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

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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 glycocopeptides) 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)
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 measure 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 Protection 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, 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 4, 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 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 training while attending veterinary 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 [53%] 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 [33%] 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 to be restricted 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. Of the...
important. When respondents were asked to describe the
(mean score, 4.0; median score, 4) were rated as least
median score, 4) and the Veterinary Information
score, 2). Online media resources (mean score, 4.2; me-
score, 2), and service peers (mean score, 1.8; median
reviewed literature (mean score, 1.2; median score, 1),
resources rated as most important included peer-
antimicrobial use and antimicrobial resistance
Table 3—Mean and median scores assigned by veterinarians at a
resources when choosing an antimicrobial (scored on a scale from 1 to 5, where 1 =
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Table 4—Mean and median scores assigned by veterinarians at a
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more commonly used source for antimicrobial information, 13 of the 66 (20%) respondents listed more than 1
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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, restric-
tions on antimicrobial use, and antimicrobial resistance
remain understudied in veterinary medicine. The pres-
tent study targeted faculty members, clinical veterin-
arians, residents, and interns at a US veterinary
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 opin-
ions 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 anti-
microbial-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 con-
cerned). We did not determine whether respondents
interpreted this question in the context of concern for
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 hu-
mans were identified as drugs that respondents
were uncomfortable prescribing. Interestingly, the number of
carbenem prescriptions (2.3 cases/1,000 accessions)
in the present study was higher than that reported in
a previous study12 involving a small animal veterinary
hospital (1.3 cases/1,000 accessions). 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 anti-
microbial agent, and we did not determine whether dis-
comfort with prescribing any particular drug affected
individual respondents’ prescribing behavior. A poten-
Table 3—Mean and median scores assigned by 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
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
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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 study19 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.20 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 studies21,22 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 an important mechanism to decrease inappropriate antimicrobial use.18

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 studies13,14 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 work17 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.

References

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JAVMA, Vol 247, No. 8, October 15, 2015
Scientific Reports 943


