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Scientific Article

Descriptive epidemiological study of the use of antimicrobial drugs by companion animal veterinarians in New Zealand

EJ Pleydell*§, K Souphavanh*†, KE Hill*, NP French* and DJ Prattley*

Abstract

AIM: To describe the patterns of use of antimicrobial drugs by veterinary surgeons treating commonly presented bacterial infections in companion animals in New Zealand.

METHODS: A postal survey of 800 randomly selected companion animal veterinarians practicing in New Zealand was conducted between August and December 2008. Data were collected regarding the antimicrobials prescribed for recent cases of skin, ear and urinary tract infections; the use of culture and susceptibility testing; and veterinarian characteristics such as proportion of time spent treating companion animals and recent attendance at continuing professional development (CPD) events. Potential associations within the data were explored using extended mosaic plots and multivariable regression models.

RESULTS: Completed surveys from 393 respondents were available for analysis, providing data on systemic antimicrobial drug use for 1,799 cases of presumptive bacterial infections. The most frequently prescribed drugs were amoxicillin-clavulanic acid (864 cases, 48%), cephalexin (558, 31%), and fluoroquinolones (198, 11%). Of 359 cases of canine superficial pyoderma, 157 (44%) were treated with amoxicillin-clavulanic acid and 155 (43%) were treated with cephalexin with median reported treatment durations of 7 and 10 days, for these two drugs respectively. Culture and susceptibility tests had been used in 376 of 1,984 (19%) of all reported cases and 160 (43%) of these were suspected urinary tract infections. Practitioners that spent 100% of their time treating companion animals and who had attended a CPD course related to companion animals within the 12 months prior to completing the survey were more likely to submit a sample for culture and susceptibility testing and to prescribe longer courses of antimicrobials for the treatment of canine pyoderma than practitioners who spent less than 100% of their time treating companion animals and had not attended a CPD course in the last 12 months.

CONCLUSIONS: Broad-spectrum drugs considered by the World Health Organisation to be critically important for human health, such as fluoroquinolones and amoxicillin-clavulanic acid, are amongst the most frequently prescribed antimicrobials in companion animal medicine, and these drugs are often prescribed without submitting a sample for culture and susceptibility testing.

CLINICAL RELEVANCE: Many cases of superficial pyoderma were treated for less than the recommended duration of 21 days, which may contribute to a higher rate of recurrent pyoderma and the development of drug resistance within the causal bacteria. Veterinarians should be aware that the use of fluoroquinolones, in particular, should be based upon the results of a culture and susceptibility test.

KEY WORDS: *Antimicrobial, antibiotic, antibacterial, resistance, companion animals, pets, skin infections, pyoderma, ear infections, urinary tract infections, New Zealand*

Introduction

Antimicrobial drugs play a vital role in the health and welfare of humans and domestic animals. However, the use of antimicrobial drugs in veterinary medicine and their contribution to the development of antimicrobial resistance in human pathogens is the subject of ongoing scientific and public debate. For the past 40 years this debate has largely focused upon the use of antimicrobial drugs in food animals and the potential for the spread of drug-resistant bacteria to humans via the food chain (Swann 1969; Phillips *et al.* 2004; Soulsby 2007; Jensen *et al.* 2008). The potential human health risks associated with the carriage of antimicrobial-resistant bacteria by companion animals had received less attention (Guardabassi *et al.* 2004) until it was recently recognised that methicillin-resistant staphylococci could be transmitted between humans and animals, with clinical implications for both (Weese *et al.* 2006; Grinberg *et al.* 2008; Kempker *et al.* 2009).

Over recent decades, the number of companion animals has increased substantially in western societies, and veterinary medical care is now devoted to maintaining a high standard of welfare for pet animals (Guardabassi *et al.* 2004). The quantities of antimicrobial drugs used in companion animal medicine remain far smaller than the quantities used in food animal production, but the quantities of drugs administered to pet animals are increasing. Furthermore, the diagnostic and

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CPD	Continuing professional development
NZVA	New Zealand Veterinary Association
VCNZ	Veterinary Council of New Zealand
WHO	World Health Organisation

treatment options for companion animals are similar to those for humans, and the agents that are frequently used to treat animals often include drugs that are important in human medicine (DeVincent and Reid-Smith 2006). An area of particular public health concern is the possibility that pet animals could become reservoirs of bacteria that are resistant to drugs that are critically important in human medicine (Lloyd 2007).

In order to ascertain whether bacteria are becoming resistant to the antimicrobial drugs used in companion animal practices, as well as to allow for an informed assessment of the public health risks associated with this possibility, a variety of data are required to be collected. Surveillance activities are needed to ascertain to what degree companion animals are carrying drug-resistant bacteria and the extent to which such bacteria are causing infections in these species. However, it is also vital to obtain statistically valid estimates of the quantities of antimicrobial drugs that are being used to treat pet animals, in conjunction with an understanding of the common patterns of drug use in companion animal medicine (DeVincent and Reid-Smith 2006).

In recent years, tremendous efforts have been made to collect data on the use of antimicrobial drugs in food animals in many countries, and systems for surveying antimicrobial-resistant bacteria along the food chain are increasingly sophisticated. In contrast, data on the use of antimicrobials in companion animals are extremely limited (DeVincent and Reid-Smith 2006; Lloyd 2007). With respect to data from New Zealand, figures are available regarding the sales of antimicrobial drugs for veterinary purposes (Anonymous 2010a), but data on how antimicrobials are used in companion animal practices are not available.

To this end, a national cross-sectional survey was conducted to investigate the patterns of use of antimicrobial drugs by veterinary surgeons treating companion animals across New Zealand. In order to give the study an appropriate focus, information was sought regarding the most common clinical presentations that are treated using antimicrobial drugs. It has been noted elsewhere that canine pyoderma is the primary reason for antimicrobial treatment in companion animal practice, followed by other skin infections, wounds, otitis externa, urinary tract infections and respiratory infections (Guardabassi *et al.* 2004; Pedersen *et al.* 2007; Guardabassi *et al.* 2008).

Therefore, the objectives of this descriptive epidemiological study were to collect baseline data on the veterinary use of antimicrobials for the treatment of skin, ear and urinary tract infections in companion animals in New Zealand and to use these data to describe the patterns of use of antimicrobial drugs by veterinary surgeons. In particular, the aim was to ascertain which drugs were commonly chosen to treat each disease, the durations of treatments prescribed and for which cases culture and susceptibility tests would be utilised. The data were also explored for potential associations between the use of various drug and veterinarian characteristics, such as the percentage of time spent in companion animal practice, participation in continuing education programmes and postgraduate qualifications. This dataset will also provide a valuable reference for comparison with patterns of drug resistance in bacterial pathogens isolated from companion animals.

Materials and methods

Population and sample size

The source population for the survey was veterinarians who were registered with the Veterinary Council of New Zealand (VCNZ) and who were working in clinical practice in New Zealand in August 2008. A total of 2,325 veterinarians were registered at that time, and an official request was made to the VCNZ for access to their electronic database. Veterinarians that were not listed as treating companion animals were identified by examining the details available in the database and were excluded from the sampling frame. Those veterinarians that were practising overseas were also excluded. After these exclusions, the population of veterinarians eligible for the study comprised of 1,241 individuals.

According to sample size calculations, 400 completed questionnaires would be required to be 95% certain that an estimate of the proportion of cases treated with the most commonly used antimicrobials would fall within 5% of a true value of 50%. With an anticipated response rate of 50%, a total of 800 names and addresses were drawn randomly from the eligible population whereby every eligible veterinarian had an equal chance of being selected. Randomisation was performed using a freely available, web-based random number generator (http://stattrek.com/Tables/Random.aspx).

Data collection

A questionnaire was designed that consisted of three main sections (Supplementary Table 1[1]). The first section collected general information about the respondents, such as location and type of practice, employment status, proportion of time spent treating companion animals, post-graduate qualifications, and attendance at courses related to companion animal continuing professional development (CPD). The second section requested information about the most recent cases of skin, ear and urinary tract infections that had been treated by the respondent. Clinicians were asked about the case species, culture and susceptibility testing, the antimicrobial(s) used, the duration of treatment, and the outcome of the case. The third section asked for information regarding the respondent's most common treatment protocols, including length of drug treatment, the circumstances under which culture and susceptibility testing would be utilised, and the estimated number of cases treated per week.

In total, the questionnaire consisted of 59 questions, of which 17 (29%) were closed, 33 (56%) were open and 9 (15%) were semi-open questions. The questionnaire was pre-tested during the 2008 New Zealand Veterinary Association (NZVA) conference in Wellington. Veterinarians attending the companion animal stream of the conference were invited to fill in the questionnaire, which was distributed on the seats in the conference room. It took approximately 20 minutes for respondents to complete the questionnaire, and minor modifications were made to the questionnaire based on the responses received during this pilot survey.

The main set of data was collected through a postal questionnaire that was sent out during the second week of August 2008. A total of 800 uniquely coded questionnaires, together with a cover letter describing the study and a freepost return envelope, were posted

[1] http://dx.doi.org/10.1080/00480169.2011.643733

Table 1. Details regarding the characteristics of 393 veterinarians who responded to a postal survey regarding the use of antimicrobial drugs by companion animal veterinarians in New Zealand.

	Respondents	
	Number	Percentage
Type of practice		
Specialised CA practice	161	41
Other type of veterinary practice	226	58
Unspecified	6	2
Working at a referral centre		
No	380	97
Yes	12	3
Unspecified	1	0.3
Employment status		
Full-time	253	64
Part-time	114	29
Unspecified	26	7
Percentage of time spent treating CA		
0–33%	52	13
34–66%	50	13
67–99%	84	21
100%	205	52
Unspecified	2	0.5
Have attended CPD on CA medicine		
Yes	354	90
No	36	9
Unspecified	3	0.8
Time since attended CPD		
0–6 months	164	42
7–12 months	92	23
13–24 months	63	16
>24 months	35	9
Never attended	36	9
Unspecified	3	0.8
Hold postgraduate CA qualification		
No	336	86
Yes	56	14
Unspecified	1	0.3

CA = Companion animal; CPD = Continuing Professional Development

to the selected veterinarians. In order to maximise response rates, reminder postcards were subsequently mailed to all non-respondents 4 weeks after the original questionnaire had been posted. A further 4 weeks after this, a final reminder was sent together with an additional questionnaire and another freepost return envelope.

Statistical analysis

All returned questionnaires were recorded and the data were transferred into spreadsheets (Microsoft Office Excel, 2003). If individual questions were not answered they were registered as unspecified answers. When a respondent supplied more than one answer to a question, non-complete disjunctive coding was used with each answer being given equal weighting. Simple descriptive statistics were computed with percentages being reported as a proportion of the total respondents answering a particular question.

Preliminary data explorations were undertaken using extended mosaic plots as implemented within the VCD package (Meyer *et al.* 2006) of R v2.13.0 (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria 2011). More details regarding this technique are provided in the supplementary material, including three extended mosaic plots with explanations to aid their interpretation (Supplementary Figures 1–3[2]).

Three mixed-effects regression models, two logistic and one linear, were used to evaluate the factors that influenced the approach that the attending veterinarian had taken towards a case of suspected bacterial infection. The binary outcome variable for the first logistic regression model was whether or not a practitioner had submitted a clinical sample from the case they were treating for culture and susceptibility testing. The outcome variable for the second logistic regression model was whether or not a fluoroquinolone drug had been prescribed as part of the treatment protocol for a case. The linear regression model specifically looked at canine pyodermas, and the outcome variable for this model was the log of the duration (in days) of antimicrobial treatment that had been prescribed. The explanatory covariates for each model included the veterinarian as a random effect and the disease being treated as a fixed effect. In all models, the veterinarian-related explanatory covariates that were assessed for fit were: the percentage of work time spent treating companion animals, whether they were full time or part time workers, whether they had attended any companion animal CPD training, and whether they held post-graduate qualifications. Relevant case-related information was also evaluated, such as: whether a culture and susceptibility test had been run; whether the case had resolved or was on-going; and whether a single drug or multiple antimicrobial drugs had been prescribed. Initially, fully saturated multivariable models were fitted, and the final models were chosen by eliminating variables with $p > 0.15$ using a backward selection process. All regression models were fitted using functions within R v 2.13.0. The mixed-effects linear regression model was fitted using restricted maximum likelihood within the package for fitting linear and nonlinear mixed-effects models ('nlme' Pinheiro *et al.* 2011). The mixed-effects logistic regression models were fitted using the binomial family within the package for fitting linear and generalized linear mixed-effects models ('lme4' Bates *et al.* 2011).

Results

Respondents and cases

Of the 800 questionnaires, 415 (52%) were returned. Responses came from 129 towns and city suburbs that were distributed across the main areas of human population in New Zealand. A total of 22 questionnaires were excluded from the analyses because respondents were only occasionally involved in treating clinical cases (n=8), practiced almost exclusively with large animals (n=6), work was no longer related to the treatment of clinical cases (n=5) or were not currently involved in clinical practice (n=3). Therefore, a total of 393 questionnaires were available for analysis and the professional details of these respondents are summarised in Table 1.

In total, 1,984 cases of clinical conditions in companion animals were described by the responding veterinarians. These conditions consisted of 1,294 (65%) cases of skin infections (including

[2] http://dx.doi.org/10.1080/00480169.2011.643733

superficial pyoderma, recurrent pyoderma, deep pyoderma and cat-bite abscesses), 348 (18%) cases of ear infections and 342 (17%) cases of suspected urinary tract infections. Of the cases reported, 1,219 (61%) were dogs, 542 (27%) were cats, 1 was a chinchilla, and for 222 (11%) cases no species was recorded.

Commonly used antimicrobial drugs

Of the 1,984 cases described, systemic antimicrobial drugs had been included within the treatment regime for 1,799 cases, whilst 185 cases had been treated solely with topical antimicrobial preparations. Table 2 summarises the systemic antimicrobial drugs that were used. The three most commonly prescribed systemic drugs were the beta-lactam drugs amoxicillin-clavulanic acid and cephalexin, and the fluoroquinolone drug enrofloxacin. The topical preparations used included polymixin B (87 cases), neomycin (43 cases), fusidic acid (41 cases), framycetin (37 cases), chlorhexidine (21 cases) and gentamicin (9 cases).

The duration of the treatment period was specified in 1,627/1,984 (82%) cases. The shortest median treatment durations were for penicillin and tetracycline drugs, whilst some individual cases had required weeks to months of antimicrobial treatment (Table 2).

Culture and susceptibility testing

Susceptibility tests had been performed for 376 (19%) of the 1,984 reported cases. Among these 376 cases, 160 (43%) were suspected urinary tract infections, 109 (29%) were suspected ear infections, and 107 (28%) were suspected skin infections.

Table 2. Number and percentage of cases treated with different systemic antimicrobial drugs and the durations of treatment for 1,799 presumptive bacterial infections, as reported by 393 veterinarians who responded to a postal survey regarding the use of antimicrobial drugs in companion animals.

			Duration of treatment (Days)		
Drug	**N**	**Percentage**	**Median**	**Minimum**	**Maximum**
Penicillins					
Total	892	50			
Amoxicillin-clavulanic acid	868	48	7	2	63
Amoxicillin	21	1	6	3	21
Penicillin	2	0.1	ns		
Ampicillin	1	0.1	3		
Cephalosporins					
Cephalexin	559	31	14	5	90
Fluoroquinolones					
Total	200	11			
Enrofloxacin	167	9	14	5	56
Marbofloxacin	29	2	10	5	30
Ciprofloxacin	4	0.2	14	14	28
Tetracyclines					
Doxycycline	59	3	7.5	5	70
Sulphonamides	56	3	10	5	56
Others	33	2			
Clindamycin	24	1.3	10	5	49
Erythromycin	5	0.3	42	14	42
Metronidazole	2	0.1	10	10	10
Rifampicin	1	0.1	ns		
Spiramycin	1	0.1	ns		

ns = treatment duration not specified by respondents

The results of modelling the association between submission of samples for culture and susceptibility, and explanatory variable are shown in Table 3. From this model, samples for culture and susceptibility tests were more likely to be submitted for cases of recurrent pyoderma, deep pyoderma, ear infections and urinary tract infections than for cases of superficial pyoderma. In addition, two practitioner related covariates were also associated with the submission of samples for culture; mixed animal practitioners were less likely to do so than 100% companion animal practitioners, and those practitioners who had not attended a companion animal CPD course in the previous 12 months were less likely than practitioners who had recently attended CPD training. The incorporation of veterinarian as a random effect showed a within-veterinarian variance of 0.58, indicating that the practices of an individual clinician varied between cases due to case-related factors that were not specifically modelled here.

When asked to specify under which circumstances they would be more likely to recommend culture and susceptibility tests to their clients, 234/391 (60%) respondents said they would recommend culture and susceptibility tests for cases of recurrent pyoderma, and 120 (31%) recommended culture for cases of deep pyoderma. For ear infections, 349 (89%) said they would recommend culture for recurrent cases, and 134 (18%) would recommend culture if they saw Gram-negative rods on a cytology smear. Similarly, for urinary tract infections, respondents reported that culture would be most commonly offered in cases of relapsing or persistent infections (342 respondents, 87%). Conversely, 41 (10%) respondents said they never offered culture and susceptibility tests when treating cases of suspected bacterial skin disease.

The use of fluoroquinolones

Fluoroquinolones were prescribed in 209 (12%) of the 1,799 systemically treated cases, and a culture and susceptibility test had been undertaken in 111 (53%) of the fluoroquinolone-treated cases. The results of the model used to assess the variables that were associated with the use of this class of drug are displayed in Table 4. Fluoroquinolone drugs were more likely to be selected for ear infections and urinary tract infections than for cases of superficial pyoderma. They were also more likely to be used in cases where culture and susceptibility tests had been undertaken than where culture had not been performed. Furthermore, the use of fluoroquinolones was associated with cases for which multiple systemic drugs had been prescribed, compared with cases for which a single drug was used. The variance at the level of the veterinarian was minimal in this model (<0.0001), indicating that treatment practices were relatively uniform with respect to this class of drug. Furthermore, no veterinarian-related explanatory covariates were found to be associated with the use of fluoroquinolones.

Treatment of skin infections

Data were obtained for 1,294 cases of skin disease, comprising 376 cat bite abscesses, 359 cases of superficial pyoderma, 263 cases of deep pyoderma and 296 cases of deep pyoderma. The majority of cases of pyodermas involved dogs (779 reported cases, 85%). Only 107/1,294 (8%) cases of suspected bacterial skin disease were investigated using culture and susceptibility tests, and these were more commonly undertaken for cases of deep pyoderma (53/263, 20%) and recurrent pyoderma (49/cases,

Table 3. Results of a mixed-effects logistic regression model assessing the associations between the submission of a sample for culture and susceptibility testing for six suspected bacterial diseases with fixed-effect explanatory variables, as reported by 393 veterinarians who responded to a postal survey regarding the use of antimicrobial drugs in companion animals. The individual attending veterinarians were included as a random effect and the variance at this level is reported in the text.

Variables	Coefficients	95% CI	P-value[a]
Intercept	−4.43		<0.001
Disease			
Superficial pyoderma	Ref		
Cat-bite abscess	−1.42	−3.81 to 0.98	0.25
Recurrent pyoderma	2.98	1.86 to 4.11	<0.001
Deep pyoderma	3.24	2.11 to 4.36	<0.001
Ear infection	3.89	2.79 to 5.00	<0.001
Urinary tract infection	4.73	3.63 to 5.83	<0.001
Type of veterinarian			
100% small animal	Ref		
Mixed; large and small animals	−0.36	−0.67 to −0.04	0.03
Small animal CPD status			
Attended within last 12 months	Ref		
Attended over 12 months ago	−0.42	−0.79 to −0.05	0.02
Never attended	−1.28	−2.01 to −0.55	<0.001

[a] Significance of the coefficient
Ref = the reference category for each categorical variable

Table 4. Results of a mixed-effects logistic regression model assessing the fixed effect variables that were associated with the use of a fluoroquinolone drug to treat a case of suspected bacterial infection, as reported by 393 veterinarians who responded to a postal survey regarding the use of antimicrobial drugs in companion animals. The individual attending veterinarians were included as a random effect and the variance at this level is reported in the text.

Variables	Coefficients	95% CI	P-value[a]
Intercept	−4.37		<0.001
Disease			
Superficial pyoderma	Ref		
Cat-bite abscess	−0.49	−1.93 to 0.96	0.51
Recurrent pyoderma	1.05	0.01 to 2.08	0.05
Deep pyoderma	0.99	−0.05 to 2.03	0.06
Ear infection	3.20	2.28 to 4.13	<0.001
Urinary tract infection	1.73	0.76 to 1.60	<0.001
Culture and susceptibility test			
Not undertaken	Ref		
Undertaken	1.24	0.89 to 1.60	<0.001
Number of antibacterial drugs prescribed			
Single antibacterial	Ref		
Multiple antibacterials	1.28	0.78 to 1.60	<0.001

[a] Significance of the coefficient
Ref = the reference category for each categorical variable

17%) than for cases of superficial pyoderma (4/359, 1%) or cat-bite abscesses (1/376, 0.3%). Despite the infrequent use of confirmatory culture tests, systemic antimicrobial drugs were dispensed to 1,274/1,294 (98%) cases that were reported.

Amoxicillin-clavulanic acid was the most frequently prescribed drug for cat bite abscesses (306/376 cases, 81%), and the median recorded treatment period was 7 (min 4, max 21) days. Superficial pyoderma was most commonly treated using amoxicillin-clavulanic acid (157/359 cases, 44%) or cephalexin (155/359, 43%) with median recorded treatment periods of 7 (min 5, max 21) and 10 (min 5, max 35) days, respectively. Cephalexin was the most frequently utilised drug for recurrent pyoderma (168/296 cases, 57%) with a median treatment period of 21 (min 5, max 60) days and for deep pyoderma (168/263, 64%) with median recorded treatment period of 21 (min 5, max 90) days. An extended mosaic plot was used to explore and describe the antimicrobial treatment regimes that were used for cases of different skin diseases (Supplementary Figure 1). This plot highlighted that there were more cases of deep pyoderma that were unresolved after 28 days or more of treatment with either amoxicillin-clavulanic acid (6/6 cases) or cephalexin (20/46 cases, 43%) than would be statistically expected. There were also a larger number of unresolved cases of recurrent pyoderma after 28 days or more of cephalexin treatment (68/197 cases, 35%) than would be expected.

The results of modelling the association between duration of treatment and explanatory variable are shown in Table 5. Longer durations of treatment were prescribed for recurrent and deep pyodermas compared with superficial pyodermas, and for cases where a culture and susceptibility test was performed compared with those where culture was not performed. Shorter courses of treatment were associated with use of amoxicillin-clavulanic acid compared with cephalexin, with veterinarians in mixed practice compared with 100% small animal practice, and with those who had not attended a companion animal CPD course compared with those that had recently attended such a course. The relatively high variance (0.08) for the between veterinarian random effects in this model reflected a high degree of variation in the prescribing practices of veterinarians, whilst the high within veterinarian variance (0.13) could be related to features of the individual cases that were not fitted within the model.

Treatment of ear infections

The majority of ear infections presented in dogs (302/348 cases, 87%). More than one-third of ear infections were treated using topical medications alone (135/348, 39%). The median recorded duration of topical treatment was 10 (min 5, max 21) days, however, the length of treatment was unspecified for 52 (39%) of the topically treated cases.

The systemic antimicrobials most commonly used to treat ear infections were the fluoroquinolone group (123/348, 35%), amoxicillin-clavulanic acid (55/348, 16%) and cephalexin (20/348, 6%). The median recorded lengths of treatment for each of these three groups of drugs were 10 (min 7, max 20), 10 (min 5, max 21) and 7 (min 7, max 10) days, respectively.

Treatment of urinary tract infections

More cases of suspected urinary tract infections were reported for cats (175/350 cases, 50%) than dogs (137/350, 39%), but species was unspecified for a further 38 cases (11%). Of the 343 cases for which the drugs prescribed had been reported, the majority had been treated using amoxicillin-clavulanic acid (239, 70%). The median duration of treatment was 10 (min 2, max 42) days, with 27/343 (11%) cases requiring treatment regimens

Table 5. Results of a mixed-effects linear regression model of the association between the log transformed number of days of antimicrobial treatment prescribed for canine pyoderma and fixed-effect explanatory variables, as reported by 393 veterinarians who responded to a postal survey regarding the use of antimicrobial drugs in companion animals. The individual attending veterinarians were included as a random effect and the variance at this level is reported in the text.

Variables	Coefficient	95% CI	P-value[a]
Intercept	2.40		
Disease			
Superficial pyoderma	Ref		
Recurrent pyoderma	0.49	0.41 to 0.58	<0.001
Deep pyoderma	0.66	0.58 to 0.75	<0.001
Drug used			
Cephalexin	Ref		
Amoxicillin-clavulanic acid	−0.24	−0.33 to −0.15	<0.001
Fluoroquinolones	−0.18	−0.37 to 0.006	0.06
Other	−0.03	−0.18 to 0.11	0.63
Culture and susceptibility test			
Not undertaken	Ref		
Undertaken	0.39	0.27 to 0.50	<0.001
Disease resolved			
Yes	Ref		
No	0.07	−0.01 to 0.15	0.11
Type of veterinarian			
100% small animal	Ref		
Mixed; large and small animals	−0.13	−0.22 to −0.04	0.005
Small animal CPD status			
Attended within last 12 months	Ref		
Attended over 12 months ago	0.03	−0.69 to 0.14	0.40
Never attended	−0.25	−0.40 to −0.05	0.009

[a] Significance of the coefficient
Ref = the reference category for each categorical variable

that were longer than 21 days. Fluoroquinolones were the second most commonly prescribed drug class for urinary tract infections (48/343, 14%). The median length of treatment with a fluoroquinolone drug was 14 (min 5, max 42) days, and 6/48 (13%) cases were reported as having received over 21 days of treatment with this drug. A variety of other drugs had been prescribed for the remaining cases: doxycycline (19/343), cephalexin (16/343), potentiated sulphonamides (13/343), amoxicillin (5/343), and erythromycin (1/343). More than one drug had been prescribed for 16 (4.7%) cases, and of these cases 4 were reported as resolved, 3 were ongoing and the other 9 were described as unresolved or recurrent. The combination of drugs in most common use was amoxicillin-clavulanic acid and enrofloxacin.

Discussion

This survey identified that the systemic antimicrobial drugs most frequently prescribed for companion animals in New Zealand were beta-lactams, predominantly amoxicillin-clavulanic acid and cephalexin. Similar findings have also been reported in Australia, Finland and Denmark (Watson and Maddison 2001; Holso *et al.* 2005; Pedersen *et al.* 2007; Anonymous 2008). In this study, however, the third most frequently prescribed drugs were the fluoroquinolones, which may indicate that these drugs are being used more frequently in New Zealand than is reported in some other countries. For instance, the use of fluoroquinolones in this study (11% of 1,799 cases) was more than double the percentages of cases (3% of canine cases, 5% of feline) that were reported as being treated with fluoroquinolones in a study conducted across university pharmacies in Finland (Holso *et al.* 2005), whilst prescription figures from Denmark showed an even lower use of these drugs with an estimated 0.7% of the companion animal antimicrobial prescriptions being written for fluoroquinolones in 2007 (Anonymous 2008).

In 2005, 2007 and 2009 the World Health Organisation (WHO) arranged expert consultation workshops with the task of classifying antimicrobial drugs on the basis of their importance in human medicine, as part of a process of managing the risks associated with non-human use of antimicrobials (Angulo *et al.* 2009; Anonymous 2009a). During these meetings drugs were classified using two criteria: whether they were the sole drug available for the treatment of serious human disease, and whether they were used to treat diseases contracted from non-human sources or diseases caused by organisms that may acquire drug resistance genes from non-human sources. Drugs that fulfilled both of these criteria were labelled critically important, those that fulfilled one of the criteria were deemed highly important and those fulfilling neither criterion were deemed to be important. Those drugs that were deemed to be critically important to human medicine included all fluoroquinolones, third- and fourth-generation cephalosporins, and many of the penicillin family, including amoxicillin-clavulanic acid. Therefore, two of the three drugs that were reportedly used most commonly within companion animal practice are on the WHO list of globally critical agents.

Furthermore, these drugs were reported to be commonly prescribed without the use of culture and susceptibility tests. This is an area where veterinary drug use practices could be improved. Using critically important drugs, in particular the fluoroquinolones, as first choice agents in the absence of susceptibility testing is inconsistent with international guidelines on the prudent use of antimicrobials in animals (Guardabassi *et al.* 2008). However, a number of survey respondents reported that although they often recommended culture and susceptibility tests, clients tended not to opt for that course of action due to the costs involved. This may indicate that veterinarians and their clients are not yet fully aware of the risks posed by drug-resistant bacteria to human and animal health, or of the roles that the veterinary use of antimicrobials may play in human infections with drug-resistant bacteria.

The current study also highlighted that many of the reported cases of pyodermas were treated with short courses of systemic antimicrobials. The median treatment periods of 7 days for amoxicillin-clavulanic acid and 10 days for cephalexin are considerably less than the recommendation of 21 days and treatment to extend for 7–14 days after resolution of clinical signs (Scott *et al.* 2001; Guardabassi *et al.* 2008), although the drug labels often do not provide this information. Nonetheless, clinical studies that have assessed the treatment of canine superficial pyoderma have found that prolonged treatment periods are often

required to obtain full clinical resolution. For instance, in one study 30/40 dogs were still showing clinical signs after 14 days of treatment with oral cephalexin, 9 still showed signs after 28 days of treatment, and 3 after 42 days of treatment (Toma *et al.* 2008). In a similar manner, a randomised clinical trial involving 56 cases of canine superficial pyoderma found that 31 cases were not completely resolved after 21 days of either clindamycin or amoxicillin-clavulanic acid therapy, and 17 remained unresolved after 42 days of therapy. In this trial, clindamycin proved to be more efficacious than amoxicillin-clavulanic acid (Littlewood *et al.* 1999). In general, the complete resolution of deep pyodermas will require treatment for longer than superficial pyodermas and a minimum of 4–6 weeks treatment is recommended for this presentation (Scott *et al.* 2001; Guardabassi *et al.* 2008). Client related factors that could influence the duration of treatment chosen in this study could include the added expense of longer courses of drug therapy, and decreased owner compliance with longer courses of treatment. The regression modelling showed that the veterinarians who were not spending 100% of their time dedicated to companion animal practice or who had not attended any companion animal CPD training were more likely to prescribe the shortest courses of treatment for these presentations.

Shortly after the data for this study were collected, a long-acting, third generation, cephalosporin (cefovecin sodium) was launched for the treatment of companion animals in New Zealand. This drug is marketed as a single-injection treatment for skin disorders in dogs and cats with a second injection at 7–14 days after the first if complete resolution is not obtained. The timing of the second injection is dependent upon the causative pathogen and the manufacturers of cefovecin clearly recommend that culture and susceptibility testing is undertaken before administering the drug. European studies of the drug's efficacy for the treatment of canine pyodermas found it to be comparable to that of oral amoxicillin-clavulanic acid in the treatment of canine pyodermas, although 5–13% of superficial pyodermas required 3–4 consecutive injections to reach resolution (Stegemann *et al.* 2007). It would be interesting to assess how the availability of this drug has altered the patterns of use of antimicrobial agents in New Zealand and whether the use of culture and susceptibility testing has increased since the launch of this drug. Third-generation cephalosporins are on the WHO list of critically important antimicrobials, and indiscriminate use in the absence of culture and susceptibility testing is, therefore, not recommended.

The most common approach to a case of ear infection used by respondents was to prescribe topical preparations for 1 to 2 weeks, however for an equal number of cases the duration of topical treatment recommended was unspecified, and for almost half these cases the outcome of treatment was also unknown. This could simply be a reflection of the very frequent presentation of this complaint and the outcomes were unknown because the animals had not yet returned for re-examination. However, it may also indicate that some cases of ear infection are being given topical treatments with no specific guidelines and no request for re-examination. Re-evaluation of all cases of otitis is important to ensure that therapy is successful.

Presumptive urinary tract infections were the disease for which culture and susceptibility testing was most frequently performed in the current study, and there were a number of unresolved urinary tract infections that had been prescribed multiple systemic antimicrobials. Taken together, these results could indicate that multi-drug-resistant urinary pathogens are circulating in New Zealand and an evaluation of the susceptibility patterns of urinary tract isolates from companion animals is recommended. The other interesting observation was that more cats (50%) than dogs (39%) were reported as being treated for presumptive urinary tract infections. Bacterial urinary tract infections have been reported to be the cause of less than 5% of cases of feline lower urinary tract disease (Bailiff *et al.* 2008), and the majority of cats presenting with lower urinary tract signs, such as haematuria, pollakiuria and stranguria, had idiopathic feline lower urinary tract disease that is not of bacterial origin (Forrester and Roudebush 2007). The results of the current survey suggest that a large number of cats may have been inappropriately treated with antimicrobial therapy for lower urinary tract disease of non-bacterial origin, which is a hypothesis that is worthy of further investigation.

There are a number of aspects of the study that may have influenced the results obtained. Firstly, retrospective questionnaire-based surveys can be subject to problems with recall bias. In order to minimise this, the respondents were asked to provide details on the most recent case they had treated of each of the targeted diseases. Furthermore, the information requested was designed to be easily extracted from clinical notes rather than information that required personal recall. Generally, the returned questionnaires had been completed clearly and the questions had been answered fully, however not all respondents answered every question within the questionnaire, with species treated and duration of treatment being most commonly unanswered (11 and 18% of reported cases, respectively). However, for all questions at least 74% of respondents had supplied information, and for the majority of questions the percentage of responses was much higher. One piece of information that was not always available for ear and urinary tract infections was whether a case was being seen for the first time, or whether the animal had a history of such infections. The addition of this information could have provided further insight into the protocols used to treat these diseases as the approach to recurrent cases may differ from the approach to initial presentations.

For logistical reasons, this study focused upon the three categories of disease that are most frequently treated using antimicrobial drugs (Guardabassi *et al.* 2004; Pedersen *et al.* 2007; Guardabassi *et al.* 2008). However, the use of antimicrobials to treat other diseases, such as respiratory disease, was not captured by this study and neither was the perioperative use of these drugs. It is also possible that case definitions may have differed between practitioners because the respondents were not provided with a set of standard definitions. Nevertheless, the aim of this study was determine what the practitioners were prescribing for the cases they saw, rather than whether they were correctly diagnosing cases. Furthermore, variation between diagnoses would have been at least partially taken into account within the regression models by the incorporation of attending veterinarian as a random effect.

Descriptive epidemiological studies are an important first stage of investigations into new fields of research, they allow for preliminary descriptions of the distribution of health events across time, space or people, and play a vital role in the development of appropriate hypotheses that can be tested in future analytical studies. The study reported here is the first survey of antimicrobial drug use in companion animal medicine that has been conducted across New Zealand. Overall, the findings of the study suggest that the patterns of use of antimicrobial drugs by companion

animal veterinarians in New Zealand were largely in line with published clinical guidelines, but they were not fully compliant with guidelines for the prudent use of antimicrobial drugs. For instance, most antimicrobial treatments, including drugs classified as critically important for human health, were being administered without accompanying culture and susceptibility tests, and the duration of treatment for some skin infections was shorter than the recommended duration. Given these results, it is recommended that antimicrobial drug use guidelines are frequently included in companion animal CPD courses and that regular surveillance of drug resistance within pathogens isolated from companion animals is commenced. However, an assessment of the impact of these practices on the emergence, maintenance and spread of drug-resistant bacteria within populations of companion animals and their owners requires analytical studies that link drug use practices with data regarding the drug susceptibilities of bacteria isolated from companion animals. To this end, the data collected here are highly informative for the design of analytical studies in this area, and also provide a useful baseline for tracking future trends in antimicrobial drug usage. The current guidelines for the use of antimicrobial drugs in companion animal practice in New Zealand have been published by the New Zealand Veterinary Association Companion Animal Society (Anonymous 2009b, 2010b, 2010c).

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References

Angulo FJ, Collignon P, Powers JH, Chiller TM, Aidara-Kane A, Aarestrup FM. World Health Organization Ranking of Antimicrobials According to Their Importance in Human Medicine: A Critical Step for Developing Risk Management Strategies for the Use of Antimicrobials in Food Production Animals. *Clinical Infectious Diseases* 49, 132–41, 2009

***Anonymous.** DANMAP 2007: Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, foods and humans in Denmark. Statens Serum Institut, Danish Veterinary and Food Administration, Danish Medicines Agency, National Veterinary Institute, and National Food Institute, Copenhagen, Denmark, 2008

***Anonymous.** WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR) – Critically Important Antimicrobials for Human Medicine. World Health Organisation, Copenhagen, Denmark, 2009a

***Anonymous.** Specific antibiotic treatment guidelines: Pyoderma and ototis externa in dogs. NZVA Companion Animal Society Newsletter. 20 (3), 14, 2009b

***Anonymous.** Antibiotic sales and use overview 2004–2009. *Industry eLibrary, MAF website* http://www.foodsafety.govt.nz/elibrary/industry/antibiotic-sales-2004-2009.pdf (accessed 24 Aug 2011). Approvals and ACVM Group, Ministry of Agriculture and Forestry, Wellington, NZ, 2010a

***Anonymous.** Specific antibiotic treatment guidelines: Respiratory diseases in cats and dogs. NZVA Companion Animal Society Newsletter. 21 (1), 28–30, 2010b

***Anonymous.** Specific antibiotic treatment guidelines: Urinary tract infections in dogs and cats. NZVA Companion Animal Society Newsletter. 21 (2), 16–17, 2010c

Bailiff NL, Westropp JL, Nelson RW, Sykes JE, Owens SD, Kass PH. Evaluation of urine specific gravity and urine sediment as risk factors for urinary tract infections in cats. *Veterinary Clinical Pathology* 37, 317–22, 2008

***Bates D, Maechler, M., Bolker, B.** lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-42. http://cran.r-project.org/web/packages/lme4/index.html (accessed 31October 2011). 2011

DeVincent SJ, Reid-Smith R. Stakeholder position paper: Companion animal veterinarian. *Preventive Veterinary Medicine* 73, 181–9, 2006

Forrester SD, Roudebush P. Evidence-based management of feline lower urinary tract disease. *Veterinary Clinics of North America-Small Animal Practice* 37, 533–58, 2007

Grinberg A, Kingsbury DD, Gibson IR, Kirby BM, Mack HJ, Morrison D. Clinically overt infections with methicillin-resistant Staphylococcus aureus in animals in New Zealand: A pilot study. *New Zealand Veterinary Journal* 56, 237–42, 2008

Guardabassi L, Schwarz S, Lloyd DH. Pet animals as reservoirs of antimicrobial-resistant bacteria. *Journal of Antimicrobial Chemotherapy* 54, 321–32, 2004

***Guardabassi L, Houser GA, Frank LA, Papich MG.** Guidelines for antimicrobial use in dogs and cats. In: Guardabassi L, Jensen LB, Kruse H (eds). *Guide to antimicrobial use in animals.* Pp 183–207. Blackwell Publishing, Oxford, UK, 2008

Holso K, Rantala M, Lillas A, Eerikainen S, Huovinen P, Kaartinen L. Prescribing antimicrobial agents for dogs and cats via University Pharmacies in Finland – Patterns and quality of information. *Acta Veterinaria Scandinavica* 46, 87–93, 2005

***Jensen LB, Anguro FJ, Molbak K, Wegener HC.** Human health risks associated with antimicrobial use in animals. In: Guardabassi L, Jensen LB, Kruse H (eds). *Guide to antimicrobial use in animals.* Pp 13–27. Blackwell Publishing, Oxford, UK, 2008

Kempker R, Mangalat D, Kongphet-Tran T, Eaton M. Beware of the pet dog: a case of Staphylococcus intermedius infection. *American Journal of the Medical Sciences* 338, 425–7, 2009

Littlewood JD, Lakhani KH, Paterson S, Wood JLN, Chanter N. Clindamycin hydrochloride and clavulanate-amoxycillin in the treatment of canine superficial pyoderma. *Veterinary Record* 144, 662–5, 1999

Lloyd DH. Reservoirs of antimicrobial resistance in pet animals. *Clinical Infectious Diseases* 45, S148–S152, 2007

Meyer D, Zeileis A, Hornik K. The strucplot framework: visualizing multi-way contingency tables with VCD. *Journal of Statistical Software* 17, 1–48, 2006

Pedersen K, Pedersen K, Jensen H, Finster K, Jensen VF, Heuer OE. Occurrence of antimicrobial resistance in bacteria from diagnostic samples from dogs. *Journal of Antimicrobial Chemotherapy* 60, 775–81, 2007

Phillips I, Casewell M, Cox T, De Groot B, Friis C, Jones R, Nightingale C, Preston R, Waddell J. Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data. *Journal of Antimicrobial Chemotherapy* 53, 28–52, 2004

***Pinheiro J, Bates, D., DebRoy, S., Sarkar, D., R Development Core Team.** nlme: Linear and nonlinear mixed effects models. R package version 3.1-102 http://cran.r-project.org/web/packages/nlme/index.html (accessed 31 October 2011). 2011

***Scott DW, Miller WH, Griffin CE.** Bacterial skin diseases. In: Muller GH, Scott DW, Miller WH, Griffin CE, Kirk RW (eds). *Muller and Kirk's small animal dermatology.* Pp 274–336. WB Saunders, Philadelphia, USA, 2001

Soulsby L. Antimicrobials and animal health: a fascinating nexus. *Journal of Antimicrobial Chemotherapy* 60 (Suppl 1), i77–i78, 2007

Stegemann MR, Coati N, Passmore CA, Sherington J. Clinical efficacy and safety of cefovecin in the treatment of canine pyoderma and wound infections. *Journal of Small Animal Practice* 48, 378–86, 2007

***Swann.** Joint Committee on the Use of Antibiotics in Animal Husbandry and Veterinary Medicine. HMSO, Cmnd 4190, London, UK, 1969

Toma S, Colombo S, Cornegliani L, Persico P, Galzerano M, Gianino MM, Noli C. Efficacy and tolerability of once-daily cephalexin in canine superficial pyoderma: an open controlled study. *Journal of Small Animal Practice* 49, 384–91, 2008

Watson ADJ, Maddison JE. Systemic antibacterial drug use in dogs in Australia. *Australian Veterinary Journal* 79, 740–6, 2001

Weese JS, Dick H, Willey BM, McGeer A, Kreiswirth BN, Innis B, Low DE. Suspected transmission of methicillin-resistant Staphylococcus aureus between domestic pets and humans in veterinary clinics and in the household. *Veterinary Microbiology* 115, 148–55, 2006

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