Opinions of clinical veterinarians at a US veterinary teaching hospital regarding antimicrobial use and antimicrobial-resistant infections

Megan E. Jacob, PhD; Jane A. Hoppin, ScD; Nicola Steers, BS; Jennifer L. Davis, DVM, PhD; Gigi Davidson, RPh; Bernie Hansen, DVM; Katharine F. Lunn, DVM, PhD; K. Marcia Murphy, DVM; Mark G. Papich, DVM, MS

Objective—To determine opinions of faculty members with clinical appointments, clinical veterinarians, residents, and interns at a US veterinary teaching hospital regarding antimicrobial use and antimicrobial-resistant infections.

Design—Cross-sectional survey.

Sample—71 veterinarians.

Procedures—An online questionnaire was sent to all veterinarians with clinical service responsibilities at the North Carolina State University veterinary teaching hospital (n = 167). The survey included 23 questions regarding demographic information, educational experiences, current prescribing practices, and personal opinions related to antimicrobial selection, antimicrobial use, restrictions on antimicrobial use, and antimicrobial resistance.

Results—Of the 167 veterinarians eligible to participate, 71 (43%) responded. When respondents were asked to rate their level of concern (very concerned = 1; not concerned = 5) about antimicrobial-resistant infections, most (41/70 [59%]) assigned a score of 1, with mean score for all respondents being 1.5. Most survey participants rated their immediate colleagues (mean score, 1.9) as more concerned than other veterinary medical professionals (mean score, 2.3) and their clients (mean score, 3.4). Fifty-nine of 67 (88%) respondents felt that antimicrobials were overprescribed at the hospital, and 32 of 69 (46%) respondents felt uncomfortable prescribing at least one class of antimicrobials (eg, carbapenems or glycopeptides) because of public health concerns.

Conclusions and Clinical Relevance—Findings indicated that veterinarians at this teaching hospital were concerned about antimicrobial resistance, thought antimicrobials were overprescribed, and supported restricting use of certain antimicrobial classes in companion animals. Findings may be useful in educating future veterinarians and altering prescribing habits and antimicrobial distribution systems in veterinary hospitals. (J Am Vet Med Assoc 2015;247:938–944)

Antimicrobial use and antimicrobial-resistant infections are increasingly important public health concerns. Scientific evidence linking antimicrobial-resistant bacteria to morbidity and death is accumulating, and the CDC has suggested that antimicrobial agents considered to be critically important to human health should be restricted to use in humans.1 As a result of this increasing awareness, various groups, including the AVMA, have crafted policies and formed task forces to promote antimicrobial stewardship and judicious antimicrobial use in human and veterinary medicine.2–6 Additionally, government agencies have outlined the human health threats of antimicrobial resistance and urged improvements in antimicrobial prescribing practices and antimicrobial stewardship.1 Despite these measures, there is evidence in human hospitals of ongoing redundant and inappropriate antimicrobial prescribing practices.7–9

Several reports10–16 have described the antimicrobial prescribing habits of veterinarians in Europe and Canada; however, less is known about the appropriateness of antimicrobial prescribing practices among US veterinarians. Case selection, antimicrobial selection, and timing and duration of administration were found to be suboptimal in a survey of British veterinarians presented with various scenarios related to perioperative antimicrobial use for small animal surgical procedures.17 There is also evidence from a small animal teaching hospital that antimicrobial use guidelines may influence prescribing practices.15 Beyond prescription records, however, little is known about how the education and opinions of veterinarians toward antimicrobial use, restrictions on antimicrobial use, and antimicrobial resistance might influence prescribing practices, mentee education, or acceptance of antimicrobial stewardship programs.

Veterinary teaching hospitals provide a unique environment to influence graduate and postgraduate
clinical veterinary education and opinions about antimicrobial use and antimicrobial resistance. By providing antimicrobial treatment for both primary care and tertiary referral cases, students, interns, and residents at veterinary teaching hospitals are able to participate in the full spectrum of antimicrobial selection and use. The education of veterinarians in the principles and practices of antimicrobial stewardship is also essential to the success of animal and public health policies and programs. The American College of Veterinary Internal Medicine addressed the need for educational experiences in antimicrobial drug use and antimicrobial resistance at all levels of the veterinary profession, including veterinary students, interns, and residents, in a 2005 consensus statement. The AVMA position statement on Judicious Therapeutic Use of Antimicrobials also calls for improved “utilization of scientifically based antimicrobial use practices through education of veterinarians.” Therefore, veterinary teaching hospitals have an important role in modeling appropriate antimicrobial practices and behaviors while providing the best possible patient care.

The objectives of the study reported here were to assess opinions of clinical veterinarians at a US teaching hospital regarding antimicrobial use and antimicrobial-resistant infections and identify educational experiences and information sources that may have influenced those opinions. It was hoped that findings could serve as a marker of opinions in the broader veterinary profession and help identify opportunities to make gains in antimicrobial education and antimicrobial stewardship.

Materials and Methods

The survey and methods used in the study were approved by the North Carolina State University Institutional Review Board for the Protections of Human Subjects in Research. The survey questionnaire was constructed and validated by epidemiologists, veterinary clinicians, and research personnel prior to administration. An email with an electronic link to the survey questionnaire was distributed to eligible participants, including faculty members with clinical appointments, clinical veterinarians, residents, and interns (n = 167) at the North Carolina State University Veterinary Hospital. Follow-up email reminders were sent weekly. The survey was administered in May 2014 and remained open to access for 3 weeks. Participants were required to log in through an internal website to prevent duplicate entries; however, no personal information was attached to survey responses.

The survey included 23 questions regarding demographic information, educational experiences, current prescribing practices, and personal opinions related to antimicrobial selection, antimicrobial use, restrictions on antimicrobial use, and antimicrobial resistance. For all questions that required participants to rate perceived importance of or concern about a topic, an ordinal Likert scale of 1 (very concerned or very important) to 5 (less concerned or less important) was used. The median, mean, mode, and range for scaled data were calculated with spreadsheet software. For data analysis, questions with multiple response options were occasionally collapsed into smaller categories. As an example, participants were asked which best described how often they prescribe antimicrobials: more than once per day, once per day, once per week, once per month, infrequently, or never. These categories were collapsed into at least once per day, less than once per day, and never on the basis of similarity of categories and equal distribution of responses. Graduation year was collapsed into 2 categories—between 1975 and 2004 and between 2005 and 2013—on the basis of approximately equal frequencies. Opinions on antimicrobial use within the veterinary teaching hospital were collapsed into 3 categories: underprescribed, appropriately prescribed, or overprescribed. Free-form text and open-ended responses (eg, antimicrobials participants did not feel comfortable prescribing for public health reasons) were often coded into more broad categories on the basis of similar responses (eg, drug class or name). Finally, to compare how concerned about antimicrobial resistance respondents themselves were with how concerned they perceived colleagues, veterinary professionals in general, and clients to be, scores assigned by respondents to a question on how concerned they were about antimicrobial resistance were compared with scores assigned to questions on how concerned they perceived these other demographic groups to be. For example, if an individual rated his or her personal concern as a 1, but rated colleagues’ concern as a 3, that individual was classified as being more concerned than his or her colleagues. Because the survey sample size was small, formal statistical testing was not performed.

To obtain information on antimicrobial prescribing practices at the time of the survey, antimicrobial prescription information was obtained from electronic hospital pharmacy records for July and October 2012, January and April 2013, July and October 2013, and January and April 2014 (ie, 8 months total). The information was considered to be representative of general prescribing trends at the veterinary teaching hospital. Data obtained included case number, antimicrobial description, date, veterinarian requestor, clinical service, and species (large animal [equine or food animal], small animal, nonaccession, or anesthesia). At the time of the survey, there were no restrictions or approvals needed for hospital clinicians to prescribe any antimicrobial agent.

Results

In 2013, approximately 12,000 patients were seen at the North Carolina State University Veterinary Hospital during 27,816 visits. Of these, approximately 88% were canine or feline patients and 7.8% were equine patients. Evaluation of hospital pharmacy records for 8 individual months prior to survey administration indicated that the mean number of antimicrobial prescriptions was 1,678 prescriptions/mo (range, 1,486 to 1,949 prescriptions/mo) and mean monthly accessions (patient load) was 2,399 patients/mo (range, 2,196 to 2,639 patients/mo). Frequently, individual animals were prescribed multiple antimicrobials. Mean number of antimicrobial prescriptions was 1,031 prescriptions/mo for the small animal clinical service and 416 prescriptions/mo for the large animal (equine or food animal) clinical service. The remaining prescriptions were...
not related to a scheduled appointment and were not tracked to a specific service.

Seventy-one of the 167 (43%) eligible veterinarians responded, at least partially, to the survey (Table 1). Subjectively, the demographic distribution of participants appeared to be representative of the demographic distribution of eligible veterinarians.

For survey respondents, year of graduation from veterinary school ranged from 1975 to 2013, with an approximately equal number graduating between 1975 and 2004 as graduated between 2005 and 2013. Almost all (64/71 [90%]) respondents mentored veterinary students, and many mentored residents (35/71 [49%]) or interns (44/71 [62%]). Most (45/70 [64%]) respondents were in small animal practice. Only 3 of the 71 (4%) respondents reported never prescribing antimicrobials, whereas 35 (49%) reported prescribing antimicrobials at least once per day, and 33 (46%) reported prescribing antimicrobials once per week, once per month, or infrequently. Most respondents (66/71 [93%]) indicated that they were able to prescribe antimicrobials at their own discretion, but 5 respondents (7%) indicated that they could not prescribe antimicrobials at their own discretion. Of the 69 respondents, 63 (91%) reported that an accurate patient body weight was always obtained before antimicrobials were prescribed, whereas 6 (9%) reported they did not always weigh a patient before prescribing an antimicrobial.

To better understand respondents’ educational experiences, the survey questionnaire included a series of questions related to public health training (no definition of training was provided). Of the 71 respondents, only 2 (3%) had an MPH degree; 15 (21%) considered themselves to have no public health training. The remaining participants reported receiving public health training in veterinary school, through continuing education, at graduate school, or through other venues. Of the 56 respondents who indicated that they had received public health training, most (54/56 [96%]) reported having received training while attending veterinary school, 15 (27%) reported having received training while attending veterinary school and from 1 or more additional sources (eg, continuing education courses, graduate school, or structured internships), and 1 (2%) reported having received this training while in graduate school but not while attending veterinary school. Finally, 25 of the 36 (69%) respondents who had graduated between 1975 and 2004 reported having received public health training, compared with 28 of the 32 (88%) respondents who had graduated between 2005 and 2013.

Most respondents (37/70 [53%]) indicated that an emphasis on antimicrobials was included in multiple courses in their preclinical veterinary education (18/35 [51%] who had graduated between 1975 and 2004 and 17/31 [55%] who had graduated between 2005 and 2013); 25 of 70 (36%) respondents indicated the topic was covered thoroughly in a single preclinical course (13/35 [37%] who had graduated between 1975 and 2004 and 11/31 [35%] who had graduated between 2005 and 2013), and 8 of 70 (11%) respondents indicated the topic was lightly covered (4/35 [11%] who had graduated between 1975 and 2004 and 3/31 [10%] who had graduated between 2005 and 2013).

Respondents were asked to score (on a scale from 1 to 5, where 1 = very concerned and 5 = less concerned) how concerned they were about antimicrobial-resistant infections. Assigned scores ranged from 1 to 4 (mean score, 1.5), but most (41/70 [59%]) respondents assigned a score of 1 (very concerned; Figure 1). Mean score for degree of concern about antimicrobial-resistant infections was 1.4 for respondents who had graduated between 1975 and 2004 and was 1.6 for respondents who had graduated between 2005 and 2013 (Figure 2).

When respondents were asked to rate how concerned they thought other individuals were about antimicrobial-resistant infections, most rated their immediate colleagues (mean score, 1.9) as more concerned than other veterinary medical professionals (mean score, 2.3) and their clients (mean score, 3.4; Figure 1). Of 70 respondents, 21 (30%) rated themselves as more concerned about antimicrobial-resistant infections than their immediate colleagues and 40 (57%) rated themselves as more concerned than other veterinary medical professionals. Only 3 (4%) respondents rated themselves as less concerned than their immediate colleagues, and only 4 (6%) rated themselves as less concerned than other veterinary medical professionals.

When respondents were asked whether antimicrobials were underprescribed, appropriately prescribed, or overprescribed at the veterinary teaching hospital, 8 of 67 (12%) answered that all antimicrobials were appropriately prescribed, whereas 59 (88%) answered that some or all antimicrobials were overprescribed. Of the 8 who answered that all antimicrobials were appropri-
ately prescribed, 6 were residents or interns and 2 were faculty members. For veterinarians who responded that some or all antimicrobials were overprescribed, the mean score for concern about antimicrobial-resistant infections was 1.6; the mean score was 1.8 for veterinarians who responded that all antimicrobials were appropriately prescribed. Mean scores for how concerned respondents perceived their colleagues to be about antimicrobial-resistant infections were similar for veterinarians who responded that all antimicrobials were appropriately prescribed (mean score, 2.1) and veterinarians who responded that some or all antimicrobials were overprescribed (mean score, 2.0).

Thirty-two of 69 (46%) respondents reported there was an antimicrobial they felt uncomfortable prescribing for public health reasons. Those antimicrobials were primarily vancomycin (14/32 [44%]), carbapenems (12/32 [38%]), and chloramphenicol (9/32 [28%]), with several participants listing multiple antimicrobials. Of the 32 respondents who felt uncomfortable prescribing at least 1 class of antimicrobials, 29 (91%) felt that at least 1 class of antimicrobials should be restricted for use in companion animals. Of the 37 (54%) respondents who were comfortable prescribing any antimicrobial, 20 (54%) felt that at least 1 class of antimicrobials should be restricted for use in companion animals because of public health concerns. Seventeen of 67 (25%) respondents felt there should be no restrictions on antimicrobial use in companion animals because of public health concerns. The number of classes that an individual respondent felt should be restricted felt for use in companion animals decreased as their relative concern about antimicrobial-resistant infections decreased, although this was not analyzed statistically to identify a significant trend (Table 2).

Because of the high levels of concern associated with overprescribing of vancomycin and carbapenems, use of these antimicrobials as a percentage of the total antimicrobial prescriptions at the veterinary teaching hospital was evaluated for both the small and large animal services. Carbapenems accounted for a mean of 0.13% (range, 0% to 0.9%) of monthly prescriptions for the large animal service and a mean of 1.9% (range, 1.1% to 2.6%) of monthly prescriptions for the small animal service. However, some of these prescriptions were ordered for the same patient on multiple occasions. When evaluating specific patients prescribed an antimicrobial, carbapenems were prescribed to 2.3 cases/1,000 accessions during the 8 months for which data were collected. Vancomycin prescriptions were less frequent, with 0 prescriptions by the large animal service and a mean of 0.05% (range, 0% to 0.2%) of monthly antimicrobial prescriptions for the small animal service. Vancomycin was prescribed to 0.2 cases/1,000 accessions during the study period.

To identify factors influencing veterinarian’s choices of antimicrobial treatment for individual patients, respondents were asked to rate the importance (1 = very important; 5 = not important) of 12 factors in their decision-making process (Table 3). Factors rated as most important included results of bacteriologic culture and antimicrobial susceptibility testing (mean score, 1.1; median score, 1) and clinical signs (mean score, 1.3; median score, 1). Factors rated as least important included expectations of clients (mean score, 3.1; median score, 3) and expectations of peers or colleagues (mean score, 3.3; median score, 3). Six respondents gave either client or peer expectations a rating of 1 (very important). Cumulatively, the mean score for these individuals for all factors was 1.5, indicating they did not answer every response with a value of 1.
important. When respondents were asked to describe the
(mean score, 4.0; median score, 2) were rated as least
score, 2). Online media resources (mean score, 4.2; me-
reviewed literature (mean score, 1.2; median score, 1),
Table 4—Mean and median scores assigned by veterinarians at a
focusing on antimicrobial-resistant infections (scored on a scale from 1 to 5, where 1 = very concerned and 5 = less concerned).

Table 3—Mean and median scores assigned by veterinarians at a
choosing an antimicrobial (scored on a scale from 1 to 5, where 1 = very concerned and 5 = less concerned).

Table 2—Mean number of antimicrobial classes that veterinarians
at a US teaching hospital (n = 67) felt should be restricted for use
in companion animals because of public health concerns, as a
function of score for how concerned respondents were about
antimicrobial-resistant infections (scored on a scale from 1 to 5, where 1 = very concerned and 5 = less concerned).

6 veterinarians who rated peer or client expectations as
very important, 2 graduated between 1975 and 2004, and 4 graduated between 2005 and 2013.

The questionnaire also asked about the resources
veterinarians most valued when obtaining information on antimicrobial use and antimicrobial resistance (Table 4). Resources rated as most important included peer-reviewed literature (mean score, 1.2; median score, 1), textbook or drug handbooks (mean score, 1.7; median score, 2), and service peers (mean score, 1.8; median score, 2). Online media resources (mean score, 4.2; median score, 4) and the Veterinary Information Network (mean score, 4.0; median score, 4) were rated as least important. When respondents were asked to describe the
most commonly used source for antimicrobial information, 13 of the 66 (20%) respondents listed more than 1 source. A formulary (textbook or drug handbook or online formulary) was listed by 56 (85%), expert opinion by 11 (17%), and peer-reviewed literature by 8 (12%) respondents. Of the 52 respondents who listed only a single source, 41 (79%) indicated a formulary and 4 (8%) indicated expert opinion (these responses often indicated service peers or a pharmacist, clinical microbiologist, or clinical pharmacologist).

Discussion

Previous reviews13,17 have highlighted a need for improvements in veterinary prescribing practices, and the potential for antimicrobial stewardship programs to change prescribing habits in human and veterinary hospitals has been demonstrated.12,18 However, broader community attitudes toward antimicrobial use, restrictions on antimicrobial use, and antimicrobial resistance remain understudied in veterinary medicine. The present study targeted faculty members, clinical veterinarians, residents, and interns at a US veterinary teaching hospital who were responsible for antimicrobial prescriptions and highly involved in the mentoring of veterinary students. The study population was diverse, with respondents having received their education from many colleges (both inside and outside the United States) and representing a variety of veterinary medical specialties. Survey respondents were demographically representative of the broader eligible population at the veterinary teaching hospital, indicating strong internal validity. Still, the results may be more reflective of opinions of clinicians at other veterinary teaching hospitals than the general veterinarian population at large.

More than half of study participants (41/70 [59%]) responded that they were very concerned about antimicrobial-resistant infections (ie, a score of 1 on a scale from 1 to 5). Only 7 (10%) respondents assigned a score of 3 or 4, and none assigned a score of 5 (ie, less concerned). We did not determine whether respondents interpreted this question in the context of concern directly related to patient care or more broadly related to public health. However, respondents were apparently aware of and concerned about the use of antimicrobials considered to be critically important to public health, in that 46% (32/69) reported there was an antimicrobial they felt uncomfortable prescribing because of public health implications. Vancomycin and carbapenems, antimicrobials considered of critical importance in human medicine because of emerging antimicrobial resistance patterns,5 were frequently identified as drugs that respondents thought should be restricted or felt uncomfortable prescribing. Interestingly, the number of carbapenem prescriptions (2.3 cases/1,000 acquisitions) in the present study was higher than that reported in a previous study15 involving a small animal veterinary teaching hospital (1.3 cases/1,000 acquisitions). At the time the survey described in the present study was administered, there were no restrictions or approvals needed for hospital clinicians to prescribe any antimicrobial agent, and we did not determine whether discomfort with prescribing any particular drug affected individual respondents’ prescribing behavior. A poten-
tially important factor influencing carbapenem and glycopeptide prescribing behavior in the veterinary teaching hospital was the relatively inexpensive cost of these antimicrobials at this hospital, whereas carbapenems and glycopeptides may be cost-prohibitive in noninstitutional practices. However, veterinarians at this teaching hospital had no financial incentives to prescribe antimicrobials, which has been previously argued as influential for veterinarians in private practice.

In the present study, 96% (67/70) of respondents rated themselves as equally or more concerned about antimicrobial-resistant infections than their immediate colleagues at the veterinary teaching hospital and 94% (66/70) rated themselves as equally or more concerned about antimicrobial-resistant infections than other veterinary professionals. Similarly, a previous study\(^{19}\) at a human hospital found that most providers responding to a survey on antimicrobial prescribing and resistance felt that overprescribing of antimicrobials was a major cause of antimicrobial resistance; however, only 18% indicated they personally overprescribed. This difference between respondents’ self-reported level of concern versus their colleagues’ perceived level of concern may be explained, at least in part, by optimistic bias or illusory superiority.\(^ {10}\) Regardless, the potential for prescribing opinions and practices to influence student practices at a veterinary teaching hospital is real. Several health-care and medical education studies\(^ {21,22}\) have demonstrated the importance and impact of role models on student and colleague practices and behaviors. In addition, 80% of pediatrician survey respondents at a children’s hospital that recently implemented an antimicrobial stewardship program felt that better training in medical school and residency programs was influential for veterinarians in private practice.

In the present study, results of bacteriologic culture and antimicrobial susceptibility testing received the highest scores when respondents were asked to rate the importance of 12 factors in choosing an antimicrobial. Many prudent-use guidelines suggest the use of such tests for accurate diagnosis and treatment.\(^ {2}\) Yet, several studies\(^ {13,14}\) have suggested that use of antimicrobials is rarely associated with laboratory testing, including antimicrobial susceptibility testing. Although antimicrobial susceptibility testing is highly valued, it is often not performed or not available. For the present study, we did not ask participants to record the frequency with which they performed antimicrobial susceptibility testing prior to or in association with antimicrobial use. Similarly, peer-reviewed literature received the highest scores when respondents were asked to rate the importance of 10 sources of information on antimicrobial use and resistance. However, when asked to describe the most commonly used source for antimicrobial information, formularies were listed by 56 of 66 (85%) respondents and peer-reviewed literature by only 8 (12%). Previous work\(^ {17}\) has identified clinical experience and colleagues as commonly cited information sources for antimicrobial use, similar to the results of our study. Together, these observations suggest that veterinarians highly value processes or practices (eg, peer-reviewed literature) that they may not routinely use to make clinical decisions. Although there are many possible explanations, including high demands on time, resources, and finances, the bias toward certain informational resources should be a point of educational opportunity and may contribute to successful antimicrobial stewardship programs.

It is likely that individual clinical services or specialties within the teaching hospital surveyed in the present study differed in regard to antimicrobial prescribing practices and opinions about antimicrobial resistance. To maintain anonymity, we did not include a question regarding specialty service on this survey, and we did not have a large enough participant pool to meaningfully compare concerns and opinions between veterinarians predominantly treating small animals versus large animals. However, we speculate that FDA restrictions on antimicrobial use in food animals may have affected opinions of respondents in that field. It seems equally likely that institutional culture and demographics may influence opinions on antimicrobial use and antimicrobial resistance. This is supported by findings of decreased antimicrobial use and more appropriate drug choice in institutions implementing and educating veterinarians or physicians on antimicrobial stewardship.\(^ {12,18}\) Although similar surveys administered at a peer teaching hospital may bring disparate results, elucidating associations with institutional practices and patient demographics would be valuable.

In conclusion, results of the present study indicated that veterinarians associated with a US veterinary teaching hospital were concerned about antimicrobial prescribing habits and antimicrobial-resistant infections. However, it was beyond the scope of this study to link these concerns to any specific antimicrobial use practices. Mean score for concern about antimicrobial-resistant infections was slightly lower among more recent graduates, but this difference was not analyzed statistically to determine significance. Although few participants had received public health training beyond veterinary school, participants were aware of antimicrobial drug classes considered critical for antimicrobial treatment in human health, and some were uncomfortable prescribing them. Most veterinarians felt that antimicrobials within the veterinary teaching hospital were overprescribed and that there was merit in restricting the use of certain antimicrobial classes (ie, carbapenems, glycopeptides, and chloramphenicol) in companion animals. These concerns indicate potential willingness by veterinary teaching hospital clinicians to educate future veterinarians in the principles of antimicrobial stewardship and to implement positive changes in hospital antimicrobial prescribing and distribution practices. It is hoped that the results of this survey will spur reevaluation of the importance of including antimicrobial stewardship principles in veterinary school curricula.


b. Excel 2010, Microsoft Corp, Redmond, Wash.

References


