were poor growth rate, swellings, abortion, abscess formation, limping and loss of appetite. Most of these consequences were not specific in nature and could be found in any of the animal species. In Oyo State, 58.3 % of producers will consult a veterinarian when confronted with the challenges of antimicrobial failure while in Kaduna, 78.2 % will seek for veterinary services in the face of antimicrobial failure. Some farmers (37.5 % in Oyo and 34.0 % in Kaduna) will combine antimicrobial agents to combat the effect of antimicrobial failure while some farmers (37.0 % in Oyo and 37.8 % in Kaduna) will simply change to another antimicrobial agent when an antimicrobial agent fails.

Discussion

This study showed that antimicrobial agents were widely distributed and readily accessible by farmers in the areas investigated. The use of antimicrobial agents in livestock production was a very common practice among the producers in the study areas. The use of antimicrobial agent was not restricted to any particular animal species, but it cut across all the animal species. The brands of antimicrobial agents encountered in this study were numerous reflecting the huge number of manufacturers involved in antimicrobial production for veterinary

Table 6 Reasons and level of antimicrobial usage in Kaduna State, Nigeria

Antimicrobial agents	Number of farmers using antimicrobial	Reason for usage			Frequency of usage	
		Growth promotion	Prophylaxis	Treatment	Regularly	Rarely
Cephalosporins	3	1 (33.3)	1 (33.3)	1 (33.3)	2 (66.7)	1 (33.3)
Chloramphenicol	59	0	8 (13.6)	51 (86.4)	38 (64.4)	21 (35.6)
Ciprofloxacin	53	5 (9.4)	6 (11.3)	42 (79.2)	46 (86.8)	7 (13.2)
Clindamycin	12	4 (33.3)	4 (33.3)	4 (33.3)	10 (83.3)	2 (16.7)
Colistin	7	0	0	7 (100.0)	4 (57.1)	3 (42.9)
Enrofloxacin	35	3 (8.6)	17 (48.6)	15 (42.9)	17 (48.6)	18 (51.4)
Erythromycin	54	4 (7.4)	10 (18.5)	40 (74.1)	35 (64.8)	19 (35.2)
Flumequine	0	0	0	0	0	0
Furazolidone	29	0	12 (41.4)	17 (58.6)	13 (44.8)	16 (55.2)
Gentamicin	45	8 (17.8)	5 (11.1)	31 (68.9)	24 (53.3)	21 (46.7)
Neomycin	53	2 (3.8)	4 (7.5)	47 (88.7)	36 (67.9)	17 (32.1)
Norfloxacin	7	0	0	7 (100.0)	5 (71.4)	2 (28.6)
Oxytetracycline LA	140	0	13 (9.3)	127 (90.7)	47 (33.6)	93 (66.4)
Oxytetracycline	68	0	14 (20.6)	54 (79.4)	45 (66.2)	23 (33.8)
Penicillin	24	0	14 (58.3)	10 (41.7)	15 (62.5)	9 (37.5)
Penicillin/Streptomycin	80	0	6 (7.5)	74 (92.5)	25 (31.3)	55 (68.7)
Streptomycin	9	0	0	9 (100.0)	5 (55.6)	4 (44.4)
Sulfa drugs	81	0	7 (8.6)	74 (91.4)	55 (67.9)	26 (32.1)
Tetracycline	43	0	8 (18.6)	35 (81.4)	27 (62.8)	16 (37.2)
Trimethoprim/sulphamethoxazole	15	1 (6.7)	3 (20.0)	11 (73.3)	8 (53.3)	7 (46.7)
Tylosin	130	0	3 (2.3)	127 (97.7)	39 (30.0)	91 (70.0)
Amoxicillin/clavulanic acid	6	0	0	6 (100.0)	4 (66.7)	2 (33.3)
Doxycycline	0	0	0	0	0	0

use. The huge number of brands provided varieties thereby affording farmers opportunity to make choices on antimicrobial agents at will. The level of usage and choice of antimicrobial agents in livestock production varied among farmers in Oyo and Kaduna State. Individual farmers in Oyo State appeared to use antimicrobials more frequently than their counterparts in Kaduna State. The rate of antimicrobial consumption is higher in Oyo than in Kaduna State. Only four antimicrobials (oxytetracycline long acting, penicillin/streptomycin, tylosin and sulphonamides) had higher rate of usage in Kaduna than in Oyo State. There were no reports of flumequine and doxycycline usage in Kaduna whereas these were used in Oyo State. The antimicrobial trade names available in the two states were very divergent. The ready availability of antimicrobial agents may promote the use of antimicrobials in livestock production and may contribute to the promotion of unwholesome practices and management laxity. Farmers may become negligent of hygiene practices and other precautionary measures to limit exposure to infectious agents. The non-involvement of laboratory investigations in disease diagnosis and prior to antimicrobial use could lead to inappropriate use of antimicrobials, which could trigger the development of antimicrobial resistance.

Many commercial antimicrobial brands available in the market contained more than one active antimicrobial agent. Some of the drugs contained up to seven different active antimicrobial agents. Combination of drugs is usually aimed at broadening the spectrum of activities of such brands. The use of broad-spectrum antimicrobial agents can be attributed mainly to the lack of proper disease diagnosis and non-existence or inadequate laboratory investigations. Ready availability of antimicrobial combinations promotes circumvention of veterinary services for proper disease diagnosis and non-utilization of laboratory investigations. Accurate diagnosis and laboratory analysis (bacteria isolation and antimicrobial susceptibility testing) would help in finding more specific narrow spectrum antimicrobial agents for treatment of specific infections. This may help in reducing the risk of early development of multi-drug resistant bacterial strains. Combination of antimicrobial agents in drug preparations can widen the scope of antimicrobial resistance and promote the emergence of multi-drug resistant bacteria. Antimicrobial agents from different classes were commonly combined in many commercial brands. Resistance to an agent in a particular class may lead to resistance to other antimicrobial agents in the same class. Resistance could also extend to antimicrobial agents in

a different class but with similar chemical structure and mechanism of action (Marshall and Levy 2011). The drug combination as seen in this study could have contributed to the high incidence of multi-drug resistant bacteria of animal origin in Nigeria (Ogunleye et al. 2008; Ojo et al. 2010).

In this study, oxytetracycline was the most commonly encountered antimicrobial in both study locations. Oxytetracycline was present in many brands either alone or in combination with other antimicrobial agents. Previous reports have shown that tetracyclines are the most commonly used antimicrobials in animals (FDA 2014). This study also showed that fluoroquinolones and other drugs considered to be critical for use in humans (WHO 2011) were widely used in animals, sometimes as prophylactics. This may degenerate to public health problems with emergence of resistance in zoonotic bacteria transmissible from animals to humans through direct or indirect contact and consumption of edible animal products. Furthermore, drugs that are considered unsafe for use in humans due to the harmful effect they precipitate were found to be widely marketed and used in livestock production in the study areas. Such drugs include furazolidone and chloramphenicol (Vass et al. 2008; Berendsen et al. 2010). Residues of these drugs in animal-source foods could be transferred to humans with attendant unpleasant consequences. Furazolidone was banned in the European Union and the USA because of its carcinogenic effect (Vass et al. 2008).

Findings from this study showed that oral and intramuscular routes were the common routes of drug administration among animal producers. Other routes of administration such as topical and subcutaneous applications were rarely practiced. Oral administration was the preferred route in Oyo State while intramuscular injection was the most preferred route in Kaduna State. This can be explained in terms of the type of animal species found in each state. In Oyo State, the percentage of respondents keeping poultry birds was higher than the combined percentages of those keeping other animals species (cattle, sheep, goat, pigs). However, the reverse was the case in Kaduna State. Oral drug administration is less labour-intensive compared to intramuscular injection and therefore more appropriate for poultry flocks where large numbers of animals would have to be treated together. Drug administration by the oral route requires less expertise than intramuscular injection. This may explain while more farmers in Kaduna State than in Oyo State would consult veterinarians before drug administration. Oral administration is more prone to misuse and could have direct effects on a larger number of bacterial populations in the gastrointestinal tract compared to intramuscularly administered drugs. In Oyo State, most antimicrobials had dual purposes with nearly equal percentages of usage for prevention and treatment of diseases. Contrarily, in Kaduna, there were wide differences between the levels of usage of antimicrobial for prophylactic and therapeutic purposes.

Overdependence on antimicrobials in animal production contributes significantly to the increasing trend of antimicrobial resistance among bacterial strains. Because of the real and perceived benefits associated with antimicrobial usage, the ease of accessibility and inadequate regulatory mechanisms, most livestock producers depend heavily on antimicrobials and do not exercise due caution while using these agents in their animals. This study showed that chicken production was the predominant activity among the respondents. Chicken and other animals with appreciable level of production (sheep and goat, turkey, pigs and cattle) can be targeted for interventions and regulatory policies for prudence use of antimicrobials, periodic monitoring and prevention of animal-to-human transfer of resistant bacterial strains. With good management, improved hygiene and emphasis on disease prevention, it is possible to reduce the need for antimicrobial usage, attain profitable production level and slow down the emergence of resistant bacterial strains in food animals (Wierup 2001).

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no competing interests.

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