Rovedar

Small Animal Advances. 2023; 2(2): 12-25.

DOI: 10.58803/saa.v2i2.13

http://SAA.rovedar.com/

Research Article

Analyses of Antimicrobial Use and Prescription Patterns in a Companion Animal Practice in Accra, Ghana, from 2015 to 2021

Paa Kobina Turkson*

School of Veterinary Medicine, University of Ghana, Legon, Accra, Ghana

*** *Corresponding author:*** Paa Kobina Turkson, School of Veterinary Medicine, University of Ghana, Accra, Ghana. Email: pkturkson@ug.edu.gh

ARTICLE INFO

Article History:
Received: 01/04/2023
Accepted: 27/05/2023

Keywords:
Antibiotics
Antimicrobial use
Ghana
Prescription
Small animals
Veterinary practice

ABSTRACT

Introduction: The overuse, misuse, or abuse of antimicrobials in pets has the potential to result in antimicrobial resistance in pathogens of animal origin. There is a need for prudent use of antimicrobials to prevent this issue. The objective of the present study was to evaluate the trend of antimicrobial use in small animals at a veterinary practice in Accra, Ghana, over the period of 2015 to 2021.

Materials and methods: Clinical records of 4324 animal patients presented to a veterinary hospital in Ghana that were given antimicrobials from September 2015 to December 2021 were analyzed for frequencies, proportions, and statistical differences. The gender of animals involved in this study were 53.1% males, 43.4% females, and 3.4% did not have the sex stated. The perceptions of antimicrobials by veterinarians and prescription patterns (to understand the basis for the prescription patterns) were considered in this study.

Results: Antimicrobial use increased significantly from 56% in the first period (September 2015 to December 2017) to 75% in 2020, dropping to 59% in 2021. The prescription diversity was calculated to be 0.82. The most common indicator for antimicrobial use was a complex of symptoms and signs of anorexia-vomiting-diarrhea (27%). The number of antimicrobials prescribed per visit ranged from 1 to 5. The penicillin type (34%), tetracyclines (26.4%), sulphonamides (18.9%), and nitroimidazoles (10.6%) were the most used antimicrobial group. The routes and dosages administered were recorded in 70.3% and 92% of cases, respectively. The intramuscular route (54.5%) was the most preferred administration method by the clinicians. Notably, 95% of the veterinarians were neither aware of nor used any prescription guidance protocol in the small animal veterinary facility.

Conclusion: Antimicrobials were used in high proportions in pets (mainly dogs) from 2015 to 2021. Penicillin, tetracyclines, and sulphonamides were more commonly used. Detailed information on antimicrobial prescriptions and use in a small animal veterinary practice setting in Ghana could provide valuable data for providing guidelines in antibacterial usage.

1. Introduction

Antimicrobials are used in veterinary medicine for the prevention, control, and treatment of diseases mainly of bacterial origin in animals, to manage secondary bacterial infections, and to serve as vital tools in the maintenance of health, well-being, and productivity of animals[1-3]. Good antimicrobial stewardship requires the judicious use of antimicrobial agents to prevent and control the development of antimicrobial resistance in microorganisms affecting humans, animals, and the environment. The options for effective antimicrobials to control emerging, difficult-to-treat and multidrug-resistant bacteria are dwindling, making good and proper antibiotic stewardship a necessity to help preserve the efficacy of available antimicrobials[4]. The information gathered from studies that identify the most frequently used antibiotics, patterns, and reasons for use could provide targets for developing guidelines for prudent antibiotic use in veterinary practices and assist in policy formulation processes for informed decisions to promote antimicrobial stewardship[5]. The misuse and/or irrational use of antimicrobials is said to adversely decrease the

Cite this paper as: Turkson PK. Analyses of Antimicrobial Use and Prescription Patterns in a Companion Animal Practice in Accra, Ghana, from 2015 to 2021. Small Animal Advances. 2023; 2(2): 12-25. DOI: 10.58803/saa.v2i2.13

quality of therapeutic outcomes, resulting in increased morbidity and mortality, heightened risk of adverse drug reactions, and contribute to the emergence of antimicrobial resistance (AMR)[1,6-8]. Antimicrobial research should prioritize the inclusion of small animal medicine, considering that certain antibiotic groups are utilized in both human and small animal practices. The close and continuous contact between owners and their pets makes it imperative to consider this issue[9].

The World Organization for Animal Health (WOAH) advocates establishing a surveillance system in countries aimed at identifying antibiotic use in veterinary services and providing information on the antibiotic classes, dosages, and routes of administration[10]. However, few studies have documented antibiotic prescription patterns in small animal practices[11], especially in developing countries, with few reports from Cameroon[12], Nigeria[13], and Trinidad and Jamaica[14]. Furthermore, there is limited information on antimicrobial use (AMU) in animal health services in West Africa[15,16]. A national survey on antibiotic prescription and use in animal health in Ghana has been recommended[17]. It has been argued that AMR is a health threat to humans and pets, which necessitates the investigation of AMU in companion animals[12].

There is sparse information on the use of antimicrobial agents in animals in Ghana. The current study aimed to contribute to AMU knowledge in Ghana by evaluating the use of antimicrobials in a veterinary practice that provided services mainly for companion animals in Accra, Ghana. The study has multiple objectives. Firstly, it aimed to analyze the extent of AMU in companion animal practice in Ghana. Specifically, the study intended to determine the frequency at which patients attending the facility were treated with antimicrobials from September 2015 to December 2021. Secondly, the study was set to describe the antimicrobial classes and groups used for various complaints or conditions in the same patient population. Thirdly, the study sought to assess whether the routes and dosages of antimicrobials were appropriately indicated in the treatment protocols. Lastly, the study aimed to gather the perspectives of attending veterinarians on antimicrobial prescription practices and use. The results could provide situational analyses of AMU in companion animal practice in Ghana.

2. Material and Methods

2.1. Ethical approval

Written approval for the use of the physical patient record forms was obtained from the management of the facility. The data for the period were aggregated and had no descriptors to identify individual patients, clients, or attending clinicians to ensure anonymity. The study was conducted according to the guideline of the veterinary clinical facility in Accra, Ghana.

2.2. Study design

A retrospective survey of clinical records for patients attending a veterinary clinical facility in Accra from September 2015 (when services began) to December 2021 was performed. The facility offered veterinary clinical services predominantly for companion animals (dogs and cats), although other animals, such as goats, avian, and rabbits, were occasionally seen.

The study analyzed data on attendance, species of animal, age, sex, complaints, diagnosis or observation, class and type of antimicrobials prescribed or dispensed, dosage and route of drug administration, and the number of antimicrobials dispensed during a visit. The details and total number of distinct antimicrobial drugs prescribed for a visit were recorded. Each visit for a patient was considered separately unless subsequent visits (follow-ups) were within a few days. If the patient was prescribed the same antibiotic multiple times within one month for the same infection, a subsequent treatment after the first one was not included on the assumption that they were similar. In case a different antimicrobial drug was administered to the same animal on the following day or a few days after the first encounter, this was recorded separately. One patient could have multiple entries based on different complaints on different dates, or if another antimicrobial was used on a different date for the same complaint. Therefore, the total number of entries exceeded the number of patients during this period.

Figure 1 presents a flow chart for the selection process for antimicrobial prescription and uses from 2015 to 2021. Data extracted were on a year-to-year basis. However, data from September 2015 to 2017 were combined as one. The case filing system adopted initially by the facility during that period was based on the names of pets, making sorting out yearly difficult. Therefore, the data for that period (September 2015 to 2017) were aggregated. Records from 2018 to 2021 were kept separately and so were available separately.

A 16-item online perception questionnaire was prepared using Google Forms. It was administered by email to present and past veterinarians of the facility to assess the basis of antimicrobial prescription and use[18]. The questionnaire (modified version of Alcantara et al.[19]) consisted of 15 closed questions and one open question. Three questions solicited socio-demographic information, including gender, age bracket, and length of practice in the veterinary facility. Ten questions were on views based on antimicrobial prescriptions at the facility with a “yes” or “no” response. One question required respondents to arrange the following, price, efficacy, ease of administration, route of administration, ease of acquisition, availability on the market, and familiarity with the drug from 1 (most important) to 7 (Least important) when prescribing antimicrobials. There was also a question requiring scoring from 7 (highest score) to 1 (lowest score) to score the importance of the prescription of drugs, administration route, availability on the market, ease of administration, efficacy, frequency of administration, ease of acquisition, and price. The results were collated mainly as proportions and weighted mean scores.

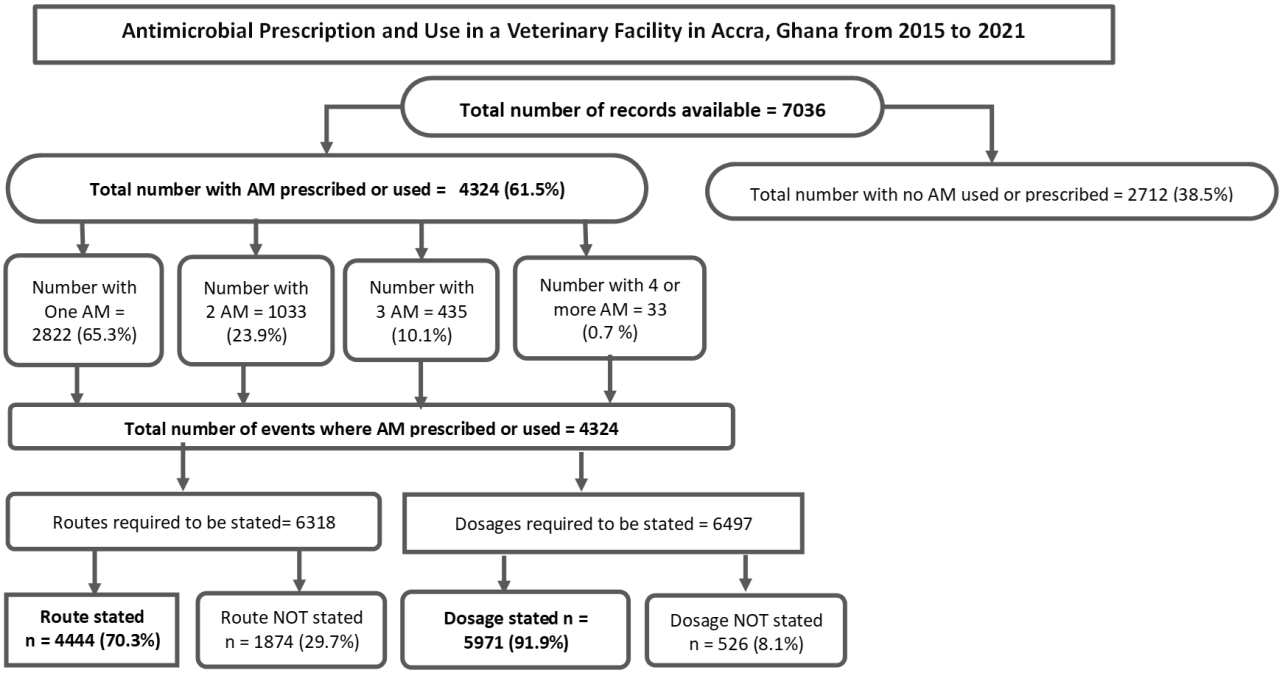

Figure 1. Flow chart for Antimicrobial Prescription and Use in a small animal veterinary practice in Accra from 2015 to 2021

There was an open question on respondents' concerns about the antimicrobial misuse or abuse in the veterinary facility.

The respondent veterinarians were categorized into two types using the following criterion, including empirical-oriented type prescribed treatments based on the signs of the animal and their own experience, and protocol-oriented type referred to a guidance protocol to assist in the prescription decision-making process[19].

2.3. Statistical analysis

An Excel sheet (Microsoft Excel 2016, Microsoft Corporation, Redmond WA, USA) was designed to manually extract and code information from hard copies kept as records. Analyses using IBM SPSS Statistics software (version 26) involved descriptive statistics, cross-tabulations, and contingency tables for testing the significance of differences in proportions using the Chi-square test. The computations included the proportion of cases, where antimicrobial was prescribed or used based on sex, species, and complaint or diagnosis or observations. Moreover, proportion of cases with 1, 2, 3, 4, or more antimicrobial prescriptions during a visit was measured. Antimicrobial prescriptions per medical visit was calculated as the Total number of antimicrobial prescriptions/Number of cases with antimicrobial prescriptions. Antimicrobial prescription proportion was calculated as (number of cases with AMU /Total number of patient visits) x 100. Prescription diversity was defined as the frequency and variety with which a practice prescribes pharmaceutical classes (PC) within a determined pharmaceutical family (PF) "[20] and calculated as follows[21]:

Prescription diversity (PD) = 1 – ((∑np(np-1)/NP(NP-(Formula 1)

Where, NP is the number of prescriptions of a particular PC within a PF, PD was measured from 0 to 1, with 1 being the highest diversity[22].

Prescription diversity was calculated as 1 - (7,089,404/40,151,232).

The classification and proportions of antimicrobial drug types and groups were analyzed. Then, the proportion of cases was calculated according to the route of antimicrobial administration. Finally, the proportions of cases based on whether or not the route of antimicrobial administration and dosages used were stated on case forms. The significance of differences was determined at $p < 0.05$.

3. Results

Table 1 presents the results of some background information. The proportion of cases where antimicrobial was used increased significantly over the study period from about 56%

Table 1. Background information of pet patients visiting a small animal veterinary hospital in Accra, Ghana, from 2015 to 2021

	Sept 2015 - Dec 2017	2018	2019	2020	2021	Total	Mean ± SD
Number of patients reporting to the facility	1712	1524	1270	1112	1418	7036	1407±231
Number with Antimicrobial during prescriptions	954	891	808	831	840	4324	865± 58
Antimicrobial prescription proportion (%)	55.8	58.5	63.6	74.7	59.2	61.4	na
Average No. of antimicrobial prescriptions per medical visit	1.2	1.2	1.4	1.4	1.5	na	1.3 ± 0.1

SD: Standard deviation, AM: Antimicrobial, na: not applicable

Table 2. Distribution of pet patients based on species seen in a veterinary hospital in Accra, Ghana, from 2015 to 2021

Species	Period					
	2015-2017 (%)	2018 (%)	2019 (%)	2020 (%)	2021 (%)	Total (%)
Dog	871 (91)	854 (96)	769 (95)	798 (96)	803 (96)	4095 (95)
Cat	61 (6)	30 (3)	17 (2)	22 (3)	23 (3)	153 (4)
Avian	0	1 (0)	5 (1)	2 (0)	3 (0)	11 (0)
Goat	0	1 (0)	13 (2)	6 (1)	7 (1)	27 (1)
Rabbit	5 (1)	5 (1)	2 (0)	3 (0)	4 (0)	19 (0)
Others	1 (0)	0	2 (0)	0	0	3 (0)
Not mentioned	16 (2)	0	0	0	0	16 (0)
Total (%)	954 (100)	891 (100)	808 (100)	831 (100)	840 (100)	4324 (100)

in the first period (September 2015 to December 2017) to 75% in 2020, dropping to 59% in 2021. The average number of antimicrobial prescriptions per visit increased from 1.2 in 2018 to a peak of 1.5 in 2021. Regarding sex, there were more male animals (53.1%;) treated with antimicrobials than females (43.4%). Patients whose sexes were not stated were (3.4%).

3.1. Patient Visits

Table 2 presents the distribution of patients based on species. There were statistically significant reductions in the numbers of dogs (X^2: 28.96, 4df, $p < 0.05$) and cats (X^2: 31.04, 4df, $p < 0.05$) treated in the facility. Table 3 shows the distribution of the patients according to the number of visits.

3.2. Complaints

About 7% of the cases presented did not complain (Table 4). The most common complaint was anorexia.

3.3. Prescription diversity and indicators

The prescription diversity was 0.82, indicating a high use of various antimicrobials. The most common indicator for AMU was a complex consisting of anorexia-vomiting-diarrhea (27%). Treatments for infections (ehrlichiosis, babesiosis, brucellosis, coccidiosis, anaplasmosis, giardiasis, tick-borne fever, and blood-borne type) made up 7.8% of AMU cases. Other uses included treatments for wounds (6.6%), skin lesions (6.5%), parvovirus (6.3%), myiasis (4.5%), ectoparasitism (4.3%), and antimicrobial cover for surgical interventions (4.0%).

3.4. Antimicrobial use patterns

The number of antimicrobial drugs administered or prescribed per visit is reported in Table 5. The number of antimicrobial administered or prescribed per visit ranged from 1 to 5. There was only one instance (in 2021), where five antimicrobial was given to one patient on a visit. Generally, the number of patients given one or two antimicrobials decreased significantly over the period. On the other hand, the number of patients given 3 antimicrobial increased significantly (X^2: 82.54, 4df, $p < 0.05$), while the number of those given 4 antimicrobial did not change significantly (X^2: 9.44, 4df, $p > 0.05$).

3.5. Antimicrobial groups and classes administered or prescribed

As can be seen in Table 6, the penicillin type was most prevalent (34%), followed by tetracyclines (26.4%), sulphonamides (18.9%), and nitroimidazoles (10.6%) regarding the antimicrobial group. About 90% of the antimicrobial used were in these 4 groups. There were significant increases in the proportions of sulphonamides (X^2: 43,0, 4 df, $p < 0.05$), nitroimidazoles (X^2: 231.80, 4df, $p < 0.05$), and fluroquinolones (X^2: 29.39, 4 df, $p < 0.05$) over the years. In contrast, the proportions of penicillin-type of antimicrobial used decreased significantly (X^2: 164.52, 4 df, $p < 0.05$), while no significant changes were seen in the proportions for tetracyclines (X^2: 6.32, 4 df, $p > 0.05$). The most frequently prescribed antimicrobial classes were amoxicillin (28.7%), oxytetracyclines (19.7%), trimethoprim-sulphate (18.6%), and metronidazole (10.6%), altogether making up about 84% of the antimicrobial used (Table 6).

Table 3. Distribution of pet patients in Accra, Ghana, from 2015 to 2021 based on number of visits

Number of visits	2015-2017 (%)	2018 (%)	2019 (%)	2020 (%)	2021 (%)	Total (%)
1	803 (84)	703 (79)	607 (75)	638 (76)	632 (75)	3377 (78)
2	117 (12)	146 (16)	151 (19)	146 (17)	154 (18)	714 (17)
3	25 (3)	28 (3)	37 (5)	31 (4)	35 (4)	156 (4)
4	7 (1)	10 (1)	12 (1)	13 (2)	11 (1)	53 (1)
5	1 (0)	2 (0)	1 (0)	6 (1)	5 (1)	15 (0)
6	1 (0)	1 (0)	0	2 (0)	1 (0)	5 (0)
7	0	1 (0)	0	1 (0)	1 (0)	3 (0)
8	0	0	0	0	1 (0)	1 (0)
Total (%)	954 (100)	891 (100)	808 (100)	831 (100)	840 (100)	4324 (100)

Table 4. Distribution of complaints, diagnosis, or conditions used as a basis for AM drug treatment in a small animal veterinary hospital in Accra, Ghana from 2015 to 2021

Complaint	Frequency	%
Anorexia/inappetence/off-feed/reduced intake/hypoxia	456	10.6
Infections[1]	338	7.8
Wounds/Sores/bruises/lacerations/bites/ulcers	284	6.6
Not stated/Missing	284	6.6
Skin lesions[2]	281	6.5
Parvovirus test positive/suspected parvovirus	274	6.3
Diarrhea/enteritis/loose stool/frequent stool/haematochezia/gastritis	252	5.8
Myiasis/larval migrans	194	4.5
Infestations (ticks or fleas or both)/Ectoparasitism	184	4.3
Surgical cover (Castration/OVH/hernia repair/neoplasia excision/eyelid)	172	4.0
Vomiting/retching	171	4.0
Vomiting and diarrhea	167	3.9
Lameness/Limping/Swollen limbs/abnormal locomotion/ pain in limbs	108	2.5
Others[3]	105	2.4
Reviews/checkups	84	1.9
Ear issues (infections/discharges/hematoma)	78	1.8
Respiratory tract infections/coughs/sneezing/pneumonia	77	1.8
Eye issues (infections/discharges/blindness)	69	1.6
Recumbency/comatose/paralysis/moribund	62	1.4
Anorexia and diarrhea	59	1.4
Tumors/Growths/swellings/myositis/granuloma	59	1.4
Abscess/pustules/pedal furunculosis	58	1.3
Emaciation/weakness/poor growth/weight loss/cachexia	52	1.2
Urinary tract infections/problems/hematuria	49	1.1
Orchitis/preputial discharges/prostatitis/paraphimosis/priapism	48	1.1
Anorexia; vomiting	46	1.1
Dull/Inactive/lethargy	41	0.9
Ascites/oedema/bloated abdomen/pain in abdomen	40	0.9
Pyometra/vaginitis/female tract infections/mastitis/eclampsia	39	0.9
Prophylaxis	28	0.6
Epistaxis/Nose bleeding/nasal discharge	26	0.6
Trauma/Accident/Runover by car	25	0.6
Allergies/flea bite dermatitis	22	0.5
Helminthosis/Helminthiasis	21	0.5
Anorexia; vomiting; diarrhoea	17	0.4
Nervous/Torticollis/pain in neck/head shaking/head tilting/seizures	15	0.3
Swollen lymph nodes/lymphadenopathy/tonsilitis	15	0.3
Fractures/hip dysplasia	11	0.3
Jaundice/icterus	7	0.2
Dystocia/stillbirth	5	0.1
Total	4323	100

[1]Infections included Erhlichiosis, Babesiosis, Brucellosis, Coccidiosis, Anaplasmosis, Tick-borne fever, heartwater, Giardiasis, blood-borne infections
[2] Skin lesions included pruritus, mange, alopecia, folliculitis, pyodermatitis, pododermatitis, demodicosis
[3]Others included anaemia, bloat, borborygmic, bone in mouth, cardiac regurgitation, constipation, dehydration, drooling/salivation, difficulty in swallowing/dysphagia, fever, glomerulonephritis, heat stroke, hepatic disease, hotspots, impacted anal glands, kyphosis, palliative, pancreatitis, periodontal disease, poisoning, polydipsia/polyuria, shivering, snake bite, tartar

Table 7 provides the antimicrobial groups and classes administered on a year-to-year basis. The contributions to AMU on a year-to-year basis were 19.5% for 2015-2017; 20.8% for 2018; 19.4% for 2019; 20.8% for 2020 and 19.6% for 2021. The findings indicated no statistically significant differences ($p > 0.05$). Amoxycillin was consistently the drug most used, followed by oxytetracycline (except in 2019 and 2020 when it was surpassed by trimethoprim sulphate (Table 7).

Table 8 presents the antimicrobial groups and classes used according to species with use in dogs highest (95.8%), followed by use in cats (2.8%).

Table 5. Number of antimicrobial drugs administered or prescribed per visit in a small animal veterinary hospital in Accra, Ghana from 2015 to 2021

Number of Antimicrobial	Period					
	2015-2017 n (%)	2018 n (%)	2019 n (%)	2020 n (%)	2021 n (%)	Total n (%)
1	704 (74)	582 (65)	486 (60)	485 (58)	565 (67)	2822 (65.3)
2	224 (23)	198 (22)	232 (29)	221 (27)	158 (19)	1033 (23.9)
3	24 (3)	107 (12)	84 (10)	115 (14)	105 (13)	435 (10.1)
4	2 (0)	4 (0)	6 (1)	10 (1)	10 (1)	32 (0.7)
5	0	0	0	0	1 (0)	1 (0)
Total	954 (100)	891 (100)	808 (100)	831 (100)	839 (100)	4324 (100)

3.6. Routes and dosages of antimicrobial administered

Of 6318 records extracted, the drug administration route was mentioned in 70.3% of cases. Regarding dosages, about 92% of the records had the dosages written. In 68.6% of cases, both route and dosage were mentioned. In 25.2% of cases route was not stated, but the dosage was, and in 1.9% route was stated but not the dosage. Both route and dose were not stated in 4.3% of cases. Significant differences existed in the proportions (X^2: 558.82, 4 df, $p < 0.05$). The observed agreement between stating the route and/or dosage used was 78.9% with a Cohen K value of 0.14, interpreted as a slight agreement[18]. The Intramuscular (IM) route was most dominant (54.5%), while topical/powder was the least used (0.5%, Figure 2). Table 9 shows the routes of administration used for various antimicrobial groups. Regarding nitroimidazoles, almost 29% of cases had no report of administration routes. Table 10 tabulates the proportions of patients given an antimicrobial by a particular route. The most commonly used route for administering antimicrobials was IM, except for aminoglycosides, where the highest proportion (53%) was administered through ocular treatment. For chloramphenicol, all three recorded treatments were administered through the ocular route.

Table 6. Proportions of various antimicrobial classes in respective antimicrobial Groups used in pet patients in Accra, Ghana from 2015 to 2021

Antimicrobial groups and classes	Frequency	% Within antimicrobial groups	% of total antimicrobials used
Tetracyclines			
Oxytetracycline	1249	74.7	19.7
Doxycycline	417	25.0	6.6
Minocycline	7	0.3	0.1
Penicillins			
Amoxycillin	1819	84.4	28.7
Penicillin streptomycin	190	8.8	3.0
Amoxicillin/Clavulanic Acid	140	6.5	2.2
Ampicillin	4	0.2	0.1
Sulphonamides			
Trimethoprim Sulphate	1181	98.6	18.6
Sulphadimidine	17	1.4	0.3
Fluoroquinolones			
Enrofloxacin	370	79.7	5.8
Ofloxacin	61	13.1	1.0
Ciprofloxacin	33	7.1	0.5
Nitroimidazoles			
Metronidazole	674	100.0	10.6
Macrolides			
Tylosin	36	61.0	0.6
Azithromycin	23	39.0	0.4
Aminoglycosides			
Gentamycin	53	91.4	0.8
Neomycin	3	5.2	0.0
Tobramycin	2	3.4	0.0
Cephalosporin	39		0.6
Cephalexin (1st Gen)	17	43.6	0.3
Ceftiofur (3rd Gen)	16	41.0	0.2
Ceftriazone (3rd Gen)	3	7.7	0.1
Ceftaxime (3rd Gen)	2	5.1	0
Cefpodoxime (3rd Gen)	1	2.6	0
Lincosamides			
Clindamycin	12	100.0	0.2
Polypeptides			
Polymixin B	1	100.0	0.0
Chlorhexidine/iodine	2	100.0	0.0
Chloramphenicol	3	100.0	0.0

3.7. Perception survey

The response proportion for a perception survey of past and present attending veterinarians in the facility was 90.9% (20 of 22), with males making up 85. Regarding age distributions, 7 (35%) individuals were under 30 years, 12 (60%) were between 30 and 39 years, and 1 (5%) person was over 50. In terms of experience at the veterinary facility, employees with 1 year were 10 (50%), 2 (10%) for 2 years, 1 (5%) for 3 years, 2 (10%) for 4 years, 4 (20%) for 5 years, and1 (5%) for more than 5 years.

Table 11 shows how respondents perceived AMU in the facility. The weighted mean scores (7 [highest] to 1 [lowest]) for the importance of prescribing drugs addressed efficacy (4.11), availability on the market (3.75), administration route (3.71), administration frequency (3.5), ease of acquisition (3.46); ease of administration (3.39) and price (2.75). The proportions of respondents who considered the following as the most important in prescribing antimicrobials were 75%, 65%, 50%, 45%, 45%, 40%, and 20% for efficacy, availability on the market, familiarity with the drug, administration route, ease of acquisition, ease of administration, and price, respectively. Efficacy and availability of antimicrobials on the market were the first and second choices for 4 out of the 6 most important and weighted average scores. At the same time, ease of administration and price was the penultimate and last items considered.

Table 7. Distribution of antimicrobial groups and classes on an annual basis in a small animal veterinary hospital in Accra, Ghana, from 2015 to 2021

Antimicrobial groups and classes	Period						
	2015-2017	2018	2019	2020	2021	Total	%
Penicillin-type	597	467	365	347	380	2156	34.0
Amoxycillin	542	427	245	293	314	1821	28.7
Penicillin streptomycin	37	6	89	29	29	190	3.0
Amoxicillin/ Clavulanic Acid	15	3	31	25	37	141	2.2
Ampicillin	3	1	0	0	0	4	0.1
Tetracyclines	316	320	323	362	350	1671	26.4
Oxytetracycline	227	248	234	265	275	1249	19.7
Doxycycline	89	69	88	96	73	415	6.6
Minocycline	0	3	1	1	2	7	0.1
Sulphonamides	168	247	243	293	247	1198	18.9
Trimethoprim Sulphate	151	247	243	293	247	1181	18.6
Sulphadimidine	17	0	0	0	0	17	0.3
Nitroimidazoles	35	178	133	169	158	673	10.6
Metronidazole	35	178	133	169	158	673	
Fluoroquinolones	67	77	125	113	82	464	7.3
Enrofloxacin	45	63	109	94	60	371	5.9
Ofloxacin	18	12	10	11	8	59	0.9
Ciprofloxacin	4	2	6	8	14	34	0.5
Macrolides	10	6	23	11	9	59	0.9
Tylosin	10	2	13	8	3	36	0.6
Azithromycin	0	4	10	3	6	23	0.4
Aminoglycosides	26	9	10	7	6	58	0.9
Gentamycin	26	9	9	6	4	54	0.9
Neomycin	0	0	1	0	1	2	0
Tobramycin	0	0	0	1	1	2	0
Cephalosporins	11	8	0	13	7	39	0.6
Lincosamides	6	2	4	0	0	12	0.2
Clindamycin	6	2	4	0	0	12	
Polypeptides	1	0	0	0	0	1	0.0
Polymixin B	1	0	0	0	0	1	
Others							
Chloramphenicol	0	2	0	1	0	3	0.0
Iodophores/chlorhexidine*	0	0	3	0	0	3	0.0
Total	1235	1316	1229	1318	1239	6337	

*Used routinely as disinfectants and may not have been recorded routinely.

Table 8. Antimicrobial groups and classes used in dogs, cats, avians, goats, rabbits, and others in a small animal veterinary hospital in Accra, Ghana, from 2015 to 2021

Antimicrobial groups and classes	Species								
	Dog	Cat	Avian	Goat	Rabbit	Others	ns	Total	%
Penicillin-type	1973	139	8	14	12	2	10	2158	34.0
Amoxycillin	1663	131	8	5	11	1	4	1821	28.7
Penicillin streptomycin	172	5	0	9	1	0	3	190	3.0
Amoxicillin/Clavulanic Acid	135	3	0	0	0	1	1	140	2.2
Ampicillin	2	0	0	0	0	0	2	4	0.1
Tetracyclines	1657	3	2	3	1	1	4	1671	26.4
Oxytetracycline	1235	2	2	3	1	1	4	1248	19.7
Doxycycline	416	0	0	0	0	0	0	416	6.6
Minocycline	6	1	0	0	0	0	0	7	0.1
Sulphonamides	1167	13	4	10	3	0	1	1198	18.9
Trimethoprim Sulphate	1151	13	4	10	3	0	0	1181	18.6
Sulphadimidine	16	0	0	0	0	0	1	17	0.3
Nitroimidazoles	664	7	2	0	0	0	0	673	10.6
Metronidazole	664	7	2	0	0	0	0	673	10.6
Fluoroquinolones	444	13	1	1	4	1	0	464	7.3
Enrofloxacin	353	10	1	1	4	1	0	370	5.8
Ofloxacin	59	2	0	0	0	0	0	61	1.0
Ciprofloxacin	32	1	0	0	0	0	0	33	0.5
Macrolides	55	1	0	3	0	0	0	59	0.9
Tylosin	33	0	0	3	0	0	0	36	0.6
Azithromycin	22	1	0	0	0	0	0	23	0.4
Aminoglycosides	54	2	0	1	1	0	0	58	0.9
Gentamycin	50	2	0	0	1	0	0	53	0.8
Neomycin	3	0	0	0	0	0	0	3	0.0
Tobramycin	1	0	0	1	0	0	0	2	0.0
Cephalosporins	35	0	0	3	0	0	1	39	0.6
Lincosamides	12	0	0	0	0	0	0	12	0.2
Clindamycin	12	0	0	0	0	0	0	12	0.2
Polypeptides	1	0	0	0	0	0	0	1	0.0
Polymixin B	1	0	0	0	0	0	0	1	0.0
Others									
Chloramphenicol	3	0	0	0	0	0	0	3	0.0
Iodophores/chlorhexidine	3	0	0	0	0	0	0	3	0.0
Total antimicrobial use per species	6068	178	15	35	21	4	16	6337	
% of Antimicrobial used	95.8	2.8	0.2	0.6	0.3	0.1	0.3	100	

ns: not stated

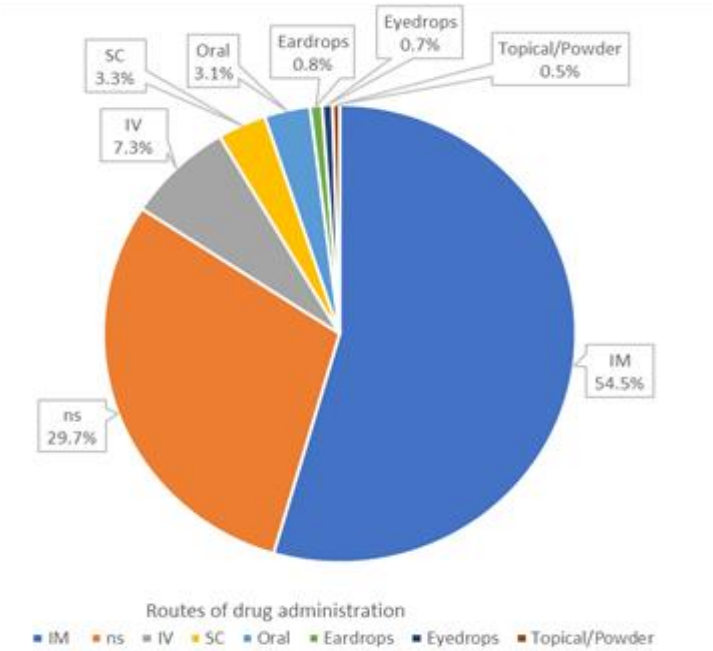

Figure 2. Distribution of routes of antimicrobial drug administration in a small animal veterinary hospital in Accra, Ghana, from 2015 to 2021
IM: Intramuscular, ns: Not stated, IV: Intravenous, SC: Subcutaneous

Table 9. Administration routes for antimicrobial groups in the treatment of pets in a small animal veterinary hospital in Accra, Ghana, from 2015 to 2021

Antimicrobial groups	IM n (%)	IV n (%)	SC n (%)	Oral n (%)	Topical n (%)	Eye n (%)	Ear n (%)	ns n (%)
Penicillins	1887 (31.7)	211 (17.5)	129 (35.3)	102 (31.5)	26 (44.8)	9 (14.8)	8 (11.8)	199 (18.7)
Sulphonamides	1415 (23.8)	310 (25.7)	100 (27.4)	37 (11.4)	3 (5.2)	2 (3.3)	1 (1.5)	205 (19.3)
Tetracycline	1316 (22.1)	91 (7.5)	66 (18.1)	78 (24.1)	22 (37.9)	4 (6.6)	3 (4.4)	185 (17.4)
Nitroimidazoles	725 (12.2)	427 (35.3)	27 (7.4)	74 (22.8)	2 (3.4)	0	1 (1.5)	306 (28.8)
Fluoroquinolones	530 (8.9)	153 (12.7)	33 (9.0)	24 (7.4)	0	4 (6.6)	45 (66.2)	146 (13.7)
Aminoglycoside	11 (0.2)	0	3 (0.8)	0	1 (1.7)	39 (63.9)	7 (10.3)	12 (1.1)
Macrolides	39 (0.7)	14 (1.2)	1 (0.3)	7 (2.2)	1 (1.7)	0	0	2 (0.2)
Cephalosporin	20 (0.3)	2 (0.2)	6 (1.6)	0	0	0	2 (2.9)	4 (0.4)
Lincosamides	3 (0.1)	0	0	2 (0.6)	0	0	0	4 (0.4)
Iodophores	3 (0.1)	0	0	0	3 (5.2)	0	0	0
Chloramphenicol	0	0	0	0	0	3 (4.9)	0	0
Polypeptides	0	0	0.0	0	0	0	1 (1.5)	0
Total	5949	1208	365	324	58	61	68	1063

*Percentages add up within columns
IM: Intramuscular, ns: Not stated, IV: Intravenous, SC: Subcutaneous

Table 10. Proportions of antimicrobial groups by routes of administration in a small animal veterinary facility in Accra, Ghana, from 2015 to 2021

Antimicrobial groups	ROUTE								
	IM n (%)	IV n (%)	SC n (%)	Oral n (%)	Topical n (%)	Eye n (%)	Ear n (%)	ns n (%)	Total n (%)
Penicillins	1887 (73.4)	211 (8.2)	129 (5.0)	102 (4.0)	26 (1.0)	9 (0.4)	8 (0.3)	199 (7.7)	2571 (100)
Sulphonamides	1415 (68.3)	310 (15.0)	100 (4.8)	37 (1.8)	3 (0.1)	2 (0.1)	1 (0)	205 (9.9)	2073 (100)
Tetracycline	1316 (74.6)	91 (5.2)	66 (3.7)	78 (4.4)	22 (1.2)	4 (0.2)	3 (0.2)	185 (10.5)	1765 (100)
Nitroimidazoles	725 (46.4)	427 (27.3)	27 (1.7)	74 (4.7)	2 (0.1)	0	1 (0.1)	306 (19.6)	1562 (100)
Fluoroquinolones	530 (56.7)	153 (16.4)	33 (3.5)	24 (2.6)	0	4 (0.4)	45 (4.8)	146 (15.6)	935 (100)
Aminoglycoside	11 (15.1)	0	3 (4.1)	0	1 (1.4)	39 (53.4)	7 (9.6)	12 (16.4)	73 (100)
Macrolides	39 (60.9)	14 (21.9)	1 (1.6)	7 (10.9)	1 (1.6)	0	0	2 (3.1)	64 (100)
Cephalosporin	20 (58.8)	2 (5.9)	6 (17.6)	0	0	0	2 (5.9)	4 (11.8)	34 (100)
Lincosamides	3 (33.3)	0	0	2 (22.2)	0	0	0	4 (44.4)	9 (100)
Iodophores	3 (50)	0	0	0	3 (50)	0	0	0	6 (100)
Chloramphenicol	0	0	0	0	0	3 (100)	0	0	3 (100)
Polypeptides	0	0	0	0	0	0	1 (100)	0	1 (100)

*Percentages add up within rows
IM: Intramuscular, ns: Not stated, IV: Intravenous, SC: Subcutaneous

Table 11. Respondents' answers about antimicrobial use in a small animal veterinary facility in Accra, Ghana, from 2015 to 2021

Perceptions	Yes (n, %)	No (n, %)	Maybe (n, %)
Aware of antimicrobial use protocols or policies in facility	1 (5)	19 (95)	
Used antimicrobial protocol in the facility	1 (5)	19 (95)	
Would use a prescription guidance protocol if available	18 (90)	0	2 (10)
antimicrobial prescription was based on animals' signs and own experience	20 (100)	0	
Antimicrobial prescription was based on reference to guidance protocol to assist in decision-making	9 (45)	11 (55)	
Prescription guidance protocol for antimicrobial use in facility is necessary	18 (90)	0	2 (10)
Concerned about antimicrobial misuse or abuse in facility	8 (40)	12 (60)	
Veterinarian's antimicrobial *prescription decision was based on:*			
Animal's clinical condition	20 (100)	0	
Efficacy of available antimicrobials	20 (100)	0	
Knowledge and experience with antimicrobials	20 (100)	0	
Means/route of antimicrobial administration	19 (95)	1 (5)	
Owner's ability to comply with directions given	18 (90)	2 (10)	
Owner's willingness to comply with directions given	15 (75)	5 (25)	
Cost of antimicrobial susceptibility test, if available	14 (70)	6 (30)	

4. Discussion

4.1. Background information

Published reports focusing on knowledge of AMU in a companion animal veterinary practice setting in Ghana are scarce. Previous reports had been on AMU in livestock and poultry with very little information on pets[17,23-28].

The average number of antimicrobial prescriptions per visit increased from 1.2 to 1.5 by 2021. There was generally an increased AMU in the facility from about 56% in the initial period to about 75% in 2020, followed by a decline to 59% in 2021 (Table 1). The difference in the proportions of AMU in those years was significant ($p < 0.05$). In Nigeria, the overall proportion of cases treated with antibiotics significantly increased, starting from 23% in 2013 to a high of 52% in 2016[29]. Due to a high rate of bacterial and viral diseases, AMU increased for surgical and wound healing purposes in veterinary hospitals in Nigeria[5,29-33] and some other countries[12,34-36]. A similar

situation was observed in the current study.

4.2. Patient visits

The veterinary facility provides access to clients for consultation with their animals. Access to veterinary services has a positive impact on animal health and welfare as well as the mental and physical health and well-being of owners[37]. In the US, although 67% of dog owners and 41% of cat owners used services from a clinic, hospital, or house call in 2016, 27% of all pets were neither seen nor examined in routine preventive care[38]. No information is available in Ghana on the use of veterinary facilities by pet owners, but the proportion not using services is likely to be higher.

There was a significant decrease in the number of patients visiting the facility once during the study period, but the number of patients visiting twice a year increased significantly. No significant differences were seen in the numbers visiting three or four times a year. There was no correlation between the type of species and the number of visits.

4.3. Complaints of pet owners

A wide range of complaints were reported, reflecting the diverse nature of the cases. Among these, a complex of symptoms consisting of anorexia, diarrhea, vomiting, or a combination of these symptoms, accounted for the highest proportion (27%) of the recorded complaints. This finding is consistent with a study conducted in the UK, where inappetence/anorexia, vomiting, and diarrhea combined contributed to 20% of the presenting problems in small animal consultations between April 2011 and June 2012[39]. The most commonly presented species in the current study were dogs, accounting for 95% of the cases, followed by cats (4%) and goats (0.6%).

4.4. Prescription diversity and indicators

In the current study, the antimicrobial prescription proportion was found to be approximately 61% on average. This rate was higher than the 53% reported in a municipal clinic at Kintampo, Ghana[17], but much higher than the 6.5% reported for an emergency outpatient population in the US[40].

The prescription diversity value of 0.82 in this study suggested a high level of various antimicrobials use in the facility. This was, however, lower than the figures for dogs (0.92 in 2017 and 0.93 in 2018) and for cats (0.89 in 2017 and 0.88 in 2018) in Germany[21]. In Britain, dogs had the highest antibiotic prescription diversity, followed by cats and rabbits[22]. There was no correlation between antibiotic prescription diversity in dogs and cats and the frequency of visits that resulted in an antibiotic prescription. In the UK, 25% of dogs and 21% of cats seen in veterinary practices received at least one antimicrobial over 2 years (2012-2014), and 42% of these animals were given repeated dosages of antimicrobials[41]. In this study, the proportions for the number of antimicrobials received by patients were 65% for 1 antimicrobial, 24% for 2 antimicrobials, and 10% for 3 antimicrobials. The correlation between the number of antimicrobials given and the frequency of visits (Pearson coefficient of -0.042) and between the number of antimicrobials given and the type of species (Pearson coefficient of -0.040) were significant but negative.

The common indicators for the prescription of antibiotics in small animal and equine practices in Minnesota and North Dakota in the US were skin conditions (24.4%), otitis (22.2%), eye (9.4%), gastrointestinal (8.3%), respiratory (8.3%) and urinary tract (7.6%)[42], while those in a small animal veterinary teaching hospital in Minnesota from November 2018 to October 2019 were for skin, respiratory, gastrointestinal, perioperative, aural and urinary conditions[43]. In the current study, the corresponding proportions in the animals treated were skin conditions (22.4%), otitis (1.8%), eye (1.6%), gastrointestinal (33.8%, including parvovirus and helminthiasis), respiratory (1.8%), urinary tract (1.1%), general infections (7.8%) and surgical cover (4.0%). In Cameroon, antimicrobials were used in dogs mostly for gastrointestinal disorders (31.9%) and skin diseases (24.1%), with use in cats primarily for surgical problems (29.8%), musculoskeletal diseases (20.4%), and gastrointestinal tract diseases (1.6%)[12].

4.5. Characterization of antimicrobial drug prescriptions

Antimicrobials have been used in companion animals to treat skin, wound, respiratory, and urinary tract infections and reduce the frequency of sepsis and infections at surgical sites[44]. In the present study, antimicrobials were used as a supportive treatment for anorexia (10.6%), infections (7.8%), wounds and sores (6.6%), skin lesions (6.5%), and parvovirus (6.3%). In 6.6% of the cases, the condition for which antimicrobial was used was not stated, raising concerns about judicious and appropriate use. In Nigeria, antimicrobials were used to treat non-bacterial pathogens, such as viral, helminth, and fungal pathogens, by almost 60% of veterinarian and para-veterinarian respondents[5]. A similar situation was seen in the current study, which suggested using supportive treatment in these situations. Antimicrobials have commonly been used in the clinical management of viral cases, in surgery to prevent infections of surgical wounds, and in many other situations as a treatment for possible secondary infections[45,46].

Among the factors influencing decisions on AMU by veterinarians were training, published literature, written guidelines, personal experience or anecdotal practices, and the type of veterinary practice[47,48]. In Cameroon, the bases for prescribing antimicrobials were clinical diagnosis (symptom-based), ease of drug administration, owners' purchasing power, and antibiogram[12]. Antimicrobial prescription is also influenced by drivers, such as the owner's compliance with treatment protocols, cost of susceptibility tests, clinical conditions of animals, the efficacy of antimicrobials, and means/routes of administration[49-51]. Efficacy was the main driver of

prescription in this study, similar to what was reported in Portugal[19]. In the current study, respondents said the prescription decisions of veterinarians were driven by the efficacy of available antimicrobials (100%, n=20), the animal's clinical condition (100%), knowledge and experience of the clinician with antimicrobial (100%), means or route of antimicrobial administration (95%), and owner's ability to comply with directions given (90%). About 70% of the respondents noted that the cost of antimicrobial susceptibility tests would affect their prescription decision.

In this study, efficacy was found to have the highest score of 4.1, followed by availability on the market, administration route, ease of acquisition, administration frequency, and ease of administration, with the price scoring the lowest at 3. The availability of antimicrobials is largely influenced by market forces. It has been observed that in a free-market environment, products with high turnover are prioritized for marketing, often at the expense of more effective options[52]. Importers of veterinary drugs may prioritize profitability over efficacy, resulting in limited choices for veterinarians. One survey respondent in this study commented on the limited range of antimicrobial agents available on the market, which leads to the inevitable overuse of the few available options. Access to veterinary drugs in Sub-Saharan Africa faces various barriers, including a fragmented market and weak distribution infrastructure. Additionally, the involvement of numerous private non-professional actors in the veterinary drug supply chain further complicates the situation[53].

No guidelines were available for prescribing and using antimicrobials in the facility, similar to other reports in Ghana[54,55]. One of the respondents in this study highlighted the need for an antibiotic prescription guidance protocol to promote the prudent and judicious use of antibiotics. It has been observed that the national drug policy in Ghana lacks sufficient provisions for controlling AMU in animal health[54,55].

Similar to earlier reports[17], some of the gaps in the documentation revealed in this study included failure to record diagnosis, antibiotic dosage, and route of administration, as noted in other developing countries[56,57]. Lack of adequate training in recording data on AMU in animal health as specified by WOAH protocols may be a contributing factor[10]. The availability of regular and comprehensive data on AMU in animal health could lead to improvement in prescribing practices[17]. There is a higher likelihood that AMU in companion animals is more liberal and not as strictly regulated as in farm animals, and also, AMU is often driven by pet owners' sentimental and emotional attachment to their pets' needs[58].

The lack of bacterial culture or sensitivity testing facilities in certain clinics, as observed in Abia, Nigeria and confirmed in this study, contributes to the prescription of antimicrobials without proper diagnostic confirmation[13]. A similar situation was seen in this study. Respondents in the study acknowledged this limitation, noting that antimicrobial use was not based on culture and sensitivity tests. One respondent expressed the desire to conduct antimicrobial susceptibility tests for all cases that required antimicrobials, but the lack of resources and time constraints made it challenging. Unfortunately, most of the cases are presented at the end stage (where the patient is almost dying). In such situations, they relied on their experience and complete blood count results to initiate treatment. Two factors come into play here, the ability of the client to afford it and the availability of a facility to run susceptibility tests. A respondent highlighted that the ability to rapidly diagnose microbial pathogens and obtain timely results for antimicrobial sensitivity testing would greatly enhance the responsible use of antimicrobials.

In Cameroon, bacterial susceptibility test before the antimicrobial prescription was not common[12]. Clinicians prescribed antimicrobials more often based on clinical signs and history of the disease and gave antimicrobial without prior confirmatory diagnosis and bacterial susceptibility tests[12]. In Belgium and Chile, only 12.7% and 15% of veterinarians did laboratory diagnostic tests before prescribing antimicrobials, respectively[59,60]. The lack of nearby laboratories for susceptibility tests was cited as a key reason by respondents in this study for not performing such tests. Furthermore, a respondent in this study indicated that most animal patients were presented at the end stage, almost dying, necessitating using one's experience to initiate treatment rather than waiting for antimicrobial susceptibility test results. Among the reasons given for not doing susceptibility tests before treatment in Portugal was the use of the empirical approach, which did not justify requesting a susceptibility test (41%). Moreover, the urgency of the patient's condition requiring urgent treatment (31%), clinical situations related to specific systems or diseases, and the unavailability of nearby laboratories to perform tests within a reasonable timeframe were reported as other reasons[19]. In Nsukka, Nigeria, antimicrobials were used in 88% of cases without a definitive diagnosis using an antibiotic sensitivity test since bacterial culture and identification took a long time and clinicians and owners of animals could not wait for days before beginning treatment[29]. It has been said that among the factors responsible for veterinarians not relying on laboratory tests for diagnosis are the unavailability of veterinary laboratories and the high costs of services[61]. In Ethiopia, about 97%[15] and 98%[62] of clinicians reportedly used antibiotics before definitive diagnosis in veterinary hospitals. The various reasons given above may explain the similar findings in the present study. A recommendation has been made for heightened awareness of health professionals of the dangers inherent in the irrational use of antimicrobials through the tendency to prescribe and start AMU before a definitive diagnosis is made[63].

4.6. Antimicrobial groups and classes administered or prescribed

In the US, aminopenicillins, nitroimidazoles, and fluoroquinolones were the most frequently prescribed antimicrobial classes[40]. The study found the penicillin

(34%), tetracyclines (26.4%), and sulphonamides (18.9%) as the top three groups. Together with the nitroimidazoles, these constituted about 90% of the antimicrobials used in the present study. Tetracyclines were the most commonly prescribed antibiotic class (99.6%) in a municipal veterinary clinic at Kintampo in Ghana that commonly treated dogs (71.9%) and other species[17]. In Nigeria, the antimicrobials used in dogs in Abia were amoxicillin (45%), gentamox (gentamicin and amoxicillin combination; 20%), tylosin (15%), oxytetracycline (13%), and vancomycin (7%) [13]. In Nsukka, Nigeria, where dogs formed about 84% of species treated from 2013 to 2017, the most frequently used antibiotics were penicillin-streptomycin (36.5%), oxytetracycline (32%), gentamycin (19.8%), sulphadimidine (5%), ceftriaxone (3.5%), doxycycline (2.5%), amoxicillin-clavulanate combination (1%), enrofloxacin (0.5%), amoxicillin (0.4%), neomycin (0.4%) and tylosin (0.4)[29]. The frequency ceftriaxone, oxytetracycline, and sulphadimidine use rose significantly, while that of the penicillin-streptomycin combination decreased significantly[29]. In Cote d'Ivoire, sulphonamides, tetracyclines, and beta-lactams were the most used families[64]. Antibiotics used for the treatment of pets formed a very small proportion (0.2%), with larger proportions used in livestock (84.6%) and livestock and pets (15.1%). In Cameroon, the most prescribed antimicrobials were sulfamethoxypyridazine-trimethoprim (31.2% in dogs; 28.6% in cats), benzylpenicillin-streptomycin (19.0% in dogs; 21.9% in cats) and marbofloxacin (18.3% in dogs; 16.1% in cats)[12]. Furthermore, antimicrobials in the highly important category were prescribed for 64.6% of dog and 77.9% of cat treatments. In comparison, antimicrobials in the critically important classes of antimicrobials were used for 34.9% of dogs and 22.1% of cat cases[12]. In Minnesota, common drug classes used in dogs were potentiated penicillins (28.7%), first-generation cephalosporins (22.1%), and nitroimidazoles (14.7%), with cats receiving potentiated penicillins (26.9%), fluoroquinolones (13.5%), and penicillins (11.5%)[43]. The dominance of was not different among penicillin-type, tetracyclines, sulphonamides, and nitroimidazoles.

Tetracyclines have been classified among the highly important antimicrobials in human medicine, requiring strict monitoring of their use in animals[65]. The finding of a high frequency of their use in this and other studies in Ghana should be of concern[17,66].

4.7. Routes and dosages of antimicrobial administered

In the current study, the most common route of administration was parenteral/injection (IM, intravenous, and subcutaneous, 82.7%), followed by oral (3.6%), and topical (including eye and ears, 2.0%). In a study at Kintampo, Ghana, injection (54.1%) was the most common route, followed by dermal application (37.6%) and oral (8.2%)[17]. The route of administration and antibiotic dosage was not documented in 68.9% and 37.7% of cases, respectively, in Kintampo[17]. In the present study, these proportions were 29.7% and 8.1%, respectively. The incompleteness findings in the documentation of diagnosis, antimicrobial dosage, and route of administration were similar to those reported in humans[67] and animals[17,56,57]. This could be attributed to the absence of or poor training in structured systems of recording data on AMU in veterinary medicine as per OIE protocols designed to monitor factors influencing AMR patterns[10,68].

4.8. Perception Survey results

The results from the perception study showed that all respondents could be classified as empirical-oriented[19] because their antimicrobial prescription was based on animals' clinical signs and their own experience. However, when asked if they referred to a guidance protocol to assist in the prescription decision process, 55% provided a negative response. Moreover, 95% said they were unaware of any AMU protocol in the facility. There was no officially available protocol in the facility, but one respondent referred to a guidance protocol obtained from his/her source for personal use. When asked if they would use a protocol, 90% of the respondents replied in the affirmative, while 10% said "Maybe". In Portugal, 82% of respondents said there was no guidance protocol for the prudent prescription of antimicrobials in the workplace, and they were unaware of any such protocol[19]. In Cameroon, 7 out of 16 veterinarians said they owned prescription guidelines[12]. The factors that influenced antimicrobial prescription were clinical signs for diagnosis (14/16), ease of administration (8/16), clients' purchasing power (6/16) and use of antibiogram (4/16).

Empirical prescription is associated with the frequent use of broad-spectrum antibiotics, such as amoxicillin-clavulanate combinations and fluoroquinolones in the US [49] with the efficacy of the antimicrobial[69]. Empirical prescription was the most common method among veterinarians in many countries without strict adherence to rules governing AMU[59,70,71]. A similar finding was evident in the present study.

4.9. Other information

Alcantara et al.[19] argued that knowing veterinarians' attitudes and the drivers of antimicrobial prescription will help develop antimicrobial training and stewardship programs to address content and delivery issues targeted at veterinarians. Antimicrobial stewardship refers to to a range of coordinated strategies aimed at enhancing the appropriate use of antibiotics and reducing the negative consequences associated with their use, such as resistance, toxicity, and costs by promoting the selection of optimal antibiotic regimens, dose, duration, and route of administration[72]. The importance of antimicrobial stewardship is based on its potential to optimize the use of antimicrobials for the effective treatment of infections, protection of patients from the harmful effects of improper and unnecessary use of antimicrobials, and stem the increase in AMR[73].

Self-medication was practiced by some clients in this study who treated their animals and only went to the hospital after treatment failure. For example, a client had been given ciprofloxacin and levofloxacin at home for some period before reporting to the hospital with the dogs. The full extent of such practice is unknown but is likely to lead to antimicrobial treatment failure with subsequent AMR. All the antibiotics used in veterinary medicine for animals are similar to or closely related to antimicrobials used in human medicine or could induce cross-resistance[74]. Existing guidelines emphasize the importance of using antimicrobials based on accurate diagnosis. Antibiotics should be selected with a narrow antibacterial spectrum whenever possible and should possess good tissue penetration capabilities. Furthermore, antimicrobials should be used as a last resort. It is crucial to strictly adhere to the recommended instructions provided on the medication labels, avoiding underdosing or extending dosing intervals unnecessarily. These guidelines aim to optimize the effectiveness of antimicrobial therapy while minimizing the risks associated with their use[74,75]. Objective data to guide small animal clinicians about the prudent and rational use of antimicrobials is missing or little, and it is challenging to apply the general policies set out by national and international organizations for use in clinical settings[76]. More research to generate data is necessary.

A major limitation of this study was aggregating records from September 2015 to December 2017. The records during that period were based on pet names, making sorting by years of attendance difficult. However, from 2018 the records were available as distinct entities on a year-to-year basis. Another limitation was knowing the exact diagnoses of medical conditions for which antimicrobials were used since data was insufficient. To minimize this, the complaints recorded in case files were used, as well as diagnoses arrived at by clinicians, which in most cases were not documented. The study also could not evaluate whether the dosages were accurate because some were given in different dimensions (ml per kg, mg per kg, ml), making the conversions bothersome. In addition, the weights of the animals were not always documented.

5. Conclusion

The study found that AMU in pets in a small animal veterinary facility in Accra, Ghana increased significantly from 2015 to 2021. Dogs were the major species treated in the hospital over that period. The antimicrobial prescription proportion was high (about 61%). There was high prescription diversity. The most common indicator for using antimicrobials was a complex of signs and symptoms made up of anorexia, vomiting, and diarrhea. The antimicrobial groups most used were the penicillin-type, tetracyclines, sulphonamides, and nitroimidazole. The intramuscular route was the most common. Most of the veterinarians from the hospital interviewed were not aware of any prescription guidance protocol in the hospital.

This study has presented information contributing to one of the objectives of the Veterinary Services Directorate to furnish baseline data on antimicrobial use in animals. More studies on AMU in small animals in other clinics/hospitals in Ghana would be useful to help in controlling AMU in the country.

Declarations

Competing interest

The author declares no competing interests.

Authors' Contribution

The author was responsible for all aspects of the paper.

Funding

No funding was received for the study design, collection, analysis, and interpretation of data.

Availability of data and materials

The author declares that there are no relationships and activities that might bias or be seen to bias their work.

Acknowledgments

I thank the staff of the veterinary clinical facility for the generation of and access to available patient records for the period reviewed. Statistical analyses were supported by Dr. R Ayizanga, University of Ghana, for which I am very grateful.

References

1. Beyene T, and Tesega B. Rational veterinary drug use: Its significance in public health. J Vet Med Anim Health. 2014; 6(12): 302-308. DOI: 10.5897/JVMAH2014.0332
2. Qasemi A, Bayat Z, Akbari N, and Babazadeh D. Bacterial resistance of Acinetobacter baumannii: A global concern. Res Biotechnol Environ Sci. 2022; 1(2): 36-42. DOI: 10.58803/rbes.v1i2.7
3. Waller DG, and Sampson AP. Chemotherapy of infections. In: Waller DG, Sampson AP, editors. Medical pharmacology and therapeutics. 5th ed. Netherlands, Amsterdam: Elsevier; 2018; p. 581-629. DOI: 10.1016/B978-0-7020-7167-6.00051-8
4. Aslam B, Wang W, Arshad MI, Khurshid M, Muzammil S, Rasool MH, et al. Antibiotic resistance: A rundown of a global crisis. Infect Drug Resist. 2018; 11: 1645-1658. DOI: 10.2147/IDR.S173867
5. Ogwuche A, Ekiri AB, Endacott I, Maikai BV, Idoga ES, Alafiatayo R, et al. Antibiotic use practices of veterinarians and para-veterinarians and the implications for antibiotic stewardship in Nigeria. J S Afr Vet Assoc. 2021; 92(0): e1-e14. DOI: 10.4102/jsava.v92i0.2120
6. Gautam CS, and Aditya S. Irrational drug combinations: Need to sensitize undergraduates. Indian J Pharmacol. 2006; 36(3): 169-170. DOI: 10.4103/0253-7613.25802
7. Bbosa GS, and Mwebaza N. Global irrational antibiotics/antibacterial drugs use: Current and future health consequences. Microbiology. 2013; 3(4): 1645-1655.
8. Tanwar J, Das S, Fatima Z, and Hameed S. Multidrug resistance: An emerging crisis. Interdiscip Perspect Infect Dis. 2014; 2014: 541340. DOI: 10.1155/2014/541340
9. Guardabassi L, Schwarz S, and Lloyd DH. Pet animals as reservoirs of antimicrobial-resistant bacteria. J Antimicrob Chemoth. 2005; 54(2):

321-332. DOI: 10.1093/jac/dkh332
10. Dehaumont P. OIE international standards on antimicrobial resistance. J Vet Med B Infect Dis Vet Public Health. 2004; 51(8-9): 411-414. DOI: 10.1111/j.1439-0450.2004.00784.x
11. Wayne A, MacCarthy R, and Lindenmayer J. Therapeutic antibiotic use patterns in dogs: Observations from a veterinary teaching hospital. J Small Anim Pract. 2011; 52(6): 310-318. DOI: 10.1111/j.1748-5827.2011.01072.x
12. Mouiche MMM, Mpouam SE, Moffo F, Nkassa CM, Mbah CK, Mapiefou NP, et al. Prescription pattern of antimicrobial use in small animal veterinary practice in Cameroon. Top Companion Anim Med. 2021; 44: 100540. DOI: 10.1016/j.tcam.2021.100540
13. Nwiyi PO. Choice and pattern of therapeutic antimicrobials in companion animals (dogs, cats and birds) in Afia, Abia State, Nigeria. Online J Anim Feed Res. 2014; 4(2): 29-31. Available at: https://www.ojafr.ir/main/attachments/article/102/Online%20J.%20Anim.%20Feed%20Res.,%204(2)%2029-31.pdf
14. Ismaila MS, Thomas-Rhoden A, Neptune A, Sookram K, Gopaul S, Padarath T, et al. A survey on the rationale usage of antimicrobial agents in small animal clinic and farms in Trinidad and Jamaica. Antibiotics. 2022; 11(7): 885. DOI: 10.3390/antibiotics11070885
15. Beyene T, Assefa S, Ayana D, Jibat T, Tadesse F, and Beyi AF. Assessment of rational veterinary drugs use in livestock at Adama District Veterinary Clinic, Central Ethiopia. J Vet Sci Technol. 2015; 7(3): 1000319. DOI: 10.4172/2157-7579.1000319
16. Akpan MR, Isemin NU, Udoh AE, and Ashiru-Oredope D. Implementation of antimicrobial stewardship programmes in African countries: A systematic literature review. J Glob Antimicrob Resist. 2020; 22: 317-324. DOI: 10.1016/j.jgar.2020.03.009
17. Adeapena W, Afari-Asiedu S, Najjemba R, Griensven Jv, Delamou A, Ohene Buabeng K, et al. Antibiotic use in a municipal veterinary clinic in Ghana. Trop Med Infect Dis. 2021; 6(3): 138. DOI: 10.3390/tropicalmed6030138
18. Landis JR, and Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33: 159-174. DOI: 10.2307/2529310
19. Alcantara GLC, Pinello KC, Severo M, and Niza-Ribeiro J. Antimicrobial resistance in companion animals – Veterinarians' attitudes and prescription drivers in Portugal. Comp Immunol Microbiol Infect Dis. 2021; 76: 101640. DOI: 10.1016/j.cimid.2021.101640
20. Singleton DA, Sanchez-Vizcario F, Dawson S, Jones PH, Noble PJM, Pinchbeck GL, et al. Patterns of antimicrobial agent prescription in a sentinel population of canine and feline veterinary practices in the United Kingdom. Vet J. 2017; 224: 18-24. DOI: 10.1016/j.tvjl.2017.03.010
21. Schnepf A, Kramer S, Wagels R, Volk HA, and Kreienbrock L. Evaluation of antimicrobial usage in dogs and cats at a veterinary teaching hospital in Germany in 2017 and 2018. Front Vet Sci. 2021; 8: 689018. DOI: 10.3389/fvets.2021.689018
22. Rogers O. The importance of data sharing for veterinarians. 2018. Available at: https://faunalytics.org/the-importance-of-data-sharing-for-veterinarians/#
23. Turkson PK. Use of drugs and antibiotics in poultry production in Ghana. Ghana J Agric Sci. 2008; 41: 23-33. DOI: 10.4314/gjas.v41i1.46142
24. Donkor ES, Newman J, and Yeboah-Manu D. Epidemiological aspects of non-human antibiotic usage and resistance: Implications for the control of antibiotic resistance in Ghana. Trop Med Int Health. 2012; 17(4): 462-468. DOI: 10.1111/j.1365-3156.2012.02955.x
25. Boamah VE, Agyare C, Odoi H, and Daalsgard A. Practices and factors influencing the use of antibiotics in selected poultry farms in Ghana. J Antimicrob Agents. 2016; 2: 1000120. DOI: 10.4172/2471-1212.1000120
26. Johnson S, Bugyei K, Nortey P, and Tasiame W. Antimicrobial drug usage and poultry production: Case study in Ghana. Anim Prod Sci. 2017; 59(1): 177-182. DOI: 10.1071/AN16832
27. Caudell MA, Dorado-Garcia A, Eckford S, Creese C, Byarugaba DK, Afakye K, et al. Towards a bottom-up understanding of antimicrobial use and resistance on the farm: A knowledge, attitudes and practices survey across livestock systems in five African countries. PLoS ONE. 2020; 15(91): e0220274. DOI: 10.1371/journal,pone.0220274
28. Nkansa M, Agbekpornu H, Kikimoto BB, and Chandler CIR. Antibiotic use among poultry farmers in the Dormaa Municipality, Ghana. Report for fleming fund fellowship programme. Project report. London School of Hygiene & Tropical Medicine. 2020. DOI: 10.17037/PUBS.04658868
29. Ihedioha TE, Asuzu IU, and Nwanta JE. Trends in the clinical use of antibiotics in a veterinary hospital in Nigeria, 2013-2017. Thai J Vet Med. 2020; 50(4): 487-494. Available at: https://digital.car.chula.ac.th/tjvm/vol50/iss4/6?utm_source=digital.car.chula.ac.th%2Ftjvm%2Fvol50%2Fiss4%2F6&utm_medium=PDF&utm_campaign=PDFCoverPages
30. Ebbo AA, Agaie MB, Adamu U, Deneji AI, and Garba HS. Retrospective analysis of cases presented to the veterinary teaching hospital, Usmanu Danfodiyo University Sokoto (1993 - 2002). Niger Vet J. 2003; 24(3): 133-136.
31. Garba A, Ahmed A, Ambursa AU, Faruk A, Kalgo KS, Garba GJ, et al. Frequently encountered animal diseases at Animal Hospital Birnin Kebbi, Kebbi State, Nigeria. Niger Vet J. 2011; 32(1): 49-53. DOI: 10.4314/nvj.v32i1.68994
32. Shima KF, Tion TM, Mosugu IJ, and Apaa TT. Retrospective study of disease incidence and other clinical conditions diagnosed in owned dogs in Delta State, Nigeria. J Adv Vet Anim Res. 2015; 2(4): 435-449. DOI: 10.5455/javar.2015.b115
33. Smith SI, Kwaga JKP, Ngulukun SS, Adedeji A, Jolaiya TF, Ajayi A, et al. Antibiotic prescription practices amongst veterinarians in Nigeria. Res Vet Sci. 2022; 152: 219-227. DOI: 10.1016/j.rvsc.2022.07.028
34. Sarker YA, Miah AH, Sharif N, Himel MH, Islam S, Ray RC, et al. A retrospective study of common diseases at veterinary teaching hospital, Bangladesh Agricultural University, Mymensingh. Bangl J Vet Med. 2015; 13(2): 55-61. DOI: 10.3329/bjvm.v13i2.26629
35. Chipangura JK, Eagar H, Kgoete M, Abernethy D, and Vinny Naidoo V. An investigation of antimicrobial usage patterns by small animal veterinarians in South Africa. Prev Vet Med. 2017; 136: 29-38. DOI: 10.1016/j.prevetmed.2016.11.017
36. Islam O, Khatun S, Azad SAK, Famous M, and Uddin MM. Prevalence of different diseases of dogs recorded at Central Hospital, Dhaka, Bangladesh. Res J Vet Pract. 2019; 7(9): 53-57. DOI: 10.17582/journal.rjvp/2019/7.2.53.57
37. Baker T, Rock M, Bondo K, van der Meer F, and Kutz S. 11 Years of regular access to subsidized veterinary services is associated with improved dog health and welfare in remote northern communities. Prev Vet Med. 2021; 196: 105471 DOI: 10.1016/j.prevetmed.2021.105471
38. American veterinary medical association (AVMA). Pet ownership and demographic source book. 2018. Available at: https://www.avma.org/sites/default/files/resources/AVMA-Pet-Demographics-Executive-Summary.pdf
39. Robinson RJ, Dean RS, Cobb MJ, and Brennan ML. Investigating common clinical presentations in first opinion consultations using direct observation. Vet Rec. 2015; 176(18): 463. DOI: 10.1136/VR.102751
40. Robbins SN, Goggs R, Lhermie G, Lalonde-Paul DF, and Manard J. Antimicrobial prescribing practies in small animal emergency and critical care. Front Vet Sci. 2020; 7: 110. DOI: 10.3389/fvets.2020.00110
41. Buckland EL, Neill DO, Summers J, Mateus A, Church D, Redmond L, et al. Characterisation of antimicrobial usage in cats and dogs attending UK primary care companion animal veterinary practices. Vet Rec. 2016; 179(19): 489. DOI: 10.1371/journal,pone.0220274
42. Bollig ER, Granick J, Webb TL, Ward C, and Beaudoin AL. A quarterly survey of antibiotic prescribing in small animal and equine practices – Minnesota and North Dakota, 2020. Zoonoses Public Health. 2022; 69(7): 864-874. DOI: 10.1111/zph.12979
43. Hsieh ES, Bollig ER, Beaudoin AL, Morrow A, and Granick JL. Serial point-prevalence surveys to estimate antibiotic use in a small animal veterinary teaching hospital, November 2018 to October 2019. J Vet Intern Med. 2022; 36(1): 244-252. DOI: 10.1111/jvim.16314
44. Vasseur P, Levy J, Dowd E, and Eliot J. Surgical wound infection rates in dogs and cats' data from a teaching hospital. Vet Surg. 1988; 17(2): 60-64. DOI: 10.1111/j.1532-950X.1988.tb00278.x
45. Beading C, and Slifka MK. How do viral infections predispose patients to bacterial infections?. Curr Opin Infect Dis. 2004; 17(3): 185-191. DOI: 10.1097/00001432-200406000-00003
46. Hendaus MA, Johma FA, and Alhammadi AH. Virus-induced secondary bacterial infection: A concise review. Ther Clin Risk Manag. 2015; 11: 1265-1271. DOI: 10.2147/TCRM.S87789
47. De Briyne ND, Atkinson J, Pokludová L, Borriello SP, and Price S. Factors influencing antibiotic prescribing habits and use of sensitivity

testing amongst veterinarians in Europe. Vet Rec. 2013; 173(19): 475-475. DOI: 10.1136/vr.101454
48. Norris JM, Zhuo A, Govendir M, Rowbotham SJ, Labbate M, Degeling C, et al. Factors influencing the behaviour and perceptions of Australian veterinarians towards antibiotic use and antimicrobial resistance. PLoS One. 2019; 14(10): e0223534. DOI: 10.1371/journal.pone.0223534
49. Fowler HDM, Perkins A, Trufan S, Joy C, Buswell M, McElwain T, et al. Survey of antimicrobial prescribing practices, Washington State 2015. Vet Rec. 2016; 179(25): 651. DOI: 10.1136/vr.103916
50. Herdefeldt L, Billman-Jacobe H, Stevenson M, Thursky K, Bail K, and Browning G. Barriers to and enablers of implementing antimicrobial stewardship programs in veterinary practices. J Vet Internal Med. 2018; 32(3): 1092-1099. DOI: 10.1111/jvim.15083
51. Mateus ABD, Brodbelt DC, Barber N, and Stark KDC. Qualitative study of factors associated with antimicrobial usage in seven small animal veterinary practices in the UK. Prev Vet Med. 2014; 117(1): 68-78. DOI: 10.1016/j.prevetmed.2014.05.007
52. Turkson PK. Implications of the liberalization of veterinary drug marketing in Ghana. Trop Anim Health Prod. 2001; 32: 43-47. DOI: 10.1023/A:1010381426475
53. Jaime G, Hobeika A, and Figuie M. Access to veterinary drugs in sub-Saharan Africa: Roadblocks and current solutions. Front Vet Sci. 2022; 8: 558973. DOI: 10.3389/fvets.2021.558973
54. Kamwanja LA, Sake J, Awotedu A, Fute I, and Ndomondo-Sigonda M. Situation analysis study on medicines registration harmonisation in Africa. Final report for the economic community of West African States (ECOWAS). Midrand, South Africa: African union development agency (AUDA-NEPAD); 2011.
55. Yevutsey SK, Buabeng KO, Aikins M, Anto BP, Biritwum RB, Frimodt-Møller N, et al. Situational analysis of antibiotic use and resistance in Ghana: Policy and regulation. BMC Public Health. 2017; 17(1): 896. DOI: 10.1186/s12889-017-4910-7
56. Landers TF, Cohen B, Wittum TE, and Larson EL. A review of antibiotic use in food animals: Perspective, policy, and potential. Public Health Rep. 2012; 127(1): 4-22. DOI: 10.1177/003335491212700103
57. van Boeckel TP, Pires J, Silvester R, Zhao C, Song J, Criscuolo NG, et al. Global trends in antimicrobial resistance in animals in low- and middle-income countries. Science. 2019; 365(6459): eaaw1944. DOI: 10.1126/science.aaw1944
58. Rantala M, Houvinen P, Holso K, Lillas A, and Kaartinen L. Survey of condition-based prescribing of antimicrobial drugs for dogs at a veterinary teaching hospital. Vet Rec. 2004; 155(9): 259-262. DOI: 10.1136/VR.155.9.259
59. van Cleven A, Sarrazin S, de Rooster H, Paepe D, van der Meeren S, and Dewulf J. Antimicrobial prescribing behaviour in dogs and cats by Belgian veterinarians. Vet Rec. 2018; 182(11): 324. DOI: 10.1136/vr.104316
60. Galarce N, Arriagada G, Sanchez F, Venegas V, Cornejo J, and Lapierre L. Antimicrobial use in companion animals: Assessing veterinarians' prescription patterns through the first national survey in Chile. Animals. 2021; 11(2): 348. DOI: 10.3390/ani11020348
61. Adekanye U, Ekiri AB, Galipo E, Muhammad AB, Mateus A, La Ragione RM, et al. Knowledge, attitudes and practices of veterinarians towards antimicrobial resistance and stewardship in Nigeria. Antibiotics. 2020; 9(8): 453. DOI: 10.3390/antibiotics9080453
62. Mojo G, Fentahun S, and Bihonegn T. Assessment of rational use of veterinary drugs in Modjo veterinary clinic, Ethiopia. J Anim Res. 2019; 9(5): 667-673. DOI: 10.30954/2277.940X.05.2019.6
63. Federal ministries of agriculture, environment and health (FMAEH). Antimicrobial use and resistance in Nigeria: Situation analysis and recommendations. Abuja, Nigeria: 2017. p. 80-82.
64. Kaba S, Konan BA, Atto V, and Datte JY. Monitoring of the use of veterinary medicines containing antibiotics in Côte d'Ivoire in 2013. J Vet Med Animal Sci. 2020; 3(1): 1033. Available at: https://meddocsonline.org/journal-of-veterinary-medicine-and-animal-sciences/monitoring-of-the-use-of-veterinary-medicines-containing-antibiotics-in-2013.pdf
65. Meseko C, Makanju O, Ehizibolo D, and Muraina I. Veterinary pharmaceuticals and antimicrobial resistance in developing countries. In: Eds S, Bekoe K, Saravanan M, Adosraku RK, Ramkumar PK, editors. Veterinary medicine and pharmaceuticals. Rijeka: IntechOpen; 2019. DOI: 10.5772/intechopen.84888
66. Newman MJ, Frimpong E, Donkor ES, Opintan JA, and Asamoah-Adu A. Resistance to antimicrobial drugs in Ghana. Infect Drug Resist. 2011; 4: 215-220. Available at: https://www.tandfonline.com/doi/full/10.2147/IDR.S21769
67. Søndergaard SF, Lorentzen V, Sørensen EE, and Frederiksen K. The documentation practice of perioperative nurses: A literature review. J Clin Nurs. 2017; 26: 1757-1769. DOI: 10.1111/jocn.13445
68. American association for the advancement of science (AAAS). Veterinary clinical record keeping guidelines., Washington DC, USA: American Association for the Advancement of Science; 2018. p. 3.
69. Escher M, Vanni M, Intore I, Caprioli A, Tognetti R, and Scavia G. Use of antimicrobials in companion animal practice: A retrospective study in a veterinary teaching hospital in Italy. J Antimicrob Chemother. 2011; 66(4): 920-927. DOI: 10.1093/jac/dkq543
70. European medicines agency. Reflection paper on the risk of antimicrobial resistance transfer from companion animals. p. 1-25. Available at: https://www.ema.europa.eu/en/documents/scientific-guideline/reflection-paper-risk-antimicrobial-resistance-transfer-companion-animals_en.pdf
71. Gomez-Poveda BM, and Moreno MA. Antimicrobial prescriptions for dogs in the capital of Spain. Front Vet Sci. 2018; 5: 309. DOI: 10.3389/fvets.2018.00309
72. Mackenzie D, Rawlings M, and Mar CD. Antimicrobial stewardship: What's it all about?. Aust Prescr. 2013; 36(4): 116-120. Available at: https://research.bond.edu.au/en/publications/antimicrobial-stewardship-whats-it-all-about
73. Centers for disease control and prevention (CDC). Core elements of antibiotic stewardship. Antibiotic prescribing and use. Available at: https://www.cdc.gov/antibiotic-use/core-elements/index.html
74. Ungemach FR, Müller-Bahrdt D, and Abraham G. Guidelines for prudent use of antimicrobials and their implications on antibiotic usage in veterinary medicine. Int J Med Microbiol. 2006; 296 (Supplement 2): 33-38. DOI: 10.1016/j.ijmm.2006.01.059
75. Salahshoori Niaei F, and Farah Taj Navab A. Effects of Valeriana officinalis and Ciprofloxacin on Kidney Histopathology in Rats Pyelonephritis by Pseudomonas aeruginosa. Res Biotechnol Environ Sci. 2022; 1(1): 23-27. DOI: 10.58803/rbes.v1i1.5
76. Weese J. Investigation of antimicrobial use and the impact of antimicrobial use guidelines in a small animal veterinary teaching hospital. J Am Vet Med Assoc. 2006; 228(4): 553-558. DOI: 10.2460/javma.228.4.553