VET

Veterinary Emerging Topics Report

Are We Doing Our Part to Prevent Superbugs?

Antimicrobial Usage Patterns Among Companion Animal Veterinarians

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NAVC® The North American Veterinary Community

Banfield® PET HOSPITAL

We are pleased to share the first annual Banfield Veterinary Emerging Topics (VET) Report—a collaborative effort between Banfield Pet Hospital® and the North American Veterinary Community (NAVC).

As the world's largest veterinary practice, Banfield is committed to using its size and scale to conduct research that provides insights to our profession on topics that improve veterinary care for pets. NAVC is dedicated to advancing veterinary healthcare through education, collaboration and innovation by providing world-class continuing professional development and support services for the global veterinary healthcare community. Joining forces on the VET Report allows our two organizations to draw on our strengths to maximize the VET Report's reach and impact.

Our focus this year is one that is a critical and growing threat to public health and the veterinary profession: antimicrobial resistance (AMR). While this topic is one that the human health industry has embraced and is typically affiliated with production animal health, its reach and impacts are a reality in companion animal medicine. As a worldwide problem, we believe that AMR awareness must become a priority for companion animal practitioners and tackled in an ongoing and proactive manner.

This issue has been addressed to some degree in the past, including the development of antimicrobial use guidelines by veterinary experts, such as the International Society for Companion Animal Infectious Diseases (ISCAID). Through this first edition of the VET Report, our goal is to push the conversation forward, instigating a discussion among companion animal practitioners on how we can achieve better alignment with published guidelines.

Based on data gathered by the American Veterinary Medical Association, we know that the vast majority of companion animal practitioners are unaware that the ISCAID guidelines exist. As a first step in addressing the issue, we explored how this was reflected in antimicrobial prescription patterns among companion animal veterinarians by investigating current usage patterns as a baseline. Banfield's vast database from more than 900 companion animal practice hospitals throughout the United States gave us a unique ability to understand the opportunities for improvement, which are detailed in the following pages.

Given the importance of antimicrobial drugs for combating infectious disease, the veterinary profession will undoubtedly continue to utilize antimicrobials to promote animal health, making it absolutely critical that we use these drugs judiciously and do our part to minimize the impact of companion animal usage on this worldwide problem.

We hope the 2016 VET Report inspires and motivates you to learn more about antimicrobial resistance and steps you can take to be part of the solution. By leading in the movement to reduce pressure for antimicrobial resistance selection, veterinarians can help maintain access and efficacy of the most important antimicrobial agents for both animal and human health.

Respectfully,

Daniel Aja, DVM, Chief Medical Officer
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Thomas Bohn, CAE, Chief Executive Officer
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CLINICAL BOTTOM LINE

Antimicrobial resistance is a critical and growing threat to public health. In response to the need for improved antimicrobial usage, guidelines have been developed to direct treatment of common companion animal infections. However, studies indicating low awareness of these guidelines among veterinarians suggest that poor concordance of usage patterns with guideline recommendations might be expected. Our exploration of antimicrobial usage patterns from 926 general-practice hospitals throughout the United States revealed that, in dogs, 67.1% of non-recurrent urinary infections and 44.2% of recurrent urinary infections received a guideline-concordant antimicrobial. For respiratory infections, 79.6% of canine infectious respiratory disease episodes and 21.7% of bronchitis episodes were treated with a guideline-concordant antimicrobial. Voluntary adjustment of usage patterns to achieve improved concordance with guidelines may result in a better balance between patient care and public health. By proactively addressing this issue, the veterinary profession could avoid mandatory antimicrobial use restrictions that would compromise the ability to care for patients in the safest and most efficacious manner possible. Additionally, by leading in the movement to reduce pressure for antimicrobial resistance selection, veterinarians will help maintain access to and efficacy of the most important antimicrobial agents.

INTRODUCTION

Antimicrobials are a cornerstone of treatment for many conditions and their use can be critical for patient quality of life and survival. Veterinarians have a sworn responsibility to provide for the well-being of animals in their care, including provision of antimicrobial treatment for infections when indicated. However, veterinarians equally have a responsibility to promote public health,[1] and should strive to achieve a balance between meeting patient needs while safeguarding the public. A key facet of public health promotion is minimizing the selection for antimicrobial resistance (AMR) among bacterial species that infect, or have the potential to infect, both animals and humans.[2] Three main approaches have been recommended for limiting AMR: preventing disease, reducing antimicrobial use and improving antimicrobial use.[3] Current studies of veterinary practices indicate that there is a high degree of variability in the use of antimicrobials and alignment with established guidelines.[4,5] The purpose of this report is to promote prudent antimicrobial use among companion animal practitioners by providing a baseline of antimicrobial usage data that contributes to the discussion on how to achieve better concordance with published guidelines.

Antimicrobial resistance arises when bacteria develop the ability to grow in the presence of antimicrobial drugs. This phenomenon is a natural evolutionary process of bacteria, but develops more rapidly through misuse and overuse of antimicrobials.[6] Resistance minimizes the options available to treat bacterial infections and can challenge veterinarians' ability to provide effective therapy. Antimicrobial resistant bacteria pose risks for disease transmission and management through direct transmission of resistant organisms or by transfer of resistance between bacterial species. Circumstantial evidence indicates that transmission of antimicrobial resistant bacteria bi-directionally between humans and household animals occurs, which has implications for the treatment options available for veterinary use as well as the health of companion animal patients, their owners and caretakers. Infection with resistant organisms can lead to longer and more severe infections, increased mortality and higher costs for treatment.[3,6]

Given the importance of antimicrobial drugs for combatting infectious disease, the veterinary profession will undoubtedly continue to utilize antimicrobials to promote animal health. However, as understanding of AMR and infectious disease treatment grows, antimicrobial usage will ideally become more judicious and specific to minimize AMR. Although the concept of judicious use of antibiotics has been clearly defined,[7] and recommendations for antimicrobial use in certain companion animal disease situations have been developed,[8,9] there remain opportunities to promote better awareness and alignment with these guidelines.[10]

The World Health Organization (WHO) Advisory Group on Integrated Surveillance of Antimicrobial Resistance developed a list of critically important antimicrobials (CIAs) of highest importance to humans in order to ensure the prudent use of these drugs in veterinary and human medicine.[11] The classification of these drugs as "critically important" is based upon two established criteria:

"Criterion 1: An antimicrobial agent which is the sole, or one of limited available therapy, to treat serious human disease.

Criterion 2: Antimicrobial agent is used to treat diseases caused by either: (1) organisms that may be transmitted to humans from non-human sources or, (2) human diseases causes by organisms that may acquire resistance genes from non-human sources."

Antimicrobials classified as CIAs include aminoglycosides, 3rd and 4th generation cephalosporins, fluoroquinolones, glycopeptides, macrolides and penicillins. CIAs are further classified as "highest priority" (HPCIAs) if they are used with high frequency in human medicine, are the sole option, or one of few alternatives, to treat diseases that affect a large number of people and have a high potential for resistant bacteria to be transferred to humans through non-human sources. The highest priority CIAs are 3rd and 4th generation cephalosporins, fluoroquinolones, glycopeptides and macrolides. Many HPCIAs are commonly used in companion animal medicine, making it critical that the veterinary profession is aware of AMR and takes steps to moderate the use of antimicrobials in the treatment of companion animals.

An example of the threat of AMR to veterinary and public health can be found in the recent discovery of a multidrug resistant strain of Salmonella infecting a cat presented to an Australian veterinary clinic for an upper respiratory infection.[12] The strain was found to be resistant to approximately nine classes of antimicrobials, including carbapenems, which are frequently a last line of defense against multidrug resistant bacterial infections in humans. The infected cat was ultimately euthanized, and 3 of 8 other cats being treated at the clinic for unrelated illnesses subsequently tested positive for the bacteria, indicating that it was highly transferrable. Although this is one example, the WHO reports that AMR is present worldwide, and drug-resistant bacterial strains including *Escherichia coli, Staphylococcus aureus* and *Mycobacterium tuberculosis* have been discovered.[13]

In response to AMR concerns, the American Veterinary Medical Association (AVMA) and American Association of Feline Practitioners have developed guidelines for the judicious therapeutic use of antimicrobials.[7,14] Additionally, the Antimicrobial Guidelines Working Group of the International Society for Companion Animal Infectious Diseases (ISCAID) has developed guidelines for treatment of urinary tract infections (UTIs),[8] superficial bacterial folliculitis[9] and respiratory tract infections (RTIs).[15] In order to contextualize these guidelines and address the concern that companion animal antimicrobial use may contribute to the spread of AMR, it is important to understand current antimicrobial usage patterns of companion animal veterinarians. To this end, a recently published study examined frequency of use and primary classes of antimicrobials dispensed among companion animal veterinarians from a large sample of primary care practices throughout the United Kingdom.[16] There remains, however, a relative dearth of similar population-based information for primary care veterinarians in the United States, particularly as it pertains to treatment of specific conditions. The availability of population-based data on antimicrobial use in companion animals from the electronic medical records of Banfield Pet Hospital provides an important mechanism for describing current usage patterns in general practice, as well as a means for monitoring patterns in antimicrobial use over time, with the ultimate goal of achieving widespread concordance with published guidelines.

METHODS

All dogs evaluated at any US Banfield Pet Hospital between 1 January 2015 and 31 December 2015 were considered for inclusion. During this period, the Banfield network consisted of up to 926 general practice hospitals in 43 states with approximately 135,000 dog visits each week. The provider base consisted of 3,850 veterinarians (77% female) with an average age of 35 years. Staff at all hospitals used a common proprietary practice management system with electronic medical records uploaded nightly to a central database. The system employed standardized codes to capture visit information including diagnoses, examination findings and invoiced items and services. Individual visits were selected for inclusion if the dog received a diagnostic code indicative of one of the two conditions of interest (UTI or bacterial RTI) and was prescribed an in-hospital antimicrobial within 14 days following the visit. Antifungals and drug formulations other than oral and injectable were not included in the antimicrobials selected for evaluation. Only in-hospital dispensing of antimicrobials was able to be tracked.

Data were extracted from the pet record separately for each condition and individual visits were collapsed into a single episode of infection by combining all condition-related visits for an individual dog that occurred within an established timeframe – within 14 days of another visit for UTIs and within 30 days for RTIs. Because the primary aim of characterizing usage patterns was to evaluate concordance with current first-line treatment guidelines, only episodes in which a single antimicrobial was dispensed were included in the final analysis. Guidelines for pneumonia were not evaluated for concordance due to recommendations contingent on clinical signs not captured as diagnostic codes. In order to calculate the overall percentage of episodes in which antimicrobials were dispensed, separate denominator data were obtained for each condition by identifying all episodes of infection in 2015 regardless of whether or how many antimicrobials were dispensed.

For UTIs, data were extracted for clinic location, patient signalment, type and class of antimicrobials dispensed and number of antimicrobials dispensed. The number of UTIs experienced by each dog in the preceding year and whether a urine culture and susceptibility (C&S) test was ordered in association with the episode (defined as completion within 2 weeks before or after the episode) were noted. An episode was defined as “recurrent” if the patient experienced 2 or more UTIs in the preceding 12 months.

For RTIs, data were extracted for clinic location, patient signalment, type and class of antimicrobials dispensed, number of antimicrobials dispensed and route of administration. Diagnostic codes assigned during the visits were used to further classify RTI episodes as canine infectious respiratory disease complex (CIRD) or bacterial bronchitis. Episodes where more than one respiratory diagnostic code was applied were excluded from analysis in order to more accurately depict usage patterns for specific respiratory ailments.

Antimicrobial usage information (recommended dosage, frequency and duration) was unavailable as structured data. A utilization snapshot was obtained by conducting a manual review of the free-text medical notes from a random sample of 1,000 total visits (500 for each condition); 250 in which the most commonly used medication was dispensed (amoxicillin-clavulanate for both UTIs and RTIs) as well as 250 visits in which the ISCAID recommended first-line drug option was dispensed (amoxicillin for UTIs[8] and doxycycline for RTIs[15]). Trimethoprim-sulfonamide is an ISCAID recommended first-line treatment option for UTIs, but was not dispensed with sufficient regularity to obtain meaningful usage information. The usage variables were subsequently evaluated for normality by creation of histograms and are presented as median and interquartile range (IQR) due to having non-normal distributions.

RESULTS

› Urinary Tract Infections (UTIs)

In 2015, there were 35,402 canine UTI visits at Banfield hospitals, which accounted for 32,226 episodes of infection. Of those, in-hospital antimicrobials were dispensed in association with 84.4% (27,194). After removing episodes in which multiple antimicrobials were dispensed, the final dataset consisted of 24,801 UTI episodes among 22,596 unique dogs. Of these, 95.2% (23,606) of episodes were determined to be non-recurrent in nature, whereas 4.8% (1,195) were preceded by 2 or more UTIs in the previous year. A urine C&S was ordered for 6.2% (1,468) of non-recurrent and 24.6% (294) of recurrent episodes.

Penicillins were the most frequently dispensed class of antimicrobial for UTIs, followed by 3rd generation cephalosporins and fluoroquinolones (Table 2). CIAs were dispensed for the vast majority of UTI episodes, including non-recurrent episodes with (97.5%) and without (98.5%) C&S as well as recurrent episodes with (93.9%) and without (96.0%) C&S. The percentage of episodes in which HPCIAs were dispensed ranged from 30.6% - 54.8% and the proportion increased with recurrence of infection and availability of C&S results.

The most recently published guidelines for care of non-recurrent UTIs (Table 1) recommend initial treatment with amoxicillin (11–15 mg/kg PO q8h) or trimethoprim-sulfonamide (15 mg/kg PO q12h) for a duration of 7 days.[8] Amoxicillin-clavulanate (12.5–25 mg/kg PO q8h) is described as an acceptable option, but not recommended due to lack of evidence of the need for clavulanic acid. Based on these criteria, only 9.4% of non-recurrent UTI episodes received a guideline-concordant antimicrobial, although that number increases to 67.1% if amoxicillin-clavulanate is considered an acceptable option. For recurrent UTIs, guidelines recommend that providers consider waiting for C&S results prior to instituting therapy. In cases where immediate treatment is warranted, the same recommendations as for non-recurrent UTIs apply, with the additional recommendations that antimicrobial therapy be given for a duration of 4 weeks and that an alternative drug class to the one used for treatment of the previous UTI be dispensed. For recurrent infections, 7.1% of episodes received a guideline-concordant drug, increasing to 44.2% if amoxicillin-clavulanate is considered concordant.

Table 1 – ISCAID-recommended first-line antimicrobial options for canine urinary tract infections (UTIs)[8]

Infection Type	First-Line Drug Options	Dosage	Frequency	Duration
Non-recurrent UTI	Amoxicillin	11-15 mg/kg	q8h	7 days
	Trimethoprim-sulfonamide	15 mg/kg	q12h	7 days
	Amoxicillin-clavulanate (acceptable but not recommended)	12.5 – 25 mg/kg	q8h	7 days
Recurrent UTI (≥ 3 episodes of UTI in a 12-month period)	Guided by culture and susceptibility testing, but consider:			
	Amoxicillin	11-15 mg/kg	q8h	4 weeks
	Trimethoprim-sulfonamide	15 mg/kg	q12h	4 weeks

Table 2 – Frequency of in-hospital antimicrobial use for canine urinary tract infections (UTIs) in which a single antimicrobial was dispensed, by infection recurrence and culture and susceptibility (C&S) order status

Antimicrobial	Diagnosis			
	Non-recurrent UTI without C&S	Non-recurrent UTI with C&S	Recurrent UTI without C&S	Recurrent UTI with C&S
	n (%)	n (%)	n (%)	n (%)
Cephalosporins (1st generation)	**12 (0.1%)**	**7 (0.5%)**	**4 (0.4%)**	**4 (1.4%)**
Cefadroxil	3 (0.0%)	1 (0.1%)	1 (0.1%)	0 (0.0%)
Cefazolin	9 (0.0%)	6 (0.4%)	3 (0.3%)	4 (1.4%)
Cephalosporins (3rd generation)	**4,483 (20.3%)**	**296 (20.2%)**	**240 (26.6%)**	**76 (25.9%)**
Cefovecin**	2,243 (10.1%)	142 (9.7%)	115 (12.8%)	32 (10.9%)
Cefpodoxime**	2,240 (10.1%)	154 (10.5%)	125 (13.9%)	44 (15.0%)
Fluoroquinolones	**2,285 (10.3%)**	**341 (23.2%)**	**214 (23.8%)**	**85 (28.9%)**
Enrofloxacin**	20 (0.1%)	1 (0.1%)	1 (0.1%)	2 (0.7%)
Marbofloxacin**	2,201 (9.9%)	335 (22.8%)	210 (23.3%)	82 (27.9%)
Orbifloxacin**	64 (0.3%)	5 (0.3%)	3 (0.3%)	1 (0.3%)
Lincosamides	**148 (0.7%)**	**4 (0.3%)**	**13 (1.4%)**	**1 (0.3%)**
Clindamycin	148 (0.7%)	4 (0.3%)	13 (1.4%)	1 (0.3%)
Macrolides	**1 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**
Azithromycin**	1 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Nitroimidazoles	**0 (0.0%)**	**1 (0.1%)**	**0 (0.0%)**	**1 (0.3%)**
Nitrofurantoin	0 (0.0%)	1 (0.1%)	0 (0.0%)	1 (0.3%)
Penicillins	**15,040 (67.9%)**	**794 (54.1%)**	**411 (45.6%)**	**115 (39.1%)**
Amoxicillin*	2,054 (9.3%)	130 (8.9%)	60 (6.7%)	19 (6.5%)
Amoxicillin/clavulanic acid*	12,970 (58.6%)	662 (45.1%)	347 (38.5%)	96 (32.7%)
Ampicillin*	16 (0.1%)	2 (0.1%)	4 (0.4%)	0 (0.0%)
Sulfonamides	**119 (0.5%)**	**10 (0.7%)**	**8 (0.9%)**	**5 (1.7%)**
Sulfadimethoxine	2 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Sulfadimethoxine/Ormetoprim	99 (0.4%)	4 (0.3%)	6 (0.7%)	1 (0.3%)
Sulfamethoxazole/Trimethoprim	18 (0.1%)	6 (0.4%)	2 (0.2%)	4 (1.4%)
Tetracyclines	**50 (0.2%)**	**15 (1.0%)**	**11 (1.2%)**	**7 (2.4%)**
Doxycycline	46 (0.2%)	14 (1.0%)	11 (1.2%)	6 (2.0%)
Minocycline	4 (0.0%)	1 (0.1%)	0 (0.0%)	1 (0.3%)
Grand total	**22,138**	**1,468**	**901**	**294**
Total CIAs*	**21,809 (98.5%)**	**1,431 (97.5%)**	**865 (96.0%)**	**276 (93.9%)**
Total HPCIAs**	**6,769 (30.6%)**	**637 (43.4%)**	**454 (50.4%)**	**161 (54.8%)**

Antimicrobial classes evaluated included aminoglycosides, cephalosporins, fluroquinolones, lincosamides, macrolides, nitroimidazoles, penicillins, sulfonamides and tetracyclines. Antimicrobials that were not dispensed for a particular ailment are not provided in the table.

*WHO CIAs **WHO CIAs of highest importance

The median (IQR) dosage of amoxicillin for UTIs was 15.8 (13.3–20.3) mg/kg, with 34% of the reviewed prescriptions concordant with the ISCAID recommended dosage of 11–15 mg/kg (Figure 1). Fourteen percent of reviewed amoxicillin prescriptions were concordant with the recommended rate of q8h, while the remaining 86% were for q12h. The majority of prescriptions were for a duration of 14 days (50.8%), followed by 10 days (25.6%) and 7 days (13.6%).

The median dosage of amoxicillin-clavulanate for UTIs was 14.2 (12.8–16.0) mg/kg, with 77.6% of prescriptions concordant with the ISCAID dosage guidelines (Figure 2). Only one prescription (0.4%) was for the ISCAID recommended frequency of q8h, while the remaining 99.6% were for q12h. Fifty-eight percent of amoxicillin-clavulanate prescriptions were for a duration of 14 days, followed by 7 (27.6%) and 10 (8.4%) days.

Fig. 1 – Dosage of amoxicillin dispensed for canine urinary tract infections

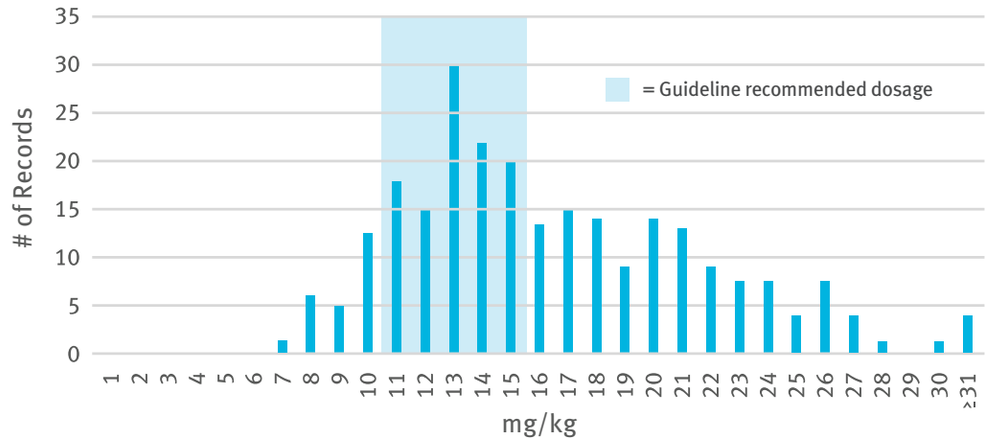
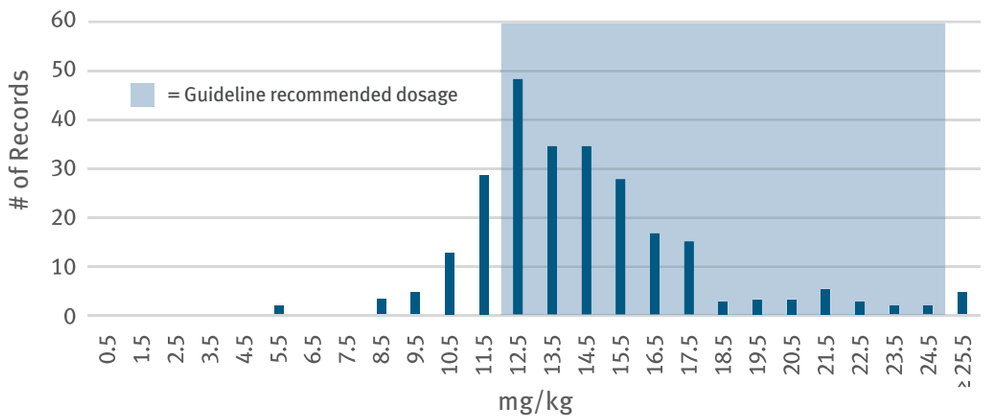


Fig. 2 – Dosage of amoxicillin-clavulanate dispensed for canine urinary tract infections



› Respiratory Tract Infections (RTIs)

In 2015, a diagnostic code indicative of a bacterial RTI was captured in the medical record during 41,245 canine visits comprising 35,655 episodes of infection. Of these, 75.9% (27,046) of episodes had in-hospital antimicrobials dispensed. After limiting the dataset to events in which a single antimicrobial was given, the final analysis consisted of 24,402 episodes of infection, 95.1% (23,211) of which were classified as CIRD and 4.9% (1,191) as bacterial bronchitis.

Penicillins were the most frequently dispensed antimicrobial class across both respiratory disease categories, comprising 59.3% of antimicrobials dispensed for CIRD and 46.7% for bronchitis (Table 4). The next most frequently dispensed classes were tetracyclines (28.9% and 25.4% for CIRD and bronchitis, respectively) and 3rd generation cephalosporins (7.0% and 15.0%). CIAs were used to treat 69.1% of CIRD episodes and 68.9% of bronchitis episodes, whereas HPCIAs were used in 9.8% of CIRD episodes and 22.1% of bronchitis episodes.

In the recently published guidelines developed by ISCAID's Antimicrobial Guidelines Working Group, 15 of 17 reviewers recommended first line treatment with doxycycline (5 mg/kg PO q12h or 10 mg/kg PO q24h) for a duration of 7-10 days for the bacterial component of CIRD (Table 3). Amoxicillin-clavulanate (11 mg/kg PO q12h) was considered a suitable alternative by 13 of 17 reviewers. Doxycycline (5 mg/kg PO q12h or 10 mg/kg PO q24h) was recommended by 16 of 17 reviewers as the preferred empirical choice for the treatment of bacterial bronchitis while waiting for results of C&S testing. Based on these criteria, 24.6% of CIRD episodes in 2015 were treated with a guideline concordant antimicrobial – increasing to 79.6% if amoxicillin-clavulanate is considered a suitable alternative – while 21.7% of bronchitis episodes received a guideline-concordant drug.

The median dosage of doxycycline for treatment of RTIs was 5.8 (5.0 – 7.8) mg/kg (Figure 3), with 28.8% of reviewed prescriptions concordant with ISCAID dosage guidelines. The majority of prescriptions were for a frequency of q12h (81.6%), while the remaining 18.4% were for q24h. Most doxycycline prescriptions were for a duration of 14 days (47.2%), followed by 10 (29.6%) and 7 (16.4%) days. The median dosage of amoxicillin-clavulanate for treatment of RTIs was 14.4 (13.2 – 16.5) mg/kg and 5.6% of reviewed prescriptions were guideline concordant for dosage (Figure 4). The most common duration of treatment was 14 days (43.2%), followed by 7 (35.2%) and 10 (16.0%) days. All amoxicillin-clavulanate prescriptions for treatment of RTIs were for a frequency of q12h.

Table 3 – ISCAID-recommended first-line antimicrobial options for canine bacterial respiratory tract infections (RTIs)[15]

*see guidelines for additional recommendations[15]

Infection Type	First-Line Drug Options	Dosage	Frequency	Duration	Reviewers in Agreement
Canine Infectious Respiratory Disease Complex	Doxycycline	5 mg/kg	q12h	7-10 days	15/17
		10 mg/kg	q24h		
	Amoxicillin-clavulanate	11 mg/kg	q12h	7-10 days	13/17
Bacterial bronchitis	Doxycycline	5 mg/kg	q12h	Administer while waiting for C&S*	16/17
		10 mg/kg	q24h		

Table 4 – Frequency of in-hospital antimicrobial use for canine bacterial respiratory tract infections (RTIs) in which a single antimicrobial was dispensed, by diagnosis

Antimicrobial	Diagnosis	
	Canine Respiratory Tract Infections	Bacterial Bronchitis
	n (%)	n (%)
Aminoglycosides	**7 (0.0%)**	**2 (0.2%)**
Cephalosporins (1st generation)	**35 (0.2%)**	**9 (0.8%)**
	13 (0.1%)	3 (0.3%)
Cephalosporins (3rd generation)	**1,622 (7.0%)**	**179 (15.0%)**
	785 (3.4%)	74 (6.2%)
	837 (3.6%)	105 (8.8%)
Fluoroquinolones	**429 (1.8%)**	**73 (6.1%)**
	12 (0.1%)	1 (0.0%)
Marbofloxacin**	387 (1.7%)	68 (5.7%)
	30 (0.1%)	4 (0.3%)
Lincosamides	**281 (1.2%)**	**43 (3.6%)**
Macrolides	**219 (0.9%)**	**11 (0.9%)**
Penicillins	**13,753 (59.3%)**	**556 (46.7%)**
	950 (4.1%)	34 (2.9%)
Amoxicillin-clavulanate *	12,763 (55.0%)	519 (43.6%)
	40 (0.2%)	3 (0.3%)
Sulfonamides	**156 (0.7%)**	**15 (1.3%)**
	42 (0.2%)	4 (0.3%)
Sulfadimethoxine/Ormetoprim	93 (0.4%)	8 (0.7%)
	21 (0.1%)	3 (0.3%)
Tetracyclines	**6,709 (28.9%)**	**303 (25.4%)**
	5,715 (24.6%)	259 (21.7%)
Grand total	**23,211**	**1,191**
Total CIAs*	**16,030 (69.1%)**	**821 (68.9%)**
Total HPCIAs**	**2,270 (9.8%)**	**263 (22.1%)**

Antimicrobial classes evaluated included aminoglycosides, cephalosporins, fluroquinolones, lincosamides, macrolides, nitroimidazoles, penicillins, sulfonamides and tetracyclines. Antimicrobials that were not dispensed for a particular ailment are not provided in the table.

*WHO CIAs **WHO CIAs of highest importance

Fig. 3 – Dosage of doxycycline dispensed for canine bacterial respiratory tract infections

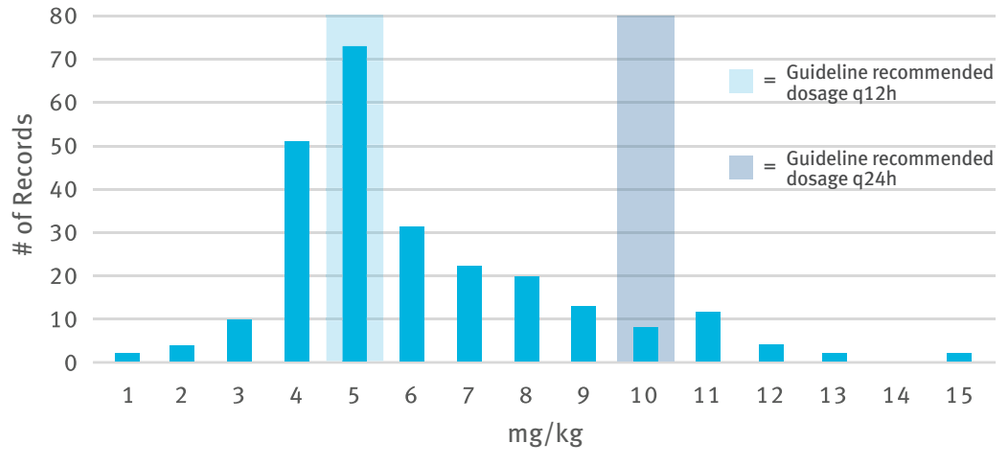
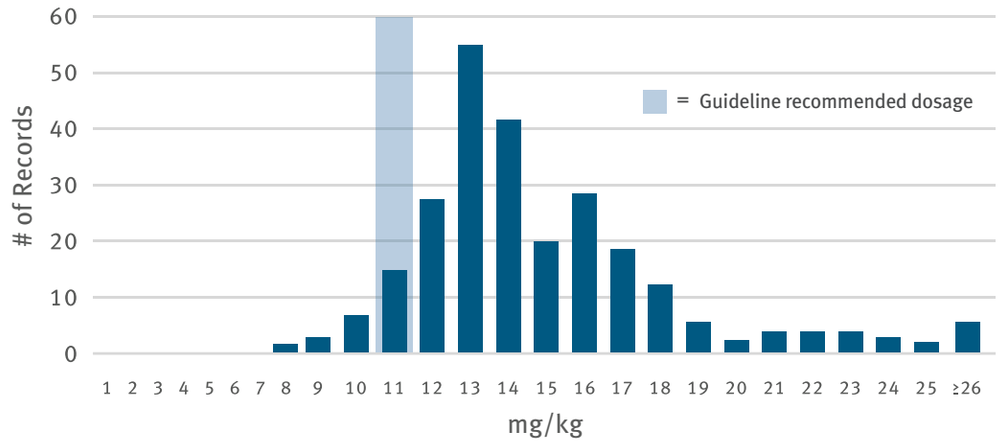


Fig. 4 – Dosage of amoxicillin-clavulanate dispensed for canine bacterial respiratory tract infections



DISCUSSION

› Guideline Concordance

The data presented here provide insight into current antimicrobial usage patterns for canine UTIs and RTIs among companion animal veterinarians practicing in a primary care, general practice setting. Indeed, our findings are consistent with previous general practice and teaching hospital research in regard to the percentage of disease events that are treated with antimicrobials[5] as well as the frequency with which certain antimicrobial classes are dispensed.[5,16-19] Studies from the United States,[18,19] United Kingdom[16,17] and Canada[5] have consistently found that β-lactams, such as penicillins and cephalosporins, are the most frequently prescribed class of antimicrobials across a variety of conditions, including RTIs and UTIs. The WHO and World Organization for Animal Health have classified β-lactams as critically important to human and veterinary medicine, highlighting the need for improved awareness of and progress toward appropriate antimicrobial use.[11,20] Antimicrobial usage guidelines have been a popular tool for influencing antimicrobial use among physicians,[21-23] although they have been relatively uncommon in companion animal medicine. Encouragingly, companion animal guidelines have been developed recently as awareness of the need has increased. We propose that the veterinary profession aim for improved concordance of antimicrobial usage with established guidelines for companion animal diseases in order to help mitigate the contribution of veterinary antimicrobial use to AMR.

Strategies are needed to make the transition from publication of guidelines to incorporation of guidelines into practice. As an example, antimicrobial usage guidelines for treatment of UTIs in dogs and cats have been publicly available since 2011.[8] However, although the present study found fair concordance with recommended first line UTI treatments (if amoxicillin-clavulanate is considered concordant), a minority of episodes were treated in accordance with the guidelines for dosage, frequency or duration. It is important to note the impact of available pill or capsule size on dosing and the fact that, for some patients, guideline-concordant dosing may be challenging due to the difficulty of splitting a pill beyond a certain level or the inability to split or partition dosing from a capsule. We did not review concentration options relative to dosing in this report, but further exploration of this topic may be warranted. Regardless, the observed difference between UTIs and RTIs in concordance with first-line treatment recommendations was minimal despite the fact that RTI guidelines have only recently been published. This may be due in large part to low awareness of existing guidelines. Among AVMA members self-identified as companion animal practitioners, a 2015 survey found that 88% were unaware of the existence of antimicrobial usage guidelines by veterinary professional associations.[10]

Guideline development and dissemination are critical first steps in influencing antimicrobial usage patterns. Improved concordance with guideline recommendations, however, requires analysis and understanding of barriers faced by veterinary practitioners in order to implement systems and processes that reinforce desired behavior changes. It is crucial to understand that, for many veterinarians, a tension will exist between their desire to see resolution of clinical signs in a patient presenting to them in the present and the knowledge that AMR is of concern. The presenting patient is a visible need with immediate outcomes, and AMR is an invisible need with delayed outcomes. In order to effectively address this tension, we should consider how to address the invisibility of AMR and the delayed positive outcomes of prescribing in concordance with guidelines. By making the invisible visible, we can create a more satisfying outcome of change as well as a system that effectively supports the “right” behaviors in clinical practice.

Although there are various methods to identify appropriate changes and assess their effectiveness, we propose one drawn from the science of quality improvement – the Model for Improvement[24] – to plan and implement changes that result in movement towards the desired outcome. This model provides a strategy for making continual progress toward our goal of improved concordance with antimicrobial treatment guidelines within the veterinary profession, while the data presented above can serve as baseline information to evaluate the results once a strategy has been implemented.

› The Model for Improvement

Quality improvement as a science was developed by W. Edward Deming and others in the 1950s and began as a tool used in the manufacturing industry. Its utility for application to a variety of other situations, including health care, was quickly recognized. The Model for Improvement helps apply key concepts to business challenges.

A journey of quality improvement begins by asking three crucial questions:[24]

1 – AIM: What are we trying to accomplish?

2 – MEASURE: How will we know that a change is an improvement?

3 – CHANGE: What changes can we make that will result in improvement?

In order to define the aim, the user must explicitly define what is to be accomplished and the timeframe in which it is to be achieved.

Objective measures are then employed to determine the point at which the goal has been reached. This requires data for baseline measurement and results to compare against. Many data sources can be used to measure antimicrobial guideline concordance within a veterinary practice, but they must be assessed for validity and accuracy to ensure appropriate interpretation. Examples include medical record reviews, logs of antimicrobial dispensing practices, case response logs, doctor surveys, or a combination of data that allow comparison of antimicrobial usage patterns with guidelines.

Finally, a plan should be created by identifying barriers to achieving the desired end goal as well as determining potential strategies and changes to address them. Brainstorming applicable barriers, strategies and goals should involve all members of the veterinary team, including veterinarians, veterinary technicians, practice managers and front desk staff, and might also include clients, pharmaceutical representatives and local professional organizations, among other stakeholders.

Not all changes to a system have equal likelihood of driving improvement. Fundamental changes that have a higher likelihood of success include those that impact how work is done, produce observable positive differences and have a lasting impact. Such changes result from design/redesign of a process or system, or those that fundamentally change how a system works and what is done to drive it forward. Examples include conducting training, implementing cross-training, soliciting feedback from customers or employees, applying standardization, streamlining choices to match the ideal and changing the order of tasks, among others.[24] After implementing a fundamental change, the Model for Improvement can also guide examination of its impact in order to understand if it has had the intended result.

Any change intended to influence medical prescribing practices requires buy-in from clinicians and ancillary team members. As such, large scale, abrupt changes may not be readily accepted or adopted, and are often operationally unfeasible or risky. Small, incremental changes can be more acceptable from both a financial and behavioral perspective, and allow for better assessment of the true effects of those changes in the complex environment of a health care facility. The implementation of incremental changes is supported by the plan, do, study, act (PDSA) cycle, a tool of the Model for Improvement. The PDSA cycle is a recognized methodology for quality improvement projects, related to the scientific method, where a hypothesis drives an experiment. Simply stated, the PDSA cycle requires you to thoughtfully plan and implement (do) a step towards your goal, study your results and act on them to ensure continual progress toward the improvement you desire to accomplish.

› Putting the model into action

Having set a clear goal, identified a model by which to achieve it, and established baseline data to evaluate our progress, the next step is to identify concrete changes that we believe will lead to meaningful progress. Our goal is to achieve voluntary adjustment of usage patterns among veterinarians to improve concordance with existing guidelines. By proactively addressing this issue, the veterinary profession may avoid mandatory antimicrobial use restrictions that would compromise the ability to care for patients in the safest and most efficacious manner possible.

To begin this process, we must understand the perceived barriers to appropriate antimicrobial use. An AVMA survey of companion animal practitioners' attitudes towards antimicrobial stewardship revealed that barriers to antimicrobial usage in concordance with existing guidelines included lack of awareness of guidelines as well as infrequent antimicrobial C&S testing.[10] Surveys of veterinary practitioners in the US and UK indicate that pressure to dispense antimicrobials to satisfy client expectations and the cost of antimicrobial C&S testing are both factors that influence antimicrobial usage.[4,10] Finally, a study of UK veterinarians found that intrinsic factors, such as personal preference, and extrinsic factors, such as perceived compliance by client and willingness/ability of the client to pay, influenced decision-making about antimicrobial use.[4,10] Additional barriers to alignment that might be considered in an individual practice include consistent availability of first-line antimicrobials, dosing regimens and owner compliance, pricing of antimicrobials and capability and pricing of appropriate C&S testing.

PLAN – During this phase, think about what you want to achieve, what you need to do to get there and what you will measure to ensure your goals are met.

DO – Next, implement your plan. Focus on small, incremental alterations rather than widespread change.

STUDY – Then, work to understand all outcomes of the alterations that you've implemented. Sometimes unintended results have a larger impact than intended results. By understanding the consequences of your change you may adjust your original plan to better achieve your stated goals.

ACT – Finally, make the adjustments that you identified as necessary in the 'Study' phase. At this point, the cycle repeats itself. You should regularly analyze the results of each new PDSA cycle to inform the next step and ensure continual progress toward your improvement goal.[24]

Surveys of veterinarians' knowledge and opinions about the use of antimicrobials indicates some degree of awareness of AMR. Fifty-nine percent of clinical veterinarians at a veterinary teaching hospital reported being very concerned about antimicrobial-resistant infections.[25] Additionally, 45% of AVMA membership survey respondents indicated concern about antimicrobial-resistant infections and 62% felt antimicrobials used in small animal practice have an impact on AMR.[10] Given profession-wide opportunities for increased awareness and knowledge, a logical place to begin the process of alignment with guidelines may be to assess levels of awareness within a specific hospital. This information can then be used as a starting point to develop a communications plan to improve awareness among veterinarians and their teams.

Although low awareness of antimicrobial usage guidelines is a common issue, the "right" level at which to intervene is dependent on the specific environment or practice. Using the Model for Improvement, the first step is to establish an "aim" and a timeline within which to achieve it. This might, for example, be declared as *"improving concordance with first-line drug recommendations by 50% over a six month period."* The next step is to establish a "measure", which would take into account available data and metrics that would allow assessment of the current state of prescriptions, as well as ongoing metrics to measure the response to change. For example, tracking the percentage of recurrent UTI cases that are dispensed antimicrobials after urine C&S testing would be useful for determining what proportion of prescriptions are being guided by susceptibility results. Finally, the potential changes would be reviewed and assessed, and one or two changes deemed to be fundamental would be selected for a PDSA cycle.

One change might be to make AMR and the positive outcomes of prescribing in concordance with guidelines more visible in a practice. The "Plan" could entail tracking of antimicrobial prescriptions across the hospital and outcomes of associated patients. Implementation, or "Do", may include a checklist designated to specific roles in the hospital where the drug and outcome is recorded and reviewed weekly. After an appropriate amount of time for implementation, the results would then be "Studied" and potential adjustments to make the process more effective would be evaluated. Based upon that assessment, the "Act" step would then involve refinement of the goal and planning for subsequent cycles. Another cycle would be started with adjustments for improvement, allowing each subsequent cycle to guide the types of improvements needed to improve guideline concordance.

This method of incremental change allows for operational and behavioral acceptance by not causing major disruption while regular measurement and assessment ensure that the right changes are being made. From a healthcare perspective, these safeguards also help to ensure patient safety and quality of care by confirming that a change has the intended effect prior to widespread implementation so that patient outcomes are not compromised.

› Limitations

The data presented here characterize disease episodes for which in-hospital antimicrobials were dispensed. The findings do not account for instances in which a prescription was provided and purchased elsewhere. However, previous internal research found that less than 2% of medications prescribed by Banfield veterinarians are written for external filling as opposed to provided in-house. Nevertheless, further research should be conducted to include and evaluate the nature of written antimicrobial prescriptions provided to clients and the frequency with which they're written. Additionally, our criteria for identifying dogs with UTIs or RTIs were based on diagnostic codes recorded by attending clinicians. Interpretation of laboratory results (*e.g.*, urinalysis, complete blood count, chemistry) in combination with professional judgement is implicit in the diagnosis or treatment of these conditions. As such, we did not require additional diagnostic criteria for inclusion. However, utilizing this information to further characterize disease state and severity would provide more specific information that could help us to achieve our goal. Finally, it will be important to incorporate temporality into future analyses in order to evaluate how prescribing patterns change as additional information (*e.g.*, treatment progress, C&S results) becomes available.

› Conclusion

This report has presented antimicrobial usage data for canine UTIs and RTIs at Banfield Pet Hospitals along with the degree of concordance with existing guidelines. The proposed intent is to improve concordance of companion animal antimicrobial use with these guidelines. The report has also proposed a method by which to achieve behavior change amongst clinicians and drive quality improvement within the veterinary profession. Using the concepts from the Model for Improvement, we believe that veterinary professionals can successfully improve overall professional concordance with guidelines in order to minimize the impact of companion animal antimicrobial usage on the worldwide problem of AMR.

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