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Original Article

Veterinarians' Perception, Knowledge and Practices of Antibiotic Stewardship in Enugu State Southeast, Nigeria

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Abstract

A cross-sectional survey utilizing structured questionnaires was used to study the veterinarians' perception, knowledge and practices of antibiotic stewardship (ABS) in Enugu State, Southeastern Nigeria. Data obtained were analyzed using chi-square on SPSS (Version 15.0) at a significance level of $P < 0.05$ to determine possible associations between variables and perceptions/knowledge about ABS. Out of 280 respondents, 41 (17.1%) had heard about ABS. Minority of the respondents perceived/knew that using antibiotics only when necessary (6.4%, 18), administering antibiotics at the appropriate dose (6.4%, 18) and administering antibiotics for appropriate duration in every case (4.3%, 12) were among the principles of ABS. The study also showed that age, gender, qualification, years of practice and locations did not exert any influence ($P > 0.05$) on the awareness of respondents about ABS. More than one-third of the respondents wrongly perceived that increasing the use of broad-spectrum antibiotics (35.4%, 99) is one of the goals of ABS, whereas the minority of the respondents rightly perceived/knew that minimizing toxicity and other adverse effects (16.8%, 47) and reducing antibiotic resistance (ABR) (43.2%, 121) are also goals of ABS. Only 21.4% (60) had overall knowledge of ABS. Prescribing antibiotics without seeing/examining the patient, prescribing antibiotics for any case suspected to be infectious, prescribing broad-spectrum antibiotics despite availability of narrow-spectrum antibiotics, prescribing different classes/types of antibiotics concurrently to ensure therapeutic efficacy, prescribing overdose of antibiotics to ensure efficacy and non-consultation of the veterinary formulary/other resources when in doubt during prescription, are some of inappropriate/untoward ABS practices/behaviors/attitudes amongst the respondents. No significant association ($P > 0.05$) was found between practices of ABS and age, gender, qualification, years of practice and location. In conclusion, the veterinarians' awareness/perception and practices of ABS is abysmally poor in the study area, thus education of Nigerian veterinarians about ABS and the teaching of the principles and practices of ABS during veterinary schools are recommended.

Keywords: antibiotic resistance, antibiotic stewardship, veterinarians, knowledge, practices

Introduction

The threat posed by antibiotic resistance (ABR) has recently been equated to climatic change and it is of grave concern globally (Castro-Sanchez *et al*., 2016). The health (substantial morbidity and mortality) and economic impact of ABR on a global scale is enormous and dreadful (Cosgrove, 2006; Castro-Sanchez *et al*., 2016). In European Union, the overall societal costs of ABR and complications arising from ABR were estimated to be €1.5-9 billion per year (Llor and Bjerrum, 2014; Cisneros *et al*., 2014) and an estimated mortality of 25,000 people annually (WHO, 2012; Scaioli *et al*., 2015). In United States, around 26,000 people die of multidrug-resistant bacterial infections each year (Spellberg *et al*., 2008; Khan *et al*., 2016), while 96,000 deaths are attributed to multidrug resistance in Southern Asia (Zaidi *et al*., 2004; Khan *et al*., 2016). Worldwide, it has been underestimated that about 700,000 lives are lost annually due to antimicrobial-resistant infections (O'Neil, 2014). It is also estimated that by 2050, the societal and financial cost of not tackling the ABR crisis will be US$100 trillion (O'Neil, 2014; Piddok, 2016). Some studies estimated population reduction of between 11 million and 444 million people and a reduction in the size of the global economy by 0.1-3.1% by 2050 if effective antimicrobial agents are not developed (Taylor *et al*., 2014; Fitchet and Attun, 2016). The cost of developing a new antibiotic has been estimated to be US$1 billion (Huttner *et al*., 2013), but no new antibiotic is expected to be on the market until 2018 at the earliest (Bartlett, 2011; Cisneros *et al*., 2014).

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Very recent, it was reported that new antibiotics are expected to be in the market earliest in 2022 (Leonard *et al*., 2017). It was also estimated that US$30 billion are needed to tackle ABR crisis now, before it becomes uncontainable (O'Neil, 2014; Piddok, 2016). In developing nations, including Nigeria, the impact of ABR is worse, and unfortunately, the cost of treatment of resistant infections and associated deaths are unaccounted for (Huyhn *et al*., 2015).

The contributions to ABR are multidimensional and range from behavioural dynamics of healthcare workers (including veterinarians) and to the biology of the microorganisms (Levy, 2002; Castro-Sanchez *et al*., 2016). The most common cause of ABR is inappropriate use (Paul and Gyssens, 2013; Cotta *et al*., 2014). Antibiotics are the most frequently prescribed drugs, but they are often misused (Chambers, 2006; WHO, 2014; Scaioli *et al*., 2015). Wrong prescribing behavior amongst clinicians has been linked as a major cause of antibiotic misuse (Scaioli *et al*., 2015). Inappropriate use of antibiotics is widespread in human/veterinary hospitals, especially in developing countries, including Nigeria, and up to 50% of antibiotic treatments prescribed have been estimated to be incorrect (Dellit *et al*., 2007; Pulicini and Gyssens, 2013; Cisneros *et al*., 2014). All clinicians (including veterinarians) are potential antibiotic prescribers; therefore, the generalization of antibiotic misuse is probably due to a misbalance between the high level of knowledge required for the appropriate use of antibiotics and the scarce training offered in this respect to the practicing clinician (Cisneros *et al*., 2014; Awad and Aboud, 2015).

Clients/patients' wrong habits and their lack of knowledge has also been reported as a leading cause for ABR (Grigoryan *et al*., 2007; Scaioli *et al*., 2015).

Because factors that triggers ABR is multidimensional, multimodal/multifaceted interventions have been suggested to be of most benefit (Awad and Aboud, 2015; Castro-Sanchez *et al*., 2016). Such interventions are aimed at strengthening the concept of One Health at the human-animal-environment interface because antibiotic-resistant organisms easily pass from one environment to the other and *vice versa* (WHO, 2014; Cabello *et al*., 2016; Kock *et al*., 2016). It is established that containment of ABR could only be possible if containment strategies are employed in all healthcare environments (Abbo *et al*., 2013). Antibiotic stewardship is an integrated and multidisciplinary approach that includes the selection of appropriate antibiotic, enhanced surveillance of prescribing and use, implementation of prescribing guidelines and policies, inclusion of infection prevention and control strategies, and increased efforts on audit and education (Cisneros *et al*., 2014; Roca *et al*., 2015). The development of antibiotic stewardship programmes (ASPs) in the hospital/veterinary setting has been encouraged by scientific societies worldwide (Dellit *et al*., 2007; Srinivasan, 2011; Cisneros *et al*., 2014; Bowater, 2015), and they have proved to be an essential measure in controlling the rise of ABR and antibiotic expenditures (Moody *et al*., 2012; Cisneros *et al*., 2014; File *et al*., 2014).

Collaboration of all healthcare providers (involved in antibiotic use) is critical for ASPs to be successfully implemented (Cotta *et al*., 2014; Viale *et al*., 2015; Cabello *et al*., 2016). Thus, veterinarians (as clinicians and educators) play a critical role in ABS and for successful implementation of ASP (Bowater, 2015; Coyne *et al*., 2016). Antibiotics used in humans, including the critically important ones, are in the same classes as those used in animals (WHO, 2011; Landers *et al*., 2012; Awad and Aboud, 2015). Emergence of resistant infections in animal populations can impact health and productivity, and potentially transfer to humans (zoonosis) (van Djuikeren *et al*., 2014; Coyne *et al*., 2016). But for veterinarians to implement and help in achieving the goals of ABS, they (as healthcare providers/professionals), should be interested in and knowledgeable about ABR and ABS (Awad and Aboud, 2015; Guardabassi and Prescott, 2015; Coyne *et al*., 2016). Knowledge about ABS is critical for veterinarians because they are anticipated (as key healthcare providers) to take prominent roles in infection control programmes in healthcare (veterinary) systems and as educators of their clients/the public about ABR and ABS (Bowater, 2015; Khan *et al*., 2016). Therefore, assessing the veterinarians' perception and level of knowledge/awareness about ABS is crucial for identifying gaps in knowledge, development of effective ASPs and improvement of the curricula in Veterinary schools (Abbo *et al*., 2013; Paul and Gyssens, 2013; Cotta *et al*., 2014; Coyne *et al*., 2016). Moreover, taking into account the potential role of veterinarians in the development and execution of ASPs, it is imperative to know the practices/behaviours/attitudes of veterinarians towards ABS (Coyne *et al*., 2016). This is crucial in order to understand the level of engagement among veterinarians as clinical stakeholders involved in antibiotics prescription and dispensing, determine key areas that will be useful in developing ASP and for education of the veterinarians/public which is an integral part of all ABR containment activities (Vickers, 2011; Abbo *et al*., 2013; Cotta *et al*., 2014).

However, while there are several reports on perception/understanding and practices of ABS among several key healthcare providers (such as pharmacists and doctors) in many parts of the world, there is paucity of information (Busani *et al*., 2004; Cattaneo *et al*., 2009; Coyne *et al*., 2016) regarding the perception/level of awareness and practices of ABS among veterinarians in available literature. In Nigeria, Veterinary Medicine is a 6 years full-time University degree programme, courses on antibiotics and ABR are taught in the 3rd and 4th years. In the final year (6th year), students are also engaged in clinical postings during which they are further exposed to antibiotic sensitivity testing and drug prescriptions in the Veterinary Teaching Hospital. Thus, every Nigerian veterinarian is expected to have basic knowledge of ABR. A 1-year post-graduation national youth service, during which a fresh Doctor of Veterinary Medicine (DVM) graduate is expected to start prescribing drugs, is often compulsory for every veterinarian in Nigeria. Although, there are Postgraduate degrees/Diploma programmes (such as Masters, Doctorate, etc), many Nigerian veterinarians may not be knowledgeable about ABS, and therefore, may be

prescribing/using antibiotics injudiciously. This sort of practice increases the problem of ABR in the country. Till date, no study has evaluated the Nigerian veterinarians' understanding of the concept and practices of ABS. This study was therefore undertaken to assess the perception/level of knowledge and practices of ABS amongst veterinarians in Enugu State, Southeast Nigeria. The data will help in identifying gaps in knowledge and to understand veterinarians' perceptions that could help in implementation of appropriate remedies in Nigerian Veterinary Schools' curricula that will subsequently affect behavioural change and lead to more appropriate use of antibiotics.

Materials and Methods

Study area and population

The study was carried out in Enugu State, Southeastern Nigeria between January and March, 2017. Enugu State is geographically located at coordinates approximately 6°30'N7°30'E and is made up of 17 Local Government Areas (L. G. As) namely: Aninri, Awgu, Enugu East, Enugu North, Enugu South, Ezeagu, Igbo Etiti, Igbo Eze North, Igbo Eze South, Isi Uzo, Nkanu, Uzouwani East, Nkanu West, Nsukka, Oji River, Udenu and Udi. Enugu South, Enugu North and Enugu East L. G. As made up the Capital Territory (Enugu) of Enugu State while Nsukka town is the Nsukka L. G. A. and it is a University town with a University Veterinary Teaching Hospital. Enugu and Nsukka are geographically located at coordinates approximately 6°27'9.60"N7°30'37.20"E and 6°51'24"N7°23'45"E, respectively. They are the two most populated towns in Enugu State, with population of about 722,664 and 309,633, respectively (NPC, 2007). Majority of veterinarians in Enugu State are practicing in government and/or privately owned clinics in these towns (Enugu and Nsukka). The study population consisted of veterinarians in Enugu State, Southeast Nigeria.

Ethical approval

Ethical approval was not necessary for this study. However, informed consent from all participants involved in the study was obtained and confidentiality/anonymity of the data obtained was ensured.

Study design and sampling procedure

This is a quantitative descriptive survey. Between January and March, 2017, a questionnaire based cross-sectional study was conducted to assess the perception/level of awareness and practices of ABS amongst veterinarians. Enugu and Nsukka were selected purposively because majority of practicing/teaching veterinarians in Enugu State are based in these towns. The sample size was estimated at 384 participants from the two towns using the method of Thrushfield (1997):

$n = 1.96^2 \times P_{exp} (1 - P_{exp})/d^2$

Where n = sample size, Pexp = expected proportion of knowledge about ABS which was assumed to be 50% and d = desired absolute precision level which was assumed to be 5%. Selection of veterinarians was based on their willingness to participate in the study.

Data collection

Information about the level of awareness and practices of ABS as well as the socio-demographic characteristics of the respondents were collected using a self-administered structured questionnaire. The questionnaire was developed after a literature review of comparable studies (Abbo *et al*., 2013; Burger *et al*., 2016; Castro-Sanchez *et al*., 2016) and validated by a pilot study on 10 veterinarians. Participation was voluntary. Upon the completion of the questionnaire, the interviewer gave the respondents opportunity to ask questions and provided them with relevant ABR and ABS information.

Data analysis

The data obtained were analyzed using SPSS version 15.0. Chi-square (χ^2) was used to determine the possible association between variables and the awareness/knowledge and practices of ABS. Values of $P < 0.05$ were considered significant. An overall knowledge score was assessed by calculating the total percentage of correct answers for the questions (Abbo *et al*., 2013; Asekun-Olarinmoye *et al*., 2014). The data of the pilot study was not used for the final analysis.

Results

Socio-demographic characteristics of respondents

A total of 384 participants were sampled from the purposively selected towns in Enugu State. Of these, 365 (95%) returned a response, but only 280 (75.9% response rate) responses were sufficiently completed to be analyzed. Of the 280 participants that sufficiently completed their response, majority (66.1%, 185) were between the ages of 25 and 40 years old (Table 1). Two hundred and one (71.8%) of the respondents were males, while 28.2% were females. One hundred and sixty four (58.6%) of the respondents were based in Enugu and 116 (41.4%) were practicing/teaching in Nsukka. Majority of the respondents (68.6%, 192) had First Degree while 26.4% (74) had Masters and 5% (14) were Doctorate degree holders.

Perceptions/Level of knowledge/awareness about ABS

Of the 280 respondents, only 60 (21.4%) had overall knowledge of ABS, 41 (17.1%) of the respondents had heard about the concept ABS, while 60 (21.4%) indicated they know the principles of ABS (Table 1). Using antibiotics only when necessary (18, 6.4%), administering antibiotics at the appropriate dose (18, 6.4%) and administering antibiotics for appropriate duration in every case (12, 4.3%) were the only principles perceived by minority of the respondents as strategies of ABS. The study also showed that age, gender, qualification and location did not exert any influence ($P > 0.05$) on the awareness of respondents about ABS. Regarding the goals of ABS, minority of the respondents perceived that ABS is aimed at increasing the use of broad-spectrum antibiotics (35.4%, 99), reducing duration of hospital stay (13.9%, 39), minimizing toxicity and other adverse effects (16.8%, 47), increasing duration of antibiotic therapy to ensure therapeutic success (27.1%, 76) and reducing ABR (43.2%, 121).

Table 1. Socio-demographic characteristics of veterinarians in the study area

Socio-demographic characteristics	Frequency	Percentage (%)
Age		
25 – 40	185	66.1
41 – 56	75	26.8
57 and above	20	7.1
Sex		
Male	201	71.8
Female	79	28.2
Qualification		
First Degree	192	68.6
Masters	74	26.4
Doctorate	14	5
Years of practice		
1 and below	18	6.4
2 – 4	73	26.1
5 and above	189	67.5
Location		
Enugu	164	58.6
Nsukka	116	41.4

Table 2. Perceptions/Level of knowledge possessed by respondents about antibiotic stewardship

Perception/level of knowledge	Frequency	Percentage (%)
Overall knowledge of antibiotic stewardship	60	21.4
Heard about antibiotic stewardship		
Yes	48	17.1
No	232	82.9
Know the principles of antibiotic stewardship		
Yes	60	21.4
No	220	78.6
Principles of antibiotic stewardship		
Using antibiotics only when necessary	18	6.4
Choosing the appropriate antibiotics	6	2.1
Administering antibiotics at the appropriate dose	18	6.4
Administering antibiotics for appropriate duration in every case	12	4.3
Therapeutic monitoring of antibiotics	5	1.8
Study of antibiotics	7	2.5
Improved hygiene	4	1.4
Antibiotic stewardship goals		
Reducing duration of hospital stay	39	13.9
Minimizing toxicity and other adverse effects	47	16.8
Increasing use of broad spectrum antibiotics	99	35.4
Increasing duration of antibiotic therapy to ensure therapeutic success	76	27.1
Reducing antibiotic resistance	121	43.2

Behaviours/attitudes/practices of antibiotic stewardship

With regards to prescribing behaviour, 38.6% (108) of the respondents prescribe or has prescribed antibiotics without seeing/examining their patient while majority of the respondents (250, 89.3%) prescribe antibiotics for any case suspected to be infectious (Table 3). Nearly all the respondents (262, 93.6%) prescribe broad-spectrum antibiotics when bacterial infection is suspected whereas a lower proportion of the respondents (27.9%, 78) prescribe narrow-spectrum antibiotics on suspicion of bacterial infection. Majority of the respondents (87.1%, 244) prescribe different classes/types of antibiotics to ensure therapeutic efficacy while more than two-third of the respondents (61.4%, 172) prescribe/administer antibiotics for prevention/treatment of diseases in a herd/flock. Majority of the respondents (80%, 224) prescribe newer-generation antibiotics than older one while nearly half of the respondents (47.1%, 132) prescribe overdose of antibiotics to ensure efficacy. Less than one-third (78, 27.9%) of the respondents adhere strictly to the recommended dose of antibiotics during prescription and less than half of the respondents (42.9%, 120) consider whether an infection is self-limiting before prescribing antibiotics. Minority of the respondents consult veterinary

formulary/other resources when skeptical about a drug's mechanism of action during prescription (39.3%, 110) and request for antibiogram of animal isolates within the locality to guide and update on choice of antibiotic for empiric treatment (1.1%, 3), while more than one-third (34.2%, 96) of the respondents prescribe antibiotics requested by their clients. On microbiological analysis that guides antibiotics prescription, low proportions of the respondents submit samples for bacteriological studies (27.9%, 78), isolate infectious agent to prove bacterial involvement before prescribing antibiotics (19.3%, 54) and conduct sensitivity test before prescribing antibiotics (23.6%, 66), respectively.

Concerning administration of antibiotics to patients, majority of the respondents (71.4%, 200) allow their clients to administer antibiotics to their animals at home, change antibiotics when therapeutic failure is perceived following the use of an antibiotic (93.6%, 262), encourage/advise clients to buy antibiotics and administer to their animals (67.9%, 190) and administer antibiotics to their patients without determining their body weight properly (69.3%, 194). Majority of respondents also ensure that antibiotics are administered to patients for the appropriate duration (91.4%, 256) and adhere to the recommended route when giving antibiotics to their patients (89.3%, 250). A low proportion of the respondents, considers whether an antibiotic is of substandard quality before acquisition for use in treating animals (11.1%, 31) and uses antibiotics for a prolonged duration (17.1%, 48), while 41.9% (117) of the respondents wash their hands always and properly with disinfectants after handling/examining a patient

Regarding education of clients and role of veterinarians in ABS programs, majority of the respondents (68.2%, 191) educate their clients on the need for vaccinating their animals against preventable diseases and almost all (97.1%, 270) of them agreed that veterinarians have major role to play in ensuring proper antibiotic use. Minority of the respondents educate their clients on appropriate use of antibiotics (32.5%, 91) whereas majority of the respondents (67.9%, 190) admit animals in their clinics for long duration. There was no significant association ($P > 0.05$) between the sex, age, qualification and location and practices of ABS. More than half of the respondents (53.9%, 151) perceived that antibiotics are overused by veterinarians nationally, all the respondents (100%, 280) agreed that strong knowledge of antibiotics is important in their veterinary career while nearly all (97.1%, 270) agreed that veterinarians have a role to play in ensuring proper use of antibiotics.

Table 3. Level of practices of antibiotic stewardship by veterinarians in the study area

Practices, Behaviours and Attitudes	Frequency	Percentage (%)
Prescribe or have prescribed antibiotics without seeing/examining the animal	108	38.6
Prescribe antibiotics for any case suspected to be infectious	250	89.3
Submit samples for microbiological analysis before prescribing/administering antibiotics	78	27.9
Isolate infectious agent to prove bacterial involvement before prescribing antibiotics	54	19.3
Conduct antibiotic sensitivity testing before prescription of antibiotics	66	23.6
Allow clients to administer antibiotics to their animals at home	200	71.4
Encourage/advise clients to buy antibiotics and administer to their animals	190	67.9
Ensure that antibiotics are administered to patients for appropriate duration	256	91.4
Change antibiotics when therapeutic failure is perceived following the use of an antibiotic	262	93.6
Prescribe broad-spectrum antibiotics when bacterial infection is suspected	262	93.6
Prescribe narrow-spectrum antibiotics when bacterial infection is suspected	78	27.9
Adhere to recommended dose when prescribing/administering antibiotics for/to patients	78	27.9
Prescribe/administer of overdose of antibiotic to patients to ensure therapeutic success	132	47.1
Combine antibiotics to ensure therapeutic success	244	87.1
Prescribe antibiotic on request of the client	96	34.2
Prescribe antibiotics for prophylactic/metaphylactic treatment of animals in a herd/flock	172	61.4
Administer antibiotics to animals without determining their body weight properly	194	69.3
Admits animals in the hospital for long duration	190	67.9
Prolong usage of an antibiotic	48	17.1
Consider whether an infection is self-limiting before prescribing antibiotics	120	42.9
Choosing new generation antibiotics (e.g., extended-spectrum) as first line of treatment rather than older generations like penicillin	224	80
Adhere to the recommended route of administration when giving antibiotics to patients	250	89.3
Consult veterinary formulary/other educational resources when in doubt of a drug's mechanism of action	110	39.3
Washing of hands always and properly with disinfectants after handling/examining an animal	117	41.9
Consider whether an antibiotic is of substandard quality before acquisition for use in treating animals	31	11.1
Strong knowledge of antibiotic is helpful in my Veterinary career	280	100
Request for antibiogram of animal isolates within the locality to guide and update on choice of antibiotic for empiric treatment	3	1.1
Educate clients to vaccinate their animals against preventable diseases	191	68.2
Educate clients on appropriate use of antibiotics, adherence to withdrawal periods and resistance-related issues	91	32.5
Veterinarians have a major role to play in ensuring proper use of antibiotics	272	97.1
Antibiotics are overused by veterinarians nationally	151	53.9

Discussion

The health and economic impact of ABR is enormous and dreadful, thus, veterinarians (as key healthcare providers) have been encouraged to hold the responsibility of ABS (principally targeted to reduce antibiotic use and development/spread of ABR) in practice area (Erku, 2016; Khan *et al*., 2016). The results obtained from this study have demonstrated that the overall level of awareness or knowledge about ABS amongst veterinarians in the study area is very poor (21.4%). This could be attributed to the fact that very few (17.1%) of the respondents in this study, had heard about ABS. Cotta *et al*. (2014) reported that 41% have heard of antimicrobial stewardship (AMS) among practitioners (physicians, surgeons, pharmacists, anaesthetists, nurses) in a large private hospital in Australia while Burger *et al*. (2016) reported that 83.5% have heard about AMS among final year pharmacy students in 3 South African universities. The differences in proportions of respondents that have heard of AMS in these studies, may be due to disparity in the level of AMS awareness education that has been conducted in the healthcare facilities/study area, awareness obtained from other sources (such as mass media, journals, etc.) and/or level of exposure to AMS in educational institutions, in the various study areas. Thus, the finding of very low proportion of respondents that have heard of ABS in this study, suggested there is little or no AMS education awareness (via mass media, in schools, social centres, etc) in the study area (Abbo *et al*., 2013; Lee *et al*., 2015).

Lack of association between ages, sex, qualification and location and awareness of respondents in this study about ABS, may be because all the respondents were similarly not exposed to the concept of ABS during Veterinary school. It equally suggested that there is no ASP in form of continuing education, conferences, seminars, symposia, etc. (Lee *et al*., 2015) organized for veterinarians in the study area. It also suggested that curricula in Nigerian Veterinary schools are deficient on issues of ABR and ABS. Therefore, the few respondents in this study that exhibited awareness of ABS, may likely be those specialized/specializing in Microbiology, Public Health or Pharmacology and/or those that could have heard of ABS through other means/from various sources (Cotta *et al*., 2014; Asekun-Olarinmoye *et al*., 2014). Cisneros *et al*. (2014) noted that antibiotic misuse is likely to be due to the scarce training offered in this respect to the practicing clinician.

Poor knowledge about ABS may underline the wrong perceptions about the principles of ABS exhibited among majority of the respondents in this study. It is worrisome that minority of the respondents in this study rightly perceived/knew that using antibiotics only when necessary (6.4%), administering antibiotics at the appropriate dose (6.4%) and administering antibiotics for appropriate duration in every case (4.3%) are among the core principles/strategies of ABS. These results are lower than the findings of Burger *et al*. (2016). It has been reported that apart from monitoring the antibiotic prescribing practice, continuous supervision of antibiotic dispensing practice and improving hygiene is a key approach to hold ABR (Cotta *et al*., 2014; Erku, 2016). Unfortunately, nearly all the respondents in the current study do not know that therapeutic monitoring of antibiotic, study of antibiotics and improved hygiene were also strategies of ABS (Abbo *et al*., 2013; Roca *et al*., 2015). The major key factor in the repression of ABR is reduction of disproportionate antibiotic utilization and this could be accomplished to a great extent by modification of prescribing manners of the clinicians/veterinarians (Dryden *et al*., 2011; Al-Harthi *et al*., 2013; Al-Harthi *et al*., 2015). Reduction in antibiotic use in veterinary settings could be achieved by improved personal hygiene by the veterinarians, animal handlers / caretakers and improved environmental sanitation (biosecurity) in the farm (Coyne *et al*., 2016: Rhouma *et al*., 2016). The audit and feedback strategy of ABS has been reported to be the most effective way of monitoring antibiotic usage (Chung *et al*., 2015).

Among the goals of ABS asked in the questionnaires, only reduction of ABR was rightly perceived by nearly half of the respondents in this work. This finding is lower than the result (52.7%) of Khan *et al*. (2016) among community pharmacists in Malaysia. It is very disturbing that more than one-third (35.4%) of the respondents perceived that ABS is aimed at increasing the use of broad-spectrum antibiotics. This finding contrasts the result (7.7%) of Burger *et al*. (2016). It is also of concern that although in the minority, some respondents (27.1%) in this study, felt that ABS aims at increasing duration of antibiotic therapy to ensure therapeutic success. This finding is also higher than that (10.4%) of Burger *et al*. (2016). Two-third of the respondents in this study agreed that they prescribe antibiotics for prophylaxis/metaphylaxis for animals in a herd/flock. Although it is still controversial on how the use of antibiotics for prophylaxis/metaphylaxis cause ABR (Bengston and Greko, 2014), an important principle of ABS is avoiding selection pressure in the patient, both on pathogen and commensal by avoiding unnecessary use, choosing the least broad-spectrum antibiotic, adequate doses, a good timing and the shortest possible duration (Pulicini and Gyssens, 2013).

Perceptions and attitudes could affect how prescribers interpret the consequences of antibiotic use and the variability in antibiotic prescribing that is seen in veterinary clinical practice (Abbo *et al*., 2013). Thus, wrong perception of most respondents in this study about ABS, may be why a high proportion of them are engaging in inappropriate practices that are untoward ABS such as prescribing antibiotics without seeing/examining their patient, changing antibiotics when therapeutic failure is perceived following the use of an antibiotic, and prescribing/administering overdose of antibiotic to patients to ensure therapeutic efficacy. Overuse of antibiotic may result from the clinician intention to fulfill the responsibility of offering optimal therapy for the individual patient under his/her care while overlooking the responsibility of preserving the efficacy of antibiotics and minimizing the development of resistance in the same patient and other patients in the future and to public health (Pulicini and Gyssens, 2013; Scaioli *et al*., 2015). Widespread and overuse of antibiotics, use of broad-spectrum antibiotics when narrow spectrum is available are among the leading causes of ABR (Pulcini *et al*., 2011;

Navarro-San Francisco *et al*., 2013; Abera *et al*., 2014; Burger *et al*., 2016). In ABS, clinicians are encouraged that where it is imperative to start effective broad-spectrum therapy quickly, subsequent daily review of these prescriptions, and de-escalation to narrow-spectrum antibiotics where possible, should be done (Wickens *et al*., 2013).

More than one-third (34.3%) of the respondents in this study prescribe antibiotics on request of the client. Al-Harthi *et al*. (2015) recorded a similar finding among general physicians in Saudi Arabia. It has been suggested that clinicians are usually under pressure from their clients/patients who expect to be prescribed antibiotics, even when they are inappropriate and unlikely to be effective (Coyne *et al*., 2016; Donald, 2016). Therefore, antibiotic prescribing decisions of veterinarians should be after consideration of intrinsic and extrinsic factors (e.g. type of husbandry practice in food-producing animals) (De Bryine *et al*. 2013; Coyne *et al*., 2014; Speksnijder *et al*., 2015; Coyne *et al*., 2016). Even more concerning is that majority of the respondents in this study choose new generation antibiotics (e.g., extended-spectrum antibiotics) as first line of treatment. In a study conducted by Busani *et al*. (2006) among veterinarians in Italy, therapeutic failure was reported as the main cause of the use of newer antibiotics. Lack of policy guiding antibiotic use in Nigeria may be why respondents in the study area engage in this imprudent practice. Fluoroquinolones, extended-spectrum β-lactams (3rd- and 4th-generation cephalosporins) and macrolides, are classified as critically important antimicrobials of the highest priority for risk management in their use, to maintain efficacy for human use (WHO, 2011; Coyne *et al*., 2016); therefore, there is need for educating veterinarians in Nigeria concerning the use of these critically-important drugs in animals.

It is worrying that a minority of the respondents in the hereby study felt that reducing duration of hospital stay (13.9%) and minimizing toxicity and other adverse effects (16.8%), are also goals of ABS. This may possibly underline why majority of these respondents admit their patients for a long time in their clinics and some others use an antibiotic for prolonged duration (17.1%). In South Africa, Burger *et al*. (2016) recorded 83.1% who knew that ABS is aimed at minimizing toxicity and other adverse effects in patients, among final year pharmacy students. ABS is the practice of escalating and sustaining the rational/judicious use of antibiotics to optimize patient outcomes, reduce costs, and avoid the collateral side effects (such as the generation of resistant organisms and untoward effects in the individual patient) linked with these medications (Struelens, 2003; Wickens *et al*., 2013; Burger *et al*., 2016; Erku, 2016).

In the current study, almost none of the respondents request for antibiogram of animal isolates within the locality to guide the choice of antibiotics in empiric treatment of bacterial infection and a minority of the respondents (23.6%) conduct antibiotic sensitivity test before prescribing antibiotics. Determination of antibiogram of isolates is crucial for guiding the choice of antibiotic therapy (Guardabassi and Prescott, 2015; Coyne *et al*., 2016). A more timely antibiotic sensitivity testing has been recognized as the best tool for combating ABR in clinically-relevant bacteria (Di Briyne *et al*., 2013; Dunne and Belkum, 2014). Thus, it is a matter of urgency that Nigerian veterinarians should be educated on ABS because antibiotic therapy not guided by antibiogram is the major cause of emergence and spread of multidrug-resistant organisms (Guardabassi and Prescott, 2015). In addition, majority of the respondents (89.3%) prescribe antibiotics for any case suspected to be infectious. This blind antibiotics prescription/therapy increases the spread of ABR and could be attributed to lack of affordable test kits and high cost of laboratory analysis in Nigeria (Sosa *et al*., 2014). Diagnosis has been recognized as an essential tool to contain ABR (Okeke *et al*., 2011). Collaboration with Microbiology laboratory has been identified as one of the requirements for establishment of ASP and to achieve ABS (Guardabassi and Prescott, 2015; Coyne *et al*., 2016). This practice of prescribing antibiotics without conducting laboratory tests by majority of the respondents in the study portends grave danger if continued, because the rate of development of ABR in veterinary settings in the country could become unprecedented and uncontainable. Veterinarians, animal handlers/caretakers and the public are at risk of acquiring resistant organisms from animals (via contact and food chain) and veterinary environment (Coyne *et al*., 2016). The most important interventions to combat ABR are considered to be education on antibiotic therapy, development of antibiotic usage policies and the development of institutional guidelines for antibiotic use (Cotta *et al*., 2014; Lee *et al*., 2015; Burger *et al*., 2016). Therefore, it is crucial that ASPs that involve evidence-based guidelines, educational programmes and regular feedback of antibiotic usage data to veterinarians to promote rationale-based and evidence-based prescribing, be developed and established in Nigeria (Wickens *et al*., 2013; Burger *et al*., 2016). Increasing awareness of national ABR patterns and knowledge of latest treatment guidelines, are the important strategies that could be implemented as a part of veterinary ABS in the study area (Khan *et al*., 2016).

The use of eco-friendly alternatives, such as vaccines, to prevent diseases thereby minimizing antibiotic use has been suggested to be one of the effective ways of containing ABR (Cabello *et al*., 2016; Coyne *et al*., 2016). In ASPs, veterinarians are supposed to be in the lead in educating clients to vaccinate their animals against preventable diseases. In the current study, more than two-third of the respondents (68.2%) advises their clients on the need for routine vaccinations. Studies have shown that minimal use of antibiotics (achievable by vaccinating against preventable diseases) by clinicians, could be a strategy for containing ABR (Llor and Bjerrum, 2014).

The use of substandard drugs has been reported as a major cause of ABR, especially in developing countries, where there are no regulations guiding the marketing and usage of antibiotics (Okeke *et al*., 1999; Laxminarayan *et al*., 2013; Burger *et al*., 2016). It is therefore a matter of serious concern, that minority of the respondents in this study, considers whether an antibiotic is of substandard quality before acquiring it for use in their patients. Pressure from the clients to prescribe affordable antibiotics may also account for low proportions of respondents in this study that check antibiotic quality before usage (Coyne *et al*.,

2016). Maximization of profit, availability, affordability on the part of the veterinarian, and/or ignorance, may also be reasons why majority of respondents in this study neglect drug quality (Okeke *et al*., 1999; Isturiz and Carbon, 2000; Coyne *et al*., 2016). Veterinarians' ability to profit from the sale of antibiotics has been highlighted as a potential conflict of interest in ABS (Rollin, 2006; WHO, 2001; Coyne *et al*., 2016). In Nigeria, high medicine prices are an important public health concern. Since the prices of drugs, including antibiotics, are not regulated in Nigeria, they vary considerably from one veterinary clinic/shop to another. Decoupling antibiotic sales to eliminate the potential that profit may drive prescribing behaviours among veterinarians have been suggested (Coyne *et al*., 2016). Moreover, there is no recognized ASP executed in veterinary clinics in Nigeria. This calls for the establishment of ASPs backed by strictly enforced policies regarding the sales and usage of antibiotics in Nigeria.

In this study, majority of the respondents ensures that their patients are given the prescribed antibiotics for the appropriate duration. This practice should be encouraged because poor patient adherence to prescribed antibiotics is the major untoward ABS attitude resulting in ABR (Pulcini *et al*., 2011; Navarro-San Francisco *et al*., 2013; Abera *et al*., 2014; Burger *et al*., 2016). Clients/patients' wrong habits and their lack of knowledge is also a leading cause for ABR (Scaioli *et al*., 2015; Coyne *et al*., 2016). The WHO urged member countries to initiate educational interventions for the general population aimed at rationalizing the use of antibiotics to combat resistance (WHO, 2001; Awad and Aboud, 2015). Veterinarians as major healthcare providers are expected to be educators of their clients/the public on the appropriate use of antibiotics and issues of ABR (Belognia and Schwartz, 1998; Lee *et al*., 2015; Erku, 2016). More than one-third (35.9%) of the respondents in this study, educates their clients on the appropriate use of antibiotics, adherence to withdrawal period and issues of ABS and ABR. This result is higher than the findings (24.2%) of Erku *et al*. (2016) among community pharmacists in Ethiopia. But it is lower than 61.2% who often educate their patients on issues of ABS and resistance-related issue amongst community pharmacists in Malaysia (Khan *et al*., 2016). Improving the clients/public knowledge and changing their attitudes towards antibiotic use, is a crucial strategy to maintain antibiotic effectiveness (Awad and Aboud, 2015). Variations in results of these studies could be related to differences in awareness about the principles of ABS, the extent to which ASP is established and the level of engagement of the various healthcare practitioners in the study areas. Low involvement of veterinarians in education of clients in this study could be related to lack of awareness about ABS and their role in ASPs.

Interestingly, more than half (53.9%) of the respondents in the present study, perceived that antibiotics are overused by veterinarians nationally. This finding is consistent with that of Abbo *et al*. (2013) among 4th-year medical students in 3 medical schools in America. Overuse of antibiotics by veterinarians in Nigeria, may be attributed to the poor knowledge about antibiotics and ABS, thus, antibiotics would be over-prescribed and disproportionately used. However, all the respondents in this study perceived that strong knowledge of antibiotics is crucial for their veterinary career and nearly all agreed that veterinarians have a major role to play in ensuring proper antibiotic use. This finding is similar to that of Erku (2016) in Ethiopia. Veterinarians are in position to coordinate ABS in veterinary clinics; therefore, they should have strong interest in and good knowledge of ABR and therapy (Guardabassi and Prescott, 2015). By taking advantage of the mostly optimistic views of the respondents in this study, on their role as veterinarians in ASPs, the Federal Ministry of Health, Veterinary Council of Nigeria, Veterinary hospital administrations, and other stakeholders, should provide strategies on how they could take action as ABS proponents (Erku, 2016).

Strengths of this study were that it highlighted an area where the availability of literature is limited. A high response rate was obtained and the survey was anonymous and voluntary, this likely reduced the tendency of the respondents to provide "socially desired" answers (Abbo *et al*., 2013; Burger *et al*., 2016). In addition, the study population is the practicing/teaching veterinarians, thus providing a better estimate of their Veterinary education after graduation. However, the results may not be generalized to all veterinarians in Nigeria since only Enugu State was sampled. Moreover, since the participants were approached randomly to collect data, they may not account for the differences within the population. Therefore, caution should be taken while interpreting these results in the context of potential identified limitations (Khan *et al*., 2016). Despite the identified limitations, the findings of this study could be useful for optimizing the use of antibiotics in veterinary settings in Nigeria.

Conclusions

The overall perception/level of awareness about ABS among veterinarians in Enugu State, Southeastern Nigeria is abysmally poor. This is attributed to lack of education/training on ABS and absence of established ASPs in the country. Consequently, veterinarians in the study area hugely engaging in inappropriate practices that are untoward ABS, thereby increasing the problem of ABR. Thus, there is urgent need for intensified education of veterinarians in Nigeria on ABS and the teaching of the principles and practices of ABS should begin during Veterinary school.

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