Paper

A survey of veterinary antimicrobial prescribing practices, Washington State 2015

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Antimicrobial resistance is a growing global health issue. It is also a recognised problem in veterinary medicine. Between September and December 2015 the authors administered a cross-sectional survey to licensed veterinarians in Washington State to assess factors affecting antimicrobial prescribing practices among veterinarians in Washington State. Two hundred and three veterinarians completed the survey. The majority of respondents (166, 82 per cent) were engaged in small animal or exotic animal practice. 24 per cent of respondents reported not ordering culture and sensitivity (C/S) testing in practice. Of the 76 per cent of veterinarians who reported ordering C/S tests, 36 per cent reported ordering such testing 'often' or 'always' when treating presumptive bacterial infections. Most respondents (65 per cent) mentioned cost as the most common barrier to ordering a C/S test. Only 16 (10 per cent) respondents reported having access to or utilising a clinic-specific antibiogram. This survey demonstrated that while antimicrobials are commonly used in veterinary practice, and veterinarians are concerned about antimicrobial resistance, cost is a barrier to obtaining C/S tests to guide antimicrobial therapy. Summaries of antimicrobial resistance patterns are rarely available to the practising veterinarian. Efforts to promote antimicrobial stewardship in a 'One Health' manner should address barriers to the judicious use of antimicrobials in the veterinary practice setting.

Introduction

Antimicrobial resistance is a growing global health issue (Travis and others 2014). Each year nearly 2 million cases resulting in 23,000 deaths in human beings in the USA are caused by drug-resistant pathogens including vancomycin-resistant enterococci, methicillin-resistant *Staphlyococcus aureus* and *Clostridium difficile* (2015a). Antimicrobial resistance is also a recognised problem in veterinary medicine. Some emerging strains of antimicrobial-resistant organisms have been reported to cause morbidity and mortality in non-human animals (Guardabassi and others 2004, Beca and others 2015, Dargatz and others 2015, Holman and Chenier 2015), and there is evidence for bidirectional transmission of antimicrobial-resistant organisms and resistance genes between human beings and other species (Sunde and Sorum 2001, Guardabassi and others 2004, Morris and others 2006, Johnson and others 2008). While attention has been drawn to the use of antimicrobials for non-therapeutic purposes in animal agriculture, the impact of such use on the overall burden of antimicrobial resistance in human beings remains poorly understood (Huijbers and others 2015). In addition to animal agriculture, companion animal veterinary practitioners would routinely treat diseased animals. Companion animals share environments with human beings, and there is ongoing potential for antimicrobial-resistant bacteria to move between animals and people in the household in addition to the farm setting. As a result, efforts to encourage the judicious use of antimicrobials need to involve veterinarians in community practice as well as human healthcare providers.

In recognition of the interrelatedness of antimicrobial use in human beings and animals, the National Action Plan for Combating Antimicrobial-Resistant Bacteria (2015c) authored by a White House interagency Task Force has called for a 'One Health' approach to addressing antimicrobial use and resistance in human beings and animals. The One Health concept is a system-based approach to interactions of human, animal and environmental health that encourages transdisciplinary efforts to improve health for all species and the environment (Osburn and others 2009, Cantas and Suer 2014, Travis and others 2014). As applied to the problem of antimicrobial resistance, a One Health approach involves moving beyond polarised debates

Veterinary Record (2016) doi: 10.1136/vr.103916

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Provenance: Not commissioned; externally peer reviewed

Accepted October 16, 2016

about whether greater blame should be placed on antimicrobial use in animal agriculture' or human healthcare (Cox and Jones 2006, Coe and others 2007, 2008, Cox and others 2009, Coe and others 2010, Cox and Popken 2010, 2014, Ciorba and others 2015, Huijbers and others 2015) to instead developing collaborative models of shared antimicrobial stewardship and surveillance across human, animal and environmental sectors.

While a number of studies have assessed the factors influencing antimicrobial prescribing practices of physicians and other human healthcare providers (Morley and others 2005, Isturiz 2010, Escher and others 2011, Mateus and others 2011, Hughes and others 2012, Coyne and others 2014, Mateus and others 2014, Riviere and Fink-Gremmels 2014, Bender and others 2015a, b , Butterweck 2015, Jacob and others 2015), there have been few studies describing antimicrobial prescribing by veterinarians (De Briyne and others 2013, 2014, Summers and others 2014, Schwechler and others 2016). One study of prescribing physicians found that concerns about and factors impacting antimicrobial prescribing practices differed dramatically by job title or specialty, and concluded that interventions would need to be tailored to each specialty group in order to improve antimicrobial stewardship (Schweizer and others 2013). In the veterinary realm, studies have focused on the small animal sector (Coyne and others 2014, Mateus and others 2014). These studies have found evidence of inappropriate use of antimicrobials such as underdosing in the small animal clinical setting. Furthermore, studies have reported that the use of antimicrobials by veterinarians is influenced by a combination of intrinsic and extrinsic factors including perceived drug efficacy, ease of administration, veterinary preferences and personal experience (Hughes and others 2012, Mateus and others 2014, Jacob and others 2015).

In the fall of 2013, a One Health initiative was implemented in the State of Washington (2013). The goal of this initiative was to foster a community of collaboration among human, animal and environmental health professionals, agencies and institutions in order to address disease overlaps between human beings, animals and the environment in the state. The Washington State Veterinary Medical Association (WSVMA) convened a veterinary workgroup to gather data related to antimicrobial stewardship in the veterinary profession. The group also serves as a resource to veterinary personnel and other interested healthcare professionals in the state. The veterinary workgroup conducted a survey of veterinarians in the state to gain a better understanding of current antimicrobial prescribing practices, and to serve as a baseline to monitor and evaluate progress in changing norms of antimicrobial usage by veterinary professionals that could be contributing to the burden of antimicrobial-resistant bacteria.

Materials and methods

Study design

A cross-sectional, anonymous survey of Washington State veterinarians was conducted between September 25 and December 1, 2015. The study was made available both in hard copy form and online. Survey questions collected information on animal species focus, years in practice, frequency and laboratory used for culture and sensitivity (C/S) testing, and common antimicrobials prescribed by organ system affected. A 5-point Likert scale with the options 'Always (>75 per cent of the time)', 'Often (50–75 per cent of the time)', 'Sometimes (25–50 per cent)', 'Rarely (<25 per cent of the time)' and 'Never (0 per cent of the time)' was used to determine how often C/S tests are ordered by a given participant. A similar 5-point scale was also used to assess agreement with the statement 'Antimicrobial resistance is a major public health issue' with responses ranging from 'strongly agree' to 'strongly disagree'.

Participants were specifically asked if they request and utilise a summary of antimicrobial sensitivities seen over a given period of time at that clinic, or clinic antibiogram, from the diagnostic laboratories where they submit their samples (see online supplementary appendix). Open-ended questions allowed for exploration to assess factors that influence decisions to order C/S tests. Participants were asked to list the drugs they commonly prescribe by body system affected and/or syndrome diagnosed. An appendix of commonly prescribed antimicrobials grouped by drug class was provided to assist participants in completing this question.

The study was open to all veterinarians practising in the state. Information on the county in which each participant practised was collected. The name of the clinic or clinics where each participant worked was not collected. Other demographics including type of practice and years in practice were collected on all participants.

Study recruitment

Veterinarians licensed and/or practising in the state were invited to participate. Study participation was voluntary. The University of Washington Institutional Review Board reviewed the protocols and determined they were exempt from further review.

The survey commencement coincided with the opening day of the Pacific Northwest Veterinary Conference and Trade show, the annual state veterinary conference organised by the WSVMA. Three hundred and fifty paper copies were distributed with registration materials to the 300 veterinarians registered for the conference. Completed surveys were to be returned to the registration desk or mailed directly to the first author. Extra blank copies were made available to veterinarians in the case of a lost form or other issue. Conference moderators were directed to make announcements at each session about the study encouraging eligible persons to participate. An additional announcement was made by the first author at the WSVMA's business luncheon held on the second day of the conference.

Following the end of the conference on September 27, 2015, a secure, web-based version of the survey was made available to veterinarians in the state using an electronic data capture tool hosted at the University of Washington (Harris and others 2009). This data capture system is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources. Links to the online survey, available on a page of the University of Washington's website, were distributed to WSVMA members through an announcement on the organisation's weekly electronic newsletter.

Statistical analysis

Participants were classified into four practice groups: 'large animal/food animal', 'small animal', 'mixed animal' and 'wildlife medicine' according to survey responses to a closed-ended question including a variety of commonly treated animal species. The small animal category included those personnel reporting treatment of dogs, cats or exotic animal species only. The remaining categories of 'Cattle', 'Horse', 'Swine' and 'Chickens' were used to create the large animal/food animal veterinarian category. The category of mixed animal veterinarian was reserved for those who indicated treating at least one large/food animal species and one small animal species on a regular basis. Wildlife veterinarians were self-identified as individuals who noted treating 'Wildlife' after endorsing the 'Other' in the animal focus question. The mode in which respondents performed C/S test and the frequency by which this test is ordered were also summarised. Qualitative text analysis of open-ended questions regarding reasons for ordering tests was performed by the first author using inductive coding to identify common themes describing factors influencing diagnostic ordering behaviour (see Table 1). Counts and proportions for the number of times a given theme was directly stated or identified were computed and are presented. Antimicrobials listed by study participants were grouped by primary drug class. Total counts of drugs and classes were dependent on the number of products listed by

TABLE 1: Major themes identified as reasons for ordering culture and sensitivity (C/S) testing

Reasons for ordering C/S	Specific examples
Animal	Age, health status, severity of infection, novel pathogen, mixed bacterial infection, animal's value, history of conditions/previous infections.
Best practices	Community standard of care or perceived best practices including educating owners on antimicrobial resistance, requiring test results before treatment, etc.
Experience	Comfort with drug, amount of time working in vet med.
Money/cost	Pet insurance, cost of test, if owner able to afford.
Non-healing	Including re-infection, treatment failure.
Other miscellaneous limiting factors	Post-op, mode of delivery, lab limitations, availability of test, etc.
Owner	Owner compliance, owner interest in ordering test.
Sampling	Ease or difficulty of collecting sample, type of sample.
Time	Time lag between ordering test and result.

the respondent. Respondents were allowed to list more than one antimicrobial per system. Responses were not mutually exclusive. The most commonly listed antimicrobial classes used for each body system were identified and are listed. All statistics were computed using a commercially available statistical software program (SAS V.9.4, SAS Institute, Cary, North Carolina, USA).

Results

A total of 203 (8 per cent) out of 2575 veterinarians licensed in the state completed the survey. Three hundred veterinarians from Washington State and the surrounding area registered and attended the Pacific Northwest Veterinary Conference and Trade Show held September 25–27, 2015. Three hundred and eighteen hard copy surveys were distributed at this event of which 59 were returned either in person or by mail. The remainder of the surveys (144, 71 per cent) was completed by participants using the online survey. A majority of respondents were engaged in small and exotic veterinary practice (166, 82 per cent). Respondents averaged 21 years in practice (see Table 2). Ninety-one per cent of participants either strongly agreed or agreed with the public health statement 'antimicrobial resistant infections is an important public health issue'.

Ordering of C/S tests

Ordering C/S testing was reported by 76 per cent of respondents (n=155) (Table 3). Of those, 17 per cent (n=26) reported performing a C/S test >75 per cent of the time. Urine was reported as the most commonly submitted specimen for C/S testing (102, 67 per cent) followed by wound swabs (20, 13 per cent) and a variety of other samples. Ninety-seven per cent reported sending out C/S tests to a diagnostic laboratory (n=151). Of the laboratories listed, three corporate, national veterinary diagnostic laboratories were the most commonly reported sites for C/S testing by this Pacific Northwest population. Ten per cent of respondents (n=26) reported receiving and/or using a clinic-specific summary of antimicrobial sensitivities for particular pathogens (i.e. clinic antibiograms).

TABLE 2: Antimicrobial Prescribing Practices Study participant demographics

Characteristic	n (%)
Years in practice, mean±sd	21±12.8
Practice type	
Small animal (including exotic and companion avian)	166 (82)
Large/food animal	13 (6)
Mixed animal	22 (11)
Zoo and wildlife	2 (1)
'Antimicrobial resistant infections are an important issue in veterinary medicine' (strongly agree or agree)	184 (91)

A number of factors, including both barriers and facilitators to ordering C/S tests were reported by respondents. Using inductive coding, a total of nine major themes and definitions were created (see Table 1).

These themes described several intrinsic and extrinsic factors including but not limited to (1) the factors relating to the animal itself, that is, age, severity of condition, (2) the non-healing nature of the wound, that is, chronic condition, re-infection, treatment failure, (3) veterinary communication style and the desire to adhere to best practices, and (4) factors related to owner compliance and willingness to order a given test and follow through with medical advice regarding medication administration. Of these identified themes, the non-healing nature of a wound or infection as well as factors related directly to the animal itself were the most common influential factors listed by the study respondents (see Table 4). Cost of C/S testing was the most commonly listed barrier (132, 65 per cent). Common facilitators included recurrent infections or treatment failure and a desire to adhere to best practices, and an ability to communicate this to pet owners/clients. These factors were listed by 27 per cent and 24 per cent of respondents, respectively.

Antimicrobials used in practice

For each system affected and/or disease syndrome, there was at least one drug class that was significantly more frequently preferred to other drug classes. β-lactams and fluoroquinolones were the most commonly identified drug classes across all systems and syndromes; β-lactams were the most commonly prescribed drug class overall (Table 5). The most commonly mentioned individual drugs included enrofloxacin (n=146), cephalexin (n=214), amoxicillin trihydrate/clavulanate potassium (n=479) and metronidazole (n=181) (data not shown). These drugs were often listed individually or in combination with other drug classes. Broad-spectrum, clinically important antimicrobials like ciprofloxacin (n=20), enrofloxacin (n=146) and third-generation cephalosporins (n=191) including cefovecin, cefpodoxime and ceftiofur were also reported in this survey. Mode of delivery of these drugs as well as extra-label use was not assessed. All drug use appears to be in accordance with federal law (Code of Federal Regulations Title 21, 2015b).

Discussion

Antimicrobial resistance is a major public health issue both domestically and worldwide (Ciorba and others 2015). The use and overuse of antimicrobials in human and veterinary healthcare as well as plant and animal agriculture are the primary sources for this emerging and worsening issue. The present study suggests that veterinarians in Washington State are concerned about the threat of antimicrobial resistance; however, 24 per cent denied using a bacterial C/S test. Of those 155persons who endorsed using this key diagnostic tool, only 17 per cent (n=26) indicated using it at least 75 per cent of the time. C/S testing provides key information on the resistance patterns and trends of a given pathogen allowing practitioners to choose the best drug for a given case. A desire to adhere to best practices was listed as one of the most common facilitators for ordering a C/S test, suggesting that veterinarians understand the need to protect the integrity of existing therapeutic agents. According to the American Veterinary Medical Association (AVMA), American College of Veterinary Internal Medicine (ACVIM) and Centers for Disease Control and Prevention (2015a), bacterial culture, isolation and sensitivity should always be used when prescribing antimicrobials to ensure that the appropriate drug is selected (Weese 2006). The ACVIM takes their recommendation a step further by encouraging veterinarians to develop protocols identifying primary, secondary and tertiary drugs to be used while either waiting for C/S test results or when such a test is cost-prohibitive. The present study suggests that participants are, in principle, following ACVIM guidelines as written, by ordering

TABLE 3: Frequency and description of culture and sensitivity (C/S) use by practice type

	Small animal (n=166) N (%)	Large animal (n=13) N (%)	Mixed animal (n=22) N (%)	Zoo/wildlife (n=2) N (%)	Total (n=203) N (%)
Perform C/S (yes)	130 (78)*	8 (62)	15 (68)	2 (100)	155 (76)
In-house (n=155)	3 (2)	3 (37)	2 (13)	1 (50)	9 (6)
Send out (n=155)	128 (98)	8 (100)	14 (93)	1 (50)	151 (97)
Do not perform (n=155)	1 (0.8)	0 (0)	0 (0)	0 (0)	1 (0.6)
Always perform C/S test (i.e. >75% of the time)	22 (17)	2 (25)	0(0)	2 (100)	26 (17)
Often or always perform C/S test (i.e. at least 50% of the time)	49 (38)	3 (37)	2 (13)	2 (100)	56 (36)
Most commonly submitted specimen					
Wounds	12 (9)	2 (25)	6 (40)	0 (0)	20 (13)
Urine	95 (73)	0 (0)	7 (47)	0 (0)	102 (67)
Other	22 (17)	6 (75)	2 (13)	1 (50)	31 (20)
Clinic antibiogram (yes)	13 (10)	2 (25)	1 (7)	0 (0)	16 (10)

*Number (per cent) of participating veterinarians in the relevant category.

TABLE 4: Factors, barriers and facilitators identified to ordering of bacterial culture and sensitivity

Reasons for ordering bacterial culture and sensitivity (themes)	Is a factor n (%)	Is a barrier n (%)	Is a facilitator n (%)
Animal	75 (37)	1 (0.5)	23 (11)
Best practices	13 (6)	1 (0.5)	49 (24)
Experience	4 (2)	0 (0)	4 (2)
Money/cost	16 (8)	**132 (65)**	19 (9)
Non-healing	**109 (54)***	0 (0)	**55 (27)**
Other	1 (0.5)	1 (0.5)	10 (5)
Owner	9 (4)	17 (8)	20 (10)
Sampling	3 (1)	5 (2)	3 (1)
Time	1 (0.5)	13 (6)	3 (1)

* Numbers in bold indicate most frequent categories of responses.

and/or attempting to order C/S tests when treating infections in their patients.

The specimen type also appeared to influence the decision to order a C/S test, with urine specimens most commonly reported as warranting C/S testing in the present study. In small animal medicine, urinary tract infections (UTIs) are a frequently diagnosed disease condition of cats and dogs and are caused by a variety of pathogens with varying susceptibilities. It is possible that this diversity of organism and susceptibility contributes to the ordering of C/S tests when such cases occur (Dowling 2009). *Escherichia coli* is the most common agent of UTI, though other causative agents include, but are not limited to, *Staphylococcus, Proteus, Streptococcus, Klebsiella* and *Pseudomonas* species. Best practices recommend urine C/S when treating UTIs in all animal species, with a need for understanding the underlying factors predisposing a given patient to the illness (Weese 2006). Commonly prescribed antimicrobials vary by the causative agent, species affected and value of the animal (Dowling 2009).

The low frequency of C/S testing use was at least partly explained by a perceived economic barrier of cost. Cost, owner compliance, animal-related factors, the non-healing nature of a given infection, and the desire to adhere to best practices were the primary themes influencing veterinary C/S test ordering behaviours in this study. Previous studies on antimicrobial prescribing practices suggest that human factor-related barriers to judicious use such as ease of administration and perceived owner compliance play a key role in resistance emergence (Mateus and others 2014, Bender 2015, Bender and others 2015a,b, Jacob and others 2015). Two Canadian studies used focus group interview with veterinarians and clients to assess factors related to veterinarian-client communication as well as monetary concerns in practice (Coe and others 2007, 2008). Results from these studies suggest that clients appreciate an upfront conversation on the cost of treatment, as well as a two-way communication pathway in which both parties could participate in the dialogue and arrive at a decision as a unit. Improved communication and financial support are needed to overcome these issues and to ensure the integrity of currently available antimicrobials.

The non-healing nature of the infection was identified by veterinarians as being the most influential facilitator allowing them to order a C/S test, more so than a desire to adhere to best practices. Previous studies assessing factors influencing antimicrobial prescribing practices found these extrinsic factors to influence veterinary practice in other countries (Hughes and others 2012, Mateus and others 2014). Unfortunately, it is possible that multiple treatment failures or repeated reoccurrence of a given condition could be due to reduced sensitivity or resistance of a pathogen to a specific antibacterial agent, further contributing to the issue of antimicrobial resistance. Thus, veterinarians must find a way to uphold best practices at all times when prescribing antibacterial agents for any condition where the primary treatment is ineffective (Morley and others 2005).

In addition to the low prevalence of C/S use indicating that empirical therapy is most common, respondents reported frequent use of critically important broad-spectrum antibiotics such as fluoroquinolones and third-generation cephalosporins; a practice that could contribute further to antimicrobial resistance (WHO 2011). National and international guidelines suggest empirical therapy can be appropriate when used in combination with bacterial culture and sensitivity; however, these rules also outline the importance of using an appropriate first-line drug that is targeted to the most likely bacterial source given the presenting signs and system affected (Weese 2006, Collignon and others 2009, Orand 2012, Corning 2014). It is important for veterinary personnel to prioritise best practices for judicious antimicrobial use in order to prevent the emergence of further resistance.

Few veterinarians indicated knowing about or not receiving clinic antibiograms which provide key information on trends in antimicrobial sensitivities among patients visiting a given clinic. It is not clear however, whether participants referred to or were comfortable with the definition of antibiogram in the survey question. It is possible that few endorsed this question due to a lack of familiarity with the term and/or the availability of the service from the diagnostic laboratory. Clinic antibiograms could provide key summary information on historic and current resistance patterns of samples submitted to a given lab (Binkley and others 2006). Being aware of such trends in resistance for samples from their clinic would help veterinary personnel carry out effective antimicrobial stewardship. Veterinary diagnostic labs could also promote the use of antibiograms by routinely providing such data to ordering clinics on a periodic basis.

Limitations of this study include its small sample size and its cross-sectional nature which precluded a more in-depth hypothesis test of antimicrobial use behaviours, and prevented generalisations to the veterinary profession overall; however, study demographics of participating veterinarians mirrored that of the profession statewide and nationally suggesting that the results may be broadly generalisable (AVMA 2014). Information on the

TABLE 5: Frequency of reported use of antimicrobials by system affected

Drug class	Frequency of reported use by system/syndrome, n						
	Bacteraemia*	Gastrointestinal	Fever of unknown origin	Dermatological	Reproductive	Respiratory	Urogenital
Aminoglycosides	20	4	7	2	6	3	1
B-lactams	**132**	**71**	**145**	**178**	**108**	**152**	**164**
Third-generation cephalosporins	11	3	25	94	11	13	34
Dihydrofolate inhibitors	6	16	3	17	2	14	23
Fluoroquinolones	**111**	14	**69**	**19**	**43**	67	**63**
Lincosamides	5	3	10	17	2	8	2
Macrolides	0	19	0	1	2	21	1
Nitroimidazoles	19	**163**	6	0	1	3	0
Phenicols	5	0	2	1	1	8	1
Tetracyclines	9	10	33	6	4	**110**	5
Other	6	0	6	2	4	2	2
Missing	20	18	19	17	31	17	17
N/A	27	4	11	2	40	5	4

*The two most commonly reported drug classes are bolded for each column

mode of delivery and frequency of administration of commonly used antimicrobials as well as the use of broad-spectrum antimicrobials with or without C/S test results would have provided additional insight on antimicrobial use beyond that of prescribing practices described here. Finally, respondents were asked to list common antimicrobials used by system/syndrome affected. Additional information on primary use versus secondary and tertiary use drugs was not collected. This flaw in survey design precluded additional analyses assessing frequency of C/S test use in combination with self-reported use of clinically important broad-spectrum antibiotics. Despite the limitations of this study, the results provide sufficient data to inform veterinary leadership charged with policy and educational development directed at improved antimicrobial use practices in the profession. Research in diagnostics can contribute significantly by developing more cost-effective diagnostic methods that can address the financial barrier identified as one of the most important impediments to use of C/S testing in this study.

In addition, these results will be used to further the One Health initiative in the state by allowing comparisons between barriers and facilitators of antimicrobial stewardship between veterinary medicine and human medicine. It is possible that solutions identified in one sector can be translated to another, although the different economic reimbursement patterns in human versus veterinary medicine will likely pose a significant obstacle. Beyond shared models of stewardship, combining antimicrobial resistance data on both human beings and animals can be used to develop a One Health shared antibiogram. The authors highly encourage other states to attempt similar assessments.

Acknowledgements

The authors thank Christian J Ie and Bianca Irimia for their assistance with data entry.

Funding This study was funded in part by the Biomedical Sciences and Biostatistics Epidemiologic and Bioinformatic Training in Environmental Health (BEBTEH) fellowship T32ES015459.

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