Antimicrobial drug usage pattern in poultry farms in Nigeria: implications for food safety, public health and poultry disease management

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Summary
Good antimicrobial drug stewardship in food-producing animals boosts productivity and limits transmission of zoonotic pathogens, but the imprudent usage is counterproductive. A nation-wide survey to determine the pattern of antimicrobial drug usage in poultry was therefore conducted across 12 of the 36 States in Nigeria. The survey was conducted using structured questionnaire designed to elicit information on socio-demographics, pattern of antimicrobial drug usage and awareness of the consequences of imprudent use of antimicrobials in food-producing animals, among 2,402 randomly selected poultry farmers. Critically important antimicrobials, belonging to the WHO's lists of 'Highest' and 'High' priority antibiotics, were administered sub-therapeutically for prophylaxis and growth enhancement purposes. Many diseases that warranted the antimicrobial administration were of viral etiology. Only 64.2% of the farmers administered the drug based on veterinary doctors' prescription. Majority (62.3%) of the farmers did not observe recommended withdrawal period after the drug administration. Awareness of the respondents on consequences of non-prudent agricultural use of antimicrobials was generally poor. There is need for enlightenment of the farmers on the benefits of prudent agricultural use of antimicrobials. Immediate discontinuation of sale of essential antimicrobials as over-the-counter drugs is imperative to safeguard their therapeutic efficacy and curtail spread of antimicrobial-resistance organisms.

Introduction

Poultry production refers to the rearing of different species of domesticated birds, for production of meat, egg, poultry manure, feather or other poultry products. With estimated poultry population of 180 million in 2015 (Heise *et al.* 2015), Nigeria is the second largest producer of poultry in Africa, producing 650,000 tonnes of eggs and 300,000 tonnes of poultry meat (FAO 2018). In Nigeria, the poultry subsector is the most commercialized agribusinesses, and has been adjudged the most dynamic and fastest growing agribusiness, contributing significantly to job creation, poverty alleviation and production of animal protein (Njoga *et al.* 2019a). With about 13 million households

involved in poultry production, the poultry industry also contributes about 10% of the agricultural GDP and 3.1% of the nation's GDP (World Bank 2017).

The boost and viability in the poultry industry may be attributed to prudent use of antimicrobials in combating most infectious poultry diseases, inimical to poultry production in the tropics (Njoga *et al.* 2018). Prudent use of antimicrobials in food-animal production has also curtailed spread of zoonotic pathogens, transmissible through the food chain. Prudent use of antimicrobial drugs in animal agriculture involves administration of the appropriate drug for the right disease, at the appropriate dose, all through the recommended treatment period. Chemotherapeutic and prophylactic uses of antibiotics in poultry production are well recognized worldwide (Chowdhury *et al.* 2015, Njoga *et al.* 2018); but use of sub-therapeutic doses for growth promotion purposes is rapidly gaining popularity in Nigeria. Escalation in demand for foods of animal origin, occasioned by boom in human population and increase in middle class income in most developing countries, is driving the sub-therapeutic usage to cater for the shortfall in a record short time.

However, sub-therapeutic use of antibiotics to fast-track poultry production is not without costs. Selection of antimicrobial-resistant pathogens which may worsen the animal's health problem or may be transmitted to humans via the food chain is perhaps the most important of the costs, from food safety and public health perspectives. Misuse or overuse of antimicrobials in animal agriculture creates selective evolutionary pressure that facilitates amplification and dissemination of antimicrobial-resistant bacteria, far above the antimicrobial-susceptible organisms (Adesokan *et al.* 2013, Chinwe *et al.* 2014, Njoga *et al.* 2018). Evidences of transfer of antibiotic-resistant bacteria from food animals to humans or antibiotic-resistant genes from non-zoonotic bacteria to zoonotic pathogens, for onward transmission to humans have been documented (Van den Bogaard and Stobberingh 2000, Martins da Costa *et al.* 2013).

Although humans are non-target population for veterinary antimicrobials, the residues could reach the human populations through consumption of poultry products (Nisha 2008, Chowdhury *et al.* 2015). This is particularly true when poultry products are sourced from antibiotic-treated birds, before the end of the stipulated withdrawal period. Consumption of antimicrobial residues in edible animal products predisposes to health problems including: allergy in sensitized individuals (Woodward 1991, Sassanya *et al.* 2008, Njoga *et al.* 2018), bone marrow depletion or aplastic anemia (Gassner and Wuethrich 1994, Young 2002, Njoga *et al.* 2018), disruption of normal intestinal flora in favour of pathogenic bacteria (Olatoye and Ehinmowo 2010), organ toxicity and carcinogenicity (Njoga *et al.* 2018).

Apart from the health problems, non-prudent use of antimicrobials in poultry production also has negative economic implications. The accumulation of residual antimicrobials in poultry products is a serious food safety concern; and hence limits the marketability and monetary value of such products at the international and local markets. In addition, Akinwumi and colleagues (Akinwumi *et al.* 2014) reported shrinkage, toughening and alteration in taste of cooked meat, as indications of reduced meat quality, due to presence of residual antimicrobials in meat. There is also drastic increase in the costs and durations of medical and veterinary treatments, due to non-susceptibility of bacterial pathogens to previously lethal antimicrobials. A report in Nigeria revealed that poultry farmers incurred additional costs (up to 35% of their cost of production) on treatment of antibiotic-resistant bacterial, which amounted to about 75 million US dollars (Adebowale *et al.* 2016).

Non-prudent agricultural use of antibiotics has deleterious effects on the environment and biodiversity. Given that antibiotics can be excreted unchanged in poultry faeces, these drugs can contaminate the environment through the use of poultry manure as feed in fisheries and piggeries (Njoga *et al.* 2019a). The unchanged drugs or its metabolites in discarded poultry waste can also contaminate natural water bodies and aquatic lives therein (Sarmah *et al.* 2006, Rahmatallah *et al.* 2018). This may disrupt the microbial flora in the new environment, in favour of harmful organisms to the detriment of animals and humans inhabiting the environment.

Despite the negative health and economic impacts of imprudent use of antimicrobials in animal agriculture, dearth of information on the pattern of antimicrobial drug administration in poultry farms in Nigeria continues to exist. This nation-wide study was therefore carried out to determine the antimicrobial drug usage pattern in poultry farmers in Nigeria, and further characterize the socio-demographics of the farmers and their awareness on consequences of non-prudent administration of antimicrobials in food animals. These will guide policy formulation for preservation of the therapeutic efficacy of antimicrobials for sustainable poultry production and to safeguard human health.

Materials and methods

Study area

Nigeria is a West African country whose geographic

center is located on latitude 9°4'55.2"N and longitude 8°40'31"E. It comprises of 36 States and the Federal Capital Territory, grouped into six geopolitical zones – Southeast, South-south, Southwest, Northeast, Northwest and North-central. Nigeria is bounded in the west by Republic of Benin, in the east by Chad and Cameroon and Niger Republic in the north. The coast lies on the Gulf of Guinea in the south and Lake Chad at the northeastern region. With a population currently estimated at 203 million, Nigeria has been ranked the most populous African country and the 7th most populated country worldwide. The total land area is 910,770 km^2 while the population density is 221 persons per km^2.

Selection of farms surveyed

A total of 12 states, 24 agricultural zones (AZ) and 2,402 poultry farms were randomly selected and surveyed. At first, four of the six geopolitical zones, namely Southeast, Southwest, North-central and Northwest were purposively selected for the study, based on the history of high poultry production activities. In each selected zone, three states and two AZs per state were selected by simple random sampling. The same sampling method was used to select at least 100 poultry farms from each selected AZ, based on the consent of the farm owners to participate in the study and accessibility of the farm.

The questionnaire survey

Structured and pretested open-ended questionnaire was used to obtain data on socioeconomic characteristics, husbandry and biosecurity practices, types and pattern of antimicrobial drug use in poultry, diseases that warranted the drug administration, and awareness of consequences of imprudent use of antibiotics in food-producing animals. The respondents were the farm owners or managers, who were acquainted in the daily running of the farms, and had earlier expressed their willingness to participate in the survey. One respondent per farm was surveyed. The content of the questionnaire was translated in native language, in the form of interview, to respondents who were not proficient in the use of English language. Thereafter, completed copies of the questionnaire were collected and the responses collated for statistical analysis.

Data analysis and presentation

Data bothering on socioeconomic characteristics and biosecurity measures adopted in the farms surveyed and awareness on consequences of imprudent use of antibiotics in poultry (ACIUAP) were analyzed descriptively and presented in tables. Chi-square statistic was used to test for significant association ($p < 0.05$) between educational levels and pattern of antimicrobial usage (PAU), purpose of antimicrobial administration (PAA) and ACIUAP. Similarly, the same statistic was used to test for association ($p < 0.05$) between farming experience and PAU and PAA. All the analyses were done at five per cent probability level using GraphPad Prism® software, version 6.04 (GraphPad® Inc., San Diego, California, USA).

Results

Socioeconomic characteristics

Majority of the farmers (67.5%) were males. Fourteen per cent of the farmers had no formal education. However, 28.2% (678/2402), 35.8% (859/2402) and 21.9% (526/2402) attained primary, secondary and tertiary educational levels, respectively. Broiler, layers, turkey, cockerel and Nigerian indigenous chicken were the major types of poultry reared. Some of the farmers reared other food animals, while 5.3% (134/2,402) kept dog or cat for security purposes or biological control of rodents. Furthermore, some (36.5%) of the farmers were new in poultry farming business, having less than 5-years' experience, while 21.9% (528/2,402) have been farming for over 10 years. Similarly, majority of the farmers (72.4%) adopted intensive husbandry system of production, while only 23.1% and 4.4% practiced semi-extensive and extensive management systems, respectively.

Antimicrobial drug usage pattern in poultry

The classes of antimicrobials administered and percentage of farmers involved were: tetracycline (25.4%), aminoglycosides (18.5%), macrolides (14.8%), quinolone and fluoroquinolone (14.8%), chloramphenicols (11.3%), sulfonamides (8.5%) and penicillin and betalactam (6.8%). Only 64.2% of the farmers administered the drug based on veterinary doctors' prescription. On the purpose of the drug administration, 36.2% used the drugs for treatment, while 36.7% and 27.1% administered it for prophylaxis and growth promotion purposes, respectively. Majority (62.3%) of the farmers who administered these drugs did not observe the recommended withdrawal period.

Biosecurity practices and common poultry diseases found

Details on biosecurity practices adopted in farms surveyed are presented in Table I. Routine vaccination against endemic diseases was the most practiced biosecurity measure, done in 81.8% of the

farms surveyed. The study found that 31.9% of the respondents adopted good biosecurity practices i.e. practiced more than eight of the 15 biosecurity measures surveyed for. Good biosecurity practices were found to be highest among farmers who attained tertiary education. In the same vain, 78.2% of the respondents who practiced good biosecurity measures were farmers having flock size greater than 500 birds. The level of good biosecurity according to husbandry management systems was intensive (69.7%), semi-intensive (29.7%) and extensive (0.6%).

Major poultry diseases that necessitated antibiotic treatment, as indicated by the farmers were: Newcastle (31.7%), coccidiosis (21.3%), gumboro (26.4%), salmonellosis and colibacillosis (13.4%).

Awareness of the consequences of imprudent agricultural use of antimicrobial

Awareness of poultry farmers surveyed on consequences of imprudent use of antimicrobial in food animal production is generally poor as presented in Table II. Some (40.1%) of the farmers were not aware that indiscriminate use of antimicrobials can worsen the health condition of their birds. Majority (70.3%) of the respondents were ignorant of the fact that antibiotic-resistant bacteria, transmissible through the food chain, can emerge following imprudent use of the drug in poultry. Similarly, 67.9% of the farmers did not know that non-observance of the stipulated withdrawal period may enhance accumulation of drug residues in edible poultry products; while 63.2% were oblivious of the fact that consumption of residual antimicrobials in animal tissues predisposes to health problems.

Table I. *Biosecurity measures adopted in poultry farms (n = 2,402) surveyed in Nigeria.*

Biosecurity measures	Number of respondents (%)
Fencing	746 (31.1)
Netting	786 (32.7)
Sanitization of drinking water	716 (29.8)
All-in-all-out stock replacement program	944 (39.3)
Quarantine of exposed or incoming birds	578 (24.1)
Traffic regulation and unidirectional movement in the farm	1,078 (44.8)
Use of protective clotting while on duty	710 (29.6)
Siting farms away from water bodies	1,942 (80.8)
Farm sited at least 200m away from residential areas	832 (34.6)
Periodic fumigation	1,108 (46.1)
Availability of rodents and migratory birds control programs	680 (28.3)
Availability and use of hand washing facilities at farm entrances	470 (19.6)
Use of only new or disinfected egg crates in the farm	464 (19.3)
Availability of foot dips at farm and pen entrances	890 (37.1)
Regular vaccination against endemic poultry diseases	1,966 (81.8)

Effects of educational and farming experiences on pattern of antimicrobial usage

Effects of educational levels and farming experience on pattern of antimicrobial usage are summarized in Tables III and IV, respectively. The correct use of antibiotic (after veterinary diagnosis) and their source were strongly associated ($p < 0.05$) with farmers' educational level. Equally, statistical associations ($p < 0.05$) were found between farming experience and antibiotic prescription by veterinarian and procuring antimicrobials from veterinary pharmacy but none existed between farming experience and diagnosis made by a veterinarian before antibiotic use at $p = 0.453$.

Discussion

The use of antimicrobial drugs in all the farms surveyed is worrisome and may be due to a number of reasons. The quest to produce more poultry meat (chicken) and eggs to satisfy demand for animal protein, which currently lags the supply (Njoga *et al.* 2018), may be one of the reasons. Apart from rapid population growth and increase in middle class income, that has increased demand for animal protein in developing countries, preference for 'white meat' over 'red meat' may have aided the increased demand for poultry meat worldwide. The

Table II. *Awareness of the consequences of imprudent agricultural use of antimicrobial on human and animal health among poultry farmers (n = 2,402) surveyed in Nigeria.*

Information required	Number of respondents (%)	
	Yes	No
Aware that imprudent antibiotic administration in poultry may worsen the health condition	1,438 (59.9)	964 (40.1)
Aware that indiscriminate use of antibiotics in poultry can enhance development of antibiotic-resistant pathogens, transferable to humans via the poultry food chain	714 (29.7)	1,688 (70.3)
Know that non-observance of withdrawal period can aid accumulation of antibiotic residues in poultry products	769 (32.0)	1,633 (67.9)
Aware that consumption of residual antibiotics in edible animal tissues can cause health problems in humans	883 (36.8)	1,519 (63.2)

Table III. *Effect of educational levels on usage of antimicrobials and awareness of the consequences of imprudent usage among poultry farmers (n = 2, 402) surveyed in Nigeria.*

Information required	Number of YES respondents				P-value
	No formal educ. (n = 339)	Primary educ. (n = 678)	Secondary educ. (n = 859)	Tertiary educ. (n = 526)	
Pattern of antimicrobial usage					
A	195	461	518	367	0.0005*
B	181	394	255	61	0.0001*
C	88	376	401	417	0.0001*
D	136	229	328	213	0.0681
Purpose of antimicrobial usage					
Treatment	156	277	338	196	0.0708
Prevention	119	308	332	223	0.0052*
Growth promotion	77	227	264	156	0.0054*
Awareness of consequences of imprudent agricultural use of antimicrobials					
E	197	391	521	329	0.3092
F	123	149	291	151	0.0010*
G	95	186	331	143	0.0001*
H	179	191	215	298	0.0001*

*Denotes statistical significance, Chi-square statistic, GraphPad prism 6.04;
A = Antibiotic prescribed by veterinarian; B = Diagnosis made by a veterinarian before antibiotic use; C = Sourced antibiotics from veterinary pharmacy; D = Observed the stipulated withdrawal period; E = Aware that imprudent antibiotic administration in poultry may worsen the health condition; F = Aware that indiscriminate use of antibiotics in poultry can enhance development and of antibiotic-resistant pathogens, transmissible via the food chain; G = Know that non-observance of withdrawal period can aid accumulation of antibiotic residues in poultry products; H = Aware that consumption of residual antibiotics in poultry products predisposes to health problems in humans.

Table IV. *Effect of farming experience on pattern and purpose of antimicrobial usage among poultry farmers (n = 2, 402) surveyed in Nigeria.*

Information required	Number of YES respondents			P-value
	Less than 5 years (n = 877)	5-10 years (n = 997)	More than 10 years (n = 528)	
Pattern of antimicrobial usage				
A	587	669	285	0.0001*
B	322	361	208	0.4526
C	488	501	293	0.0355*
D	136	229	328	0.0681
Purpose of antimicrobial usage				
Treatment	393	411	163	0.0001*
Prevention	333	338	311	0.0001*
Growth promotion	199	293	232	0.0001*

*Denotes statistical significance, Chi-square statistic, GraphPad prism 6.04;
A = Antibiotic prescribed by veterinarian; B = Diagnosis made by a veterinarian before antibiotic use; C = Sourced antibiotics from veterinary pharmacy; D = Observed the stipulated withdrawal period.

synergy of increased demand and marketability of poultry products, due to its wide acceptance by all and sundry, may have fueled the quest for increased production of poultry and hence the wide spread use of antimicrobials in the farms surveyed.

Also, traditional husbandry systems (semi-intensive and extensive) adopted by 27.5% of the farmers surveyed may have predisposed birds to diseases, and therefore necessitated antibiotic treatments. Unlike the intensive management system which has the advantage of low pathogen infectivity (Abonyi and Njoga 2019), the traditional system predisposes to disease, especially in the tropics. In these regions, most poultry diseases are endemic due to availability and interconnectivity of factors that enhance survival and proliferation of pathogens. This may explain why critically important antimicrobials, including third generation fluoroquinolone (ciprofloxacin), were used for prophylaxis in some farms.

The high rate of antimicrobial administration (63.8%) for non-therapeutic purposes in poultry production in this study is in tandem with the 68.5% found in South Africa (Eagar *et al.* 2013). Farmers may have resorted to non-therapeutic use of antimicrobials as a 'quick fix' or compensation for poor management practices in the farms surveyed. Good farm management practice promotes strict biosecurity, routine vaccination and adequate nutrition and not antibiotic doping for prophylaxis or growth enhancement. Antimicrobial-resistant organisms in poultry can spread directly to humans via the poultry food chain or less commonly by contact in occupationally exposed individuals such as poultry farmers, veterinarians and abattoir workers (Ekere *et al.* 2018). When an antibiotic-resistant organism is not zoonotic, it may transfer its resistance genes to zoonotic organisms for onward transmission to humans. Cognizant of the fact that egg is sometimes consumed raw in Nigeria (Onyenweaku *et al.* 2018), these resistant-organisms can easily reach the human population via consumption of infected raw eggs or undercooked poultry products.

The practice of administering un-prescribed antimicrobial drugs in poultry farms is unethical (Njoga *et al.* 2019b). Olatoye and Ehinmowo (Olatoye and Ehinmowo 2010) had reported that farmers administer veterinary drugs without prescriptions to cut cost of production and probably maximize profit. This attempt to save cost of veterinary services, without recourse to the negative implications on human and animal health, is counterproductive. When people, who are not formally trained in veterinary clinical practice, administer un-prescribed antimicrobials to food animals, the likelihood of incorrect doses and other chemotherapeutic errors, that may adversely affect the pharmacokinetics of the drugs, is most probable. These, no doubt, facilitate emergence and spread of antimicrobial-resistant bacteria (Alhaji *et al.* 2018), and accumulation of

antibiotic residues beyond safe levels in poultry products or the environment at the detriment of human health. Sometimes, human lives may be lost, especially in developing countries, where effective drugs for the treatment of antimicrobial-resistant pathogens may be unavailable or unaffordable (O'Neill 2014, Laxminarayan *et al.* 2016).

The continued use of chloramphenicol in poultry after over two decades of banning the use in food-producing animal in Nigeria by the National Agency for Food and Drug Administration and Control (NAFDAC) in 1996, is regrettable. The prohibition was due to haematological problems, particularly aplastic anaemia, associated with chloramphenicol, especially in children and young adults (Gassner and Wuethrich 1991, Young 2002). In Nigeria, easy access to veterinary antimicrobials, including those classified as medically important antibiotics (WHO 2016), as examplified by their sale as over-the-counter (OTC) may be contributory to the continued use of chloramphenicol for systemic administration. Most importantly, lack of legislation against this practice and obvious inadequate implementation of the available veterinary drug laws in Nigeria are to be blamed.

The problems of non-adherence to the stipulated withdrawal period and poor awareness on the consequences of non-prudent use of antimicrobials found in this study, may be attributed partly to the level of education of some farmers. Paltry level of education makes it difficult for farmers to read or follow instructions on drug labels. Additionally, excessive quest for economic gains may be contributory to non-observance of withdrawal period, given that majority of the farmers were educated enough to read and understand drug label instructions. Animal products obtained from antibiotic-treated food animals prior to the end of withdrawal period, are unsafe for human consumption and farmers may have jettisoned withdrawal period instruction for fear of economic losses.

This fear of economic losses may explain why some educated farmers, who should know the negative implication of imprudent antimicrobial usage in food-producing animals, administered antimicrobials without valid diagnosis and or veterinary prescription. Availability of medically important antimicrobials, even those in WHO list of "high" and "highest" priority antibiotics, as OTC drugs may have sustained this unethical practice. Similarly, farmers with less working experience cooperated with the veterinarians on the health needs of their birds more than those having more years of work experience, as the later believe that they have enough knowledge to use drugs without the advice of a veterinarian. The resultant effect of all these is abuse and misuse of antimicrobials at the detriment of human and animal health.

Conclusions

There is extensive imprudent administration of antimicrobials in poultry and poor awareness of the consequences on animal and human health among the poultry farmers surveyed. These underscore the urgent need to enlighten the farmers on the benefits of prudent agricultural use of antimicrobials on food safety and poultry disease management. Imprudent use of antimicrobials even among the "educated" and "experienced" farmers reiterates the needs for discontinuation of sale of essential antimicrobial as OTC drugs and strict implementation of veterinary drug laws to safeguard the therapeutic efficacy for sustainable poultry production and to preserve public health.

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