Antimicrobial treatment preferences among veterinarians for Golden Retrievers in the United States

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OBJECTIVE
To identify the preferred choices of antimicrobials by veterinarians for addressing infectious diseases in Golden Retrievers across the US.

ANIMALS
3,044 Golden Retrievers enrolled in the Golden Retriever Lifetime Study.

METHODS
Demographic and veterinary visit data were retrieved from the Morris Animal Foundation Golden Retriever Lifetime Study, following 3,044 Golden Retrievers spanning from 2012 to 2020 collected through questionnaires. The R Studio program was used to clean and analyze the data in which the most common diagnoses were evaluated along with the most frequently used antimicrobials stratified by geographical region within the US.

RESULTS
The most common diagnoses reported and treated with antimicrobials were otitis externa, diarrhea/gastritis, hot spots, and bladder infections. Otitis externa was the most frequently reported medical diagnosis as well as prescribed with antibiotics. The Southern region reported the most antimicrobial use, followed by the Midwest and Northeast. Of the total reported antibiotics prescribed for infectious disease, aminoglycosides were the most frequent (370/1,874 [19.74%]) followed by first-generation cephalosporins, nitroimidazoles, and penicillins.

CLINICAL RELEVANCE
More effort in the prevention of otitis externa in Golden Retrievers may reduce overall antimicrobial usage and promote effective antimicrobial stewardship to combat further antimicrobial resistance.

Keywords: Golden Retrievers, treatment choice, antibiotic stewardship, diagnosis, antimicrobial

Veterinarians use professional expertise and discretion in making clinical decisions based on factors unique to each patient, client, or veterinary practice.1 Antimicrobials are powerful tools for fighting and preventing infections. However, their widespread use has resulted in an alarming increase in antimicrobial-resistant infections, and clinicians need to rely on broad-spectrum antibiotics that might be more toxic and expensive than those usually used for treatment. In a retrospective analysis,2 antimicrobial resistance (AMR) in Escherichia coli increased 3-fold to amoxicillin/clavulanate and 4-fold to third-generation cephalosporins from 1999 to 2014. Nonjudicious antimicrobial use can potentiate AMR, impacting patient safety and both public and animal health.

Most clinicians use an evidence-based approach when prescribing antimicrobials but will underutilize FDA/AVMA guidelines for judicious use of antimicrobials.3 Since antibiotics are often unnecessarily or inappropriately prescribed, a concerted effort to decrease or eliminate inappropriate use can have a large impact on patient safety and the problem of AMR.4 Proper antimicrobial use optimizes therapeutic efficacy, enhances treatment success, and minimizes resistance to antimicrobials.1 Most common and one of the leading reasons for antimicrobial use in dogs and cats is bacterial urinary tract disease.5 Although there have been studies3,6 focusing on the antimicrobial uses in dogs within small geographical areas during a limited time, there have been none that have been performed countrywide.
The Golden Retriever Lifetime Study (GRLS) is the most extensive prospective study ever undertaken in veterinary medicine, gathering information on more than 3,000 Golden Retrievers during their lives. The GRLS study provides the authors with an opportunity to find out the antimicrobials used in dog populations for various disease conditions. The authors utilized the 6 years of retrieved data to identify the common choices of antimicrobials by veterinarians for various conditions of the dogs. The unique analysis from the study can provide clinicians with evidence-based information on common antimicrobial drug usage in dogs stratified by infectious disease diagnosis and geographical region. The overall aim of the study was to identify the preferred choices of antimicrobials by veterinarians for various infectious diseases in Golden Retrievers across the US. The main objectives were to explore the antimicrobial classes that were commonly used and to evaluate the incidence of infectious diseases among Golden Retrievers in the US. The findings therefore indicated veterinarians’ preferred choices of antimicrobials for the common conditions.

Methods

Data collection

Data were provided for our study through a collaboration with the Morris Animal Foundation’s GRLS. Detailed information about data collection and the GRLS design has been previously described. Briefly, privately owned purebred Golden Retriever dogs aged 6 months to 2 years and free of life-limiting disease were recruited within the contiguous US from 2012 to 2015. Participating owners and veterinarians provided informed consent and agreed to the study requirements. Participation included annual veterinary exams, sample collection, and veterinarian- and owner-completed online questionnaires, which were completed until the death of the dog or withdrawal from the study. The Morris Animal Foundation provided us with 2 sets of data containing the demographics of patients and all reported diagnoses and medications prescribed as reported on the annual veterinarian-completed questionnaires, including medications used as treatment or prophylaxis. Demographic data reported at each visit included a unique identifier of each dog, date of birth, sex, and geographic region. The data set included all longitudinal information for 3,044 Golden Retrievers enrolled in the study and was collected from September 18, 2012, to July 17, 2020.

Data cleaning

The data set obtained on diagnosis included 18,915 reports, of which 18,850 reported a geographical region. Among the 18,915, only 8,326 reported an infectious disease diagnosis. The demographic data consisting of both diagnosis and region included 8,301 reports. The original data on medications consisted of 16,704 entries alongside the veterinary visit.

Only antimicrobial medications were initially considered in this analysis, which included antibiotics, antifungals, and antiparasitic drugs. Drug classes removed from the data set included anti-inflammatory, antihistamines, antidiarrheal, and steroid drugs. After the data were cleaned for relevant drug classes, the data set included 11,606 reports. Prescriptions of annual parasite medication (eg, heartworm, flea, and tick preventatives) were reported alongside antimicrobial drugs for a given veterinary visit alongside a single diagnosis (eg, pneumonia). Due to the way data were collected, differentiating between parasiticides administered for yearly parasite prophylaxis rather than treatment of a diagnosis was not possible. For this reason, parasiticides were removed from the analysis when looking at treatments administered for each infectious disease diagnosis, which accounted for 9,056 reports.

Using R Studio Version 1.4.1106,9 the 2 data sets were merged using 2 common data fields: the unique dog identifier and the date questionnaire was submitted. These 2 data fields allowed us to link the diagnosis reported from 1 data set with the medication prescribed on the same date in the second data set. Visits without any medications prescribed or without a match between the visit date and unique dog identifier were removed from further analysis of the medications prescribed per diagnosis. The data remaining after merging data sets and removing medications not meeting our described criteria was 2,729 reports of prescribed antimicrobial usage with a matching infectious disease diagnosis. When assessing only antibiotics, the data set included 1,874 reports.

Data analysis

Microsoft Excel and R Studio Version 1.4.1106 were utilized to clean and descriptively analyze the data sets. Our demographic analysis of the GRLS cohort involved sorting the data into geographical regions, sex, and reported age at diagnosis. Five geographical regions were recognized in our data analysis: Midwest, Mountain, Northeast, Pacific, and South. Midwest included North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, Michigan, and Ohio. Mountain included Colorado, Arizona, Nevada, Idaho, Utah, Wyoming, Montana, and New Mexico. Northeast included Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine, District of Columbia. Pacific included California, Oregon, Washington, and South included Oklahoma, Texas, Maryland, Delaware, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, Kentucky, Tennessee, South Carolina, North Carolina, West Virginia, and Virginia. Sex at diagnosis was divided into 4 categories: male neutered, male intact, female spayed, and female intact. Veterinary questionnaires were reported annually for most patients, and for this reason, the authors were unable to determine the exact age of onset for a given diagnosis and instead used reported age at diagnosis. The reported age at diagnosis was calculated by finding the difference between the date of birth and the date of the
veterinary questionnaire. The mean reported age was recorded for each diagnosis, along with SD, minimum, and maximum reported age of onset.

The frequency of reported infectious diagnoses was assessed along with accompanying demographic information. Sixty-four infectious disease diagnoses were identified, and some diagnoses combined overlapping conditions such as diarrhea, gastritis, and gastroenteritis to better reflect the frequency of infection among the population. Other combined diagnoses included bladder infections and cystitis, and cough with tracheobronchitis. Both the number of instances and the number of dogs diagnosed were reported. Instances of disease meant that the individual dogs may be counted more than once if they had received the same reported diagnosis on separate visit dates. The number of dogs diagnosed with a given condition combined different instances of the same diagnosis even if they occurred on different dates. The instances of disease were further stratified by geographic region.

Reported medications were classified by drug subtype (ie, antibiotic) and drug class (ie, penicillin). When a medication contained more than 1 drug, the medication was reported as a separate category during antimicrobial analysis. For example, several ear medications contained both an imidazole antifungal and an aminoglycoside antibiotic. However, when conducting the descriptive analysis on antibiotics, the above medication would only be considered an aminoglycoside antibiotic.

For the antibiotic analysis, medications were categorized into 15 antibiotic classes/combinations: aminoglycosides, nitroimidazoles, penicillins, first-generation cephalosporins, third-generation cephalosporins, tetracyclines, fluoroquinolones, macrolides, sulfonamides, amphenicols, aminoglycosides/polyenes/thiopепtides, potentiated sulfonamides, lincosamides, mupirocins, and aminoglycosides/fluoroquinolones. Total instances of each drug were obtained regardless of whether it matched with the diagnosis and were stratified by region. Data points were removed if they did not report the antibiotic prescribed. There was a total of 1,874 reported antibiotic prescriptions with regional data associated and 1,272 reports with an associated infectious disease diagnosis. The frequency of antibiotic prescription by class was assessed, along with regional differences and frequency among different diagnoses.

Results

Demographic analysis

The total number of enrolled Golden Retrievers in the study was 3,044 (1,504 female and 1,540 male) from 2012 to 2020, representing 18,915 instances stated in the methods. The study population ranged from 0.51 years to 10.08 years of age with a mean age of 4.05 years. The data spanned across 5 geographical regions within the US: Midwest, Mountain, Northeast, Pacific, and South. The total number of dogs diagnosed with 1 or more infectious diseases was 2,637 incorporating 8,326 individual events or instances, encompassing 64 different disease conditions. The mean age of initial diagnosis for any infectious disease was 3.74 years (range, 0.51 to 10.08). Of the 8,326 individual event reports, 35.07% were represented by female spayed, 13.64% by female intact, 32.2% by male neutered, and 19.08% by male intact. The top 5 frequently reported events were otitis externa (39.84%) representing 1,651 dogs, diarrhea/gastritis (890/8,326 [10.69%]) among 751 dogs, hot spots (624/8,326 [7.49%]) among 502 dogs, bladder infections (506/8,326 [6.08%]) among 436 dogs, and tracheobronchitis/cough (302/8,326 [3.63%]) among 294 dogs (Supplementary Material S1).

Dogs with otitis externa diagnoses (n = 1,651) had a mean age of first reported onset at 3.29 years (range, 0.53 to 10.09 years), with the majority (31.31%) represented by female spayed, followed by 31.19% male neutered, 21.68% male intact, and 15.81% female intact. The mean age of first reported onset for dogs with diarrhea and gastritis was 3.37 years (range, 0.54 to 9.06), hot spots with a mean age of onset at 3.74 years (range, 0.59 to 8.81), bladder infections with a mean age of onset at 3.78 years, and tracheobronchitis/cough with a mean age first reported onset at 3.31 years. The South region reported the highest instances of infectious disease diagnoses for otitis externa, diarrhea/gastritis, hot spots, bladder infections, and tracheobronchitis/cough. The data provided were acquired through veterinary surveys that were submitted annually, making the real age of diagnosis unable to be determined. Since the real age was challenging to analyze, mean reported age was considered instead as mentioned before. The most common diagnoses and the total number of dogs representing the diagnosis are provided (Figure 1).

Regional diagnoses

The Southern region reported the highest frequency of diagnoses (2,355/8,301 [28.37%]), followed by the Midwest (22.99%) and the Northeast (21.48%). All 5 geographical regions reported otitis externa as the most frequent diagnosis. Of the otitis externa reports (n = 3,317), the Southern region had the highest frequency (28.82%), followed by the Midwest (23.64%), Northeast (20.20%), Pacific (16.61%), and Mountain (10.55%) regions. Diarrhea/gastritis was the second most frequent diagnosis among the regions, followed by hot spots. Lyme disease was included in the top 5 diagnoses for the Northeast, accounting for 45.25% (100/223) of total cases. Identifies The top 5 most reported diagnoses for each region and the number of instances the given diagnosis was reported alongside an antibiotic treatment are provided (Table 1).

Veterinary antimicrobial usage

There were a total of 2,096 instances that included both an antimicrobial prescription and regional information. Among the 2,096 instances, the highest frequency of reported antimicrobials prescribed was found in the South (25.81%), followed by
the Midwest (24.48%), Northeast (19.85%), Mountain (11.98%), and Pacific (17.89%).

There were 1,874 total reported antibiotic prescriptions by veterinarians matched with the diagnosis instances. The top 5 most frequent antimicrobials reported were aminoglycosides (370/1,874 [19.7%]), nitroimidazoles (338/1,874 [18.04%]), penicillins (265/1,874 [14.14%]), first-generation cephalosporins (238/1,874 [12.66%]), and tetracyclines (227/1,874 [12.06%]).

Figure 1—Most common diagnoses and the total number of dogs representing the diagnosis.

Table 1—Top 5 reported diagnoses and the reported antibiotic prescriptions stratified by region (n = total number of diagnoses per region).

<table>
<thead>
<tr>
<th>Region/diagnosis</th>
<th>No. dogs diagnosed</th>
<th>No. instances diagnosed</th>
<th>No. instances treated with antibiotics</th>
<th>Top reported antibiotic treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest (n = 1,908)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otitis externa</td>
<td>406</td>
<td>784</td>
<td>132</td>
<td>Aminoglycoside, imidazole</td>
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<tr>
<td>Diarrhea/gastritis</td>
<td>178</td>
<td>200</td>
<td>21</td>
<td>Nitroimidazole</td>
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<tr>
<td>Hot spots</td>
<td>111</td>
<td>132</td>
<td>23</td>
<td>First-generation cephalosporin</td>
</tr>
<tr>
<td>Bladder infection</td>
<td>101</td>
<td>121</td>
<td>29</td>
<td>Penicillin</td>
</tr>
<tr>
<td>Tracheobronchitis (kennel cough)</td>
<td>66</td>
<td>69</td>
<td>9</td>
<td>Tetracycline</td>
</tr>
<tr>
<td>Mountain (n = 978)</td>
<td></td>
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<td></td>
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<tr>
<td>Otitis externa</td>
<td>198</td>
<td>350</td>
<td>84</td>
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<tr>
<td>Diarrhea/gastritis</td>
<td>105</td>
<td>132</td>
<td>32</td>
<td>Nitroimidazole</td>
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<tr>
<td>Bladder infection</td>
<td>60</td>
<td>68</td>
<td>22</td>
<td>Penicillin</td>
</tr>
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<td>52</td>
<td>54</td>
<td>6</td>
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<tr>
<td>Hot spots</td>
<td>37</td>
<td>45</td>
<td>11</td>
<td>First-generation cephalosporin</td>
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<tr>
<td>Northeast (n = 1,783)</td>
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<td></td>
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<tr>
<td>Otitis externa</td>
<td>331</td>
<td>670</td>
<td>87</td>
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<tr>
<td>Diarrhea/gastroenteritis</td>
<td>154</td>
<td>179</td>
<td>42</td>
<td>Nitroimidazole</td>
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<tr>
<td>Hot spots</td>
<td>110</td>
<td>145</td>
<td>21</td>
<td>Third-generation cephalosporin,</td>
</tr>
<tr>
<td>Lyme disease</td>
<td>77</td>
<td>100</td>
<td>28</td>
<td>Tetracycline</td>
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<tr>
<td>Bladder infection/cystitis</td>
<td>89</td>
<td>95</td>
<td>26</td>
<td>Penicillin</td>
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<tr>
<td>Pacific (n = 1,277)</td>
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<tr>
<td>Otitis externa</td>
<td>271</td>
<td>551</td>
<td>97</td>
<td>Aminoglycoside, imidazole</td>
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<tr>
<td>Diarrhea/gastroenteritis</td>
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<td>112</td>
<td>13</td>
<td>Nitroimidazole</td>
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<tr>
<td>Hot spots</td>
<td>84</td>
<td>112</td>
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<td>Third-generation cephalosporin</td>
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<td>Giardia</td>
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<td>57</td>
<td>14</td>
<td>Penicillin</td>
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<tr>
<td>Otitis externa</td>
<td>474</td>
<td>956</td>
<td>145</td>
<td>Aminoglycoside, imidazole</td>
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<tr>
<td>Diarrhea/gastroenteritis</td>
<td>224</td>
<td>267</td>
<td>36</td>
<td>Nitroimidazole</td>
</tr>
<tr>
<td>Hot spots</td>
<td>161</td>
<td>188</td>
<td>20</td>
<td>First-generation cephalosporin</td>
</tr>
<tr>
<td>Bladder infection/cystitis</td>
<td>132</td>
<td>161</td>
<td>37</td>
<td>Penicillin</td>
</tr>
<tr>
<td>Tracheobronchitis (kennel cough)</td>
<td>76</td>
<td>77</td>
<td>4</td>
<td>Tetracycline</td>
</tr>
</tbody>
</table>
candida, E. coli, and pseudomonas. The presence in the study largely represent antiprobiotic practices in veterinary primary care where bacterial culture and antibiotic use practices in veterinary primary care where bacterial culture and antibiotic susceptibility testing is less likely to be utilized due to cost limitations among other factors. However, the use of culture and susceptibility testing in veterinary primary care needs to be promoted for purposes of antimicrobial stewardship. A survey conducted on antimicrobial use practices of veterinary clinicians at the University of Tennessee Veterinary Medical Center in 2017 revealed 47 clinicians (75.8%) reporting results from bacteriological culture and susceptibility tests to be an extremely important factor in deciding their choice of antimicrobial. Other studies have reported similar findings where veterinarians rated bacteriologic culture and antimicrobial susceptibility among the most important factors in clinical decision-making. Clinicians’ opinions on antimicrobial use practices differed as per Ekakoro and Okafor, where the majority (61.3%) believed that antimicrobials were sometimes prescribed for suspected and not confirmed infections. Most clinicians utilize an evidence-based approach to antimicrobial use practices. Although in the present study there were no clinician opinions obtained, there were differences noted in antimicrobial practices. Therefore, there is a critical need to increase awareness about judicious AMU practices among clinicians, increase emphasis on AMR in the present veterinary curriculum, and implement an antimicrobial stewardship program. Antimicrobial use is also dependent on the availability of the drug of choice when needed. Ekakoro and Okafor indicated that the availability of antimicrobial agents is very important as a factor driving the choice of antimicrobials.

The choice of drugs in the present study differed between various geographical regions depending on the diagnoses made by the veterinarians; however, one of the limitations was that inferential statistical analysis looking at associations between potential risk factors and outcomes could not be carried out given the descriptive nature of the study. The resulting antimicrobial prescribed from the study is in part up to the veterinarian, but there may be other factors involved, such as cost and availability, that may be influenced by the owner and other sources. It is also possible that the detection of disorders in this population of Golden Retrievers was higher than in the general population since this was a population of highly motivated owners who agreed to take their dogs to the veterinarian at least once a year. However, it is impossible to evaluate the population.

In conclusion, the treatment choices of veterinarians were diverse for similar conditions within geographical regions indicative of a need for more effort in the prevention of diseases in Golden Retrievers. Preventative measures may reduce overall antimicrobial usage and promote effective antimicrobial stewardship to combat further AMR.

Diagnoses and preferred antimicrobials

The analysis matched 1,272 reported diagnoses, antimicrobial prescription reports, and regions. The top 5 most frequent diagnoses that were prescribed antimicrobials for treatment included otitis externa (42.85%), diarrhea/gastritis (11.32%), bladder infections (10.06%), hot spots (7.47%), and tracheobronchitis (4.25%).

The most frequent antibiotic classes prescribed for otitis externa were aminoglycosides (208/545 [38.16%]), diarrrhea/gastritis with nitroimidazoles (93/144 [64.58%]), bladder infections with penicillin (59/128 [46.09%]), hot spots with first-generation cephalosporins (42/9 [44.21%]), and tracheobronchitis with tetracyclines (26/95 [27.37%]). While tetracyclines were reported to be the most frequently used drug for tracheobronchitis, the antibiotic was used most frequently in the treatment of both Lyme disease (27/119 [22.69%]) and tracheobronchitis (26/119 [21.85%]).

Discussion

Antimicrobial use and its link to AMR has been a global concern in medical and veterinary communities due to serious impacts on public health. Several case studies have documented the presence of antibiotic-resistant bacterial strains in small animal veterinary medicine including some that have shown that resistant strains (mostly methicillin-resistant staphylococcus aureus) can be transferred between health care providers and patients and between owners and their pets. There are various reasons that a veterinarian chooses to prescribe or administer antimicrobials to their patients. Our study indicated that otitis externa was the most frequently reported disease. This finding is in agreement with The Merck Veterinary Manual, which mentioned otitis externa as one of the most common presenting complaints in small animal practice. It is known that single or repeated exposure(s) to antibiotics could increase the level of resistance in pathogenic bacteria in humans and animals if inappropriately used. This heightened resistance underscores the importance of judicious antibiotic use, emphasizing the critical role of susceptibility testing in guiding appropriate antibiotic therapy. Although susceptibility testing was not performed or reported in the current study, the most frequently used antimicrobials were aminoglycosides and imidazoles. The findings of this study largely represent antimicrobial use practices in veterinary primary care where bacterial culture and antibiotic susceptibility testing is less likely to be utilized due to cost limitations among other factors. However, the use of culture and susceptibility testing in veterinary primary care needs to be promoted for purposes of antimicrobial stewardship. A survey conducted on antimicrobial use practices of veterinary clinicians at the University of Tennessee Veterinary Medical Center in 2017 revealed 47 clinicians (75.8%) reporting results from bacteriological culture and susceptibility tests to be an extremely important factor in deciding their choice of antimicrobial. Other studies have reported similar findings where veterinarians rated bacteriologic culture and antimicrobial susceptibility among the most important factors in clinical decision-making. Clinicians’ opinions on antimicrobial use practices differed as per Ekakoro and Okafor, where the majority (61.3%) believed that antimicrobials were sometimes prescribed for suspected and not confirmed infections. Most clinicians utilize an evidence-based approach to antimicrobial use practices. Although in the present study there were no clinician opinions obtained, there were differences noted in antimicrobial practices. Therefore, there is a critical need to increase awareness about judicious AMU practices among clinicians, increase emphasis on AMR in the present veterinary curriculum, and implement an antimicrobial stewardship program. Antimicrobial use is also dependent on the availability of the drug of choice when needed. Ekakoro and Okafor indicated that the availability of antimicrobial agents is very important as a factor driving the choice of antimicrobials.

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Disclosures

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References


Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org.