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STANDARD ARTICLE

Seeking simplicity, navigating complexity: How veterinarians select an antimicrobial drug, dose, and duration for companion animals

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Abstract

Background: Minimizing harm from antimicrobials requires use of the narrowest spectrum drug, at an effective dose for the minimum effective duration. Many prescribers are not currently following these guidelines. To address suboptimal antimicrobial use, the underlying reasons must be understood.

Objectives: To identify factors influencing choices of antimicrobial drug, dose, and duration for companion animals.

Subjects: Twenty-two veterinarians treating companion animals in Australia. Diversity of participants was deliberately sought.

Methods: Semistructured interviews were conducted online. Two case studies were discussed, and then a range of broader questions was posed. Transcripts were analyzed thematically, using an inductive approach.

Results: Few participants chose guideline-concordant management for the case studies. Prescribing choices were influenced by a complex array of factors associated with the clinical case, pet owner, drug, veterinarian, veterinary colleagues, and external factors. Key factors driving broad-spectrum antimicrobial use included a sense of safety, habit, ease of administering the drug (especially in cats), pharmaceutical marketing, and the self-perpetuating dispensary cycle. Many participants were concerned about antimicrobial resistance, but insufficiently informed about how to minimize this risk. Several participants believed that longer duration of treatment and ensuring patients finish a predetermined course would decrease the risk of antimicrobial resistance and improve clinical outcomes.

Conclusions and Clinical Importance: Veterinarians are engaged with the concept of antimicrobial stewardship, but face numerous practical barriers and require more information. In particular, improved education is needed on enhancing patient safety by minimizing both spectrum of activity and duration of treatment, and dispelling myths about “finishing the course.”

Abbreviations: amoxiclav, amoxicillin-clavulanate; AMR, antimicrobial resistance; AMS, antimicrobial stewardship; CA, companion animal; TMS, trimethoprim-sulfonamide combination; vet, veterinarian.

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KEYWORDS

agent, antibacterial, antibiotic, barriers, behavior, canine, cat, course, decision-making, dog, dose rate, enablers, feline, formulation, guideline, human factors, interview, pet, pharmaceutical, prescribing, prescription, psychology, qualitative, regimen, stewardship

1 | INTRODUCTION

Antimicrobial stewardship (AMS) has been described as a coherent set of actions that promote using antimicrobials responsibly.¹ It has 2 main objectives: (a) to eliminate unnecessary use of antimicrobials; and (b) when antimicrobials are required, to maximize the benefits of treatment while minimizing harm, both to the treated patient and the broader community. These harms include drug reactions, dysbiosis, and the selection of antimicrobial resistance (AMR) determinants, in both the treated pathogen and the patient's commensal flora, that can spread to other bacteria and other animals. To minimize these harms, prescribers should use a clinically and microbiologically suitable antimicrobial of the narrowest spectrum of activity or lowest possible importance rating, at an effective dose, for the shortest effective duration. However, this approach is not always followed in practice.

There is evidence that habitual, social, practical, and structural factors can influence human and animal prescribers' antimicrobial choices as strongly as biological considerations.²⁻⁸ Understanding all influences on veterinary antimicrobial decisions is critical when designing interventions to improve the appropriateness of prescribing. Some influences are likely to be consistent, such as the role of habit, whereas others can be context-specific. For example, substantial differences exist among countries in veterinary education;⁹ the regulation, prescription, and sale of antimicrobials;¹⁰ the availability of specific drugs and formulations;¹¹ cultural attitudes towards antimicrobials;¹² community health literacy;¹³ and uptake of pet insurance,¹⁴ all of which can affect prescribing decisions.

Qualitative research studies with companion animal (CA) veterinarians in the United Kingdom¹⁵⁻¹⁸ and the Netherlands¹⁹ have examined factors influencing antimicrobial prescribing as a whole (ie, both the decision to prescribe antimicrobials, as well as the choice of antimicrobial drug, dose, and duration). Although in practice these decisions are made almost simultaneously, it is useful to examine them as discrete events, because there are distinct factors relevant to one, but not the other. We previously have published an analysis of the interviews conducted for the study described here that examined the factors influencing the initial decision to prescribe antimicrobials or not.²⁰ The aim of our current study was to use a phenomenological approach to understand how veterinarians make decisions about drug selection, dose, and duration of treatment.

2 | METHODS

The method used has been published previously.²⁰ Briefly, the first author, a veterinarian (R.S.), conducted semistructured interviews with 22 veterinarians in Australia in 2020. Most participants

were recruited through convenience sampling using veterinary social media groups. A few additional participants were then purposively sampled to ensure a wider range of demographics and workplace types. Each interview included 2 case studies: a cat with a simple SC abscess, and a dog with a bacterial lower urinary tract infection. Participants outlined their preferred investigation and management for each case. The interview also explored a broad range of topics related to antimicrobial use. The interview guide has been published previously²⁰ and is included in Data S1. The project was approved by The University of Melbourne Human Research Ethics Committee (Project ID: 1955762).

In Australia, antimicrobial importance ratings used in veterinary and human medicine are defined by the Australian Strategic and Technical Advisory Group on Antimicrobial Resistance (ASTAG), categorizing each drug as of high, medium, or low importance.²¹ Other jurisdictions may have their own national importance ratings systems or use the World Health Organization,²² World Organization for Animal Health²³ importance ratings, or both.

Interviews were conducted and audio-recorded using Zoom Cloud Meetings (San Jose, CA). Transcripts created using Otter.ai (Mountain View, CA) were manually corrected by the interviewer. Thematic analysis was performed using NVivo (Version 12, QSR International, Burlington, MA). Two interviews were coded by 2 researchers (R.S., A.S.) to refine the codebook, with the remaining 20 interviews coded by R.S.

3 | RESULTS

3.1 | Participant characteristics

The demographics of the participants have been described previously.²⁰ In summary, the participants were mostly working exclusively with CAs (19/22), were predominantly female (16/22) and covered a broad age range (24-68 years). Participant age is generally correlated with years of clinical experience.

The interviews lasted a median of 90 minutes (interquartile range [IQR], 73-98).

3.2 | Case studies

The approaches to management of the 2 case studies by the veterinarians are presented in Figure 1. For the female dog with sporadic bacterial cystitis, local²⁴ and international²⁵ guidelines recommend low-importance amoxicillin or trimethoprim-sulfonamide (TMS) for 3 to 5 days only. When discussing this case, 5 of the 22 participants

		Local antimicrobial importance ratings of selected drug							
		n/a	Low importance			Medium importance		High importance	
		No antimicrobial therapy	Amoxicillin	Doxycycline	Trimethoprim-sulfonamide (TMS)	Cephalexin	Amoxicillin-clavulanate	Enrofloxacin	Cefovecin
Dog with sporadic bacterial cystitis (bacilli)	Number of participants	-	4 veterinarians*	-	1 veterinarian*	-	13 veterinarians	4 veterinarians	-
	Duration range	-	7-14 days		3 days*		7-21 days	3-10 days	
Cat with fight abscess, surgically drained	Number of participants	2 veterinarians*	1 veterinarian*	1 veterinarian	-	1 veterinarian	12 veterinarians	-	5 veterinarians
	Duration range	-	duration not collected	7 days		duration not collected	5-7 days		14+ days (single long-acting injection)

FIGURE 1 Management selected by interview participants for the two case studies.

selected a guideline-concordant antimicrobial drug (amoxicillin or TMS), but only 1 also selected a guideline-concordant duration of treatment. Most participants (13/22) selected medium-importance amoxicillin-clavulanate (amoxiclav) for 7 to 21 days and 4 selected high-importance enrofloxacin for 3 to 10 days.

Local guidelines²⁴ recommend that an uncomplicated cat fight abscess should be managed surgically, without systemic antimicrobials. Only 2 of the 22 veterinarians selected this management. If antimicrobials were considered necessary (eg, because of systemic illness, which was implied in the case study), guidelines recommend low-importance amoxicillin for 5 to 10 days. Of the 20 who chose to use antimicrobials, only 1 selected amoxicillin. Again, most (12/20) selected medium-importance amoxiclav and 25% (5/20) selected long-acting (14-day duration), high-importance cefovecin.

Although our study design and small sample size prohibit generalizations from these data, they are consistent with prescribing patterns in large-scale quantitative studies of Australian veterinary prescribing,²⁶⁻²⁸ that have shown that veterinarians frequently use both higher importance drugs and longer durations of treatment than guidelines recommend.

3.3 | Semistructured interviews

A wide range of factors influenced participants' choices of antimicrobial drug, dose, and duration for dogs and cats. An overview of these factors is shown in Table 1. Illustrative quotations for the listed factors are provided in subsequent tables, and referred to by their quotation codes (eg, C1) within the text.

3.4 | Individual case factors

If it's bright and happy and not systemically unwell, I'd be a lot more light-handed.

Veterinarians mentioned several case factors they considered when selecting an antimicrobial drug (Table 2). Severe clinical signs (C1, O11), particular illnesses such as peritonitis (C2), and more uncertainty about the pathogens (C2) prompted veterinarians to select broader-spectrum antimicrobials, multiple antimicrobials, or both, to “cover all bases” (C3). Relapse or recurrence of infection was cited as a reason to use both a higher-importance or broader-spectrum antimicrobial (C4) and a longer duration of treatment (C1, C4) than for an initial presentation. Where available, information about the pathogen, such as bacterial morphology (C5) or culture and susceptibility results (C6), also was considered.

The animal's temperament and environment were important, particularly for cats that were fractious (C7, C8) or free-roaming (C9). These factors made PO administration of medications more difficult for owners, prompting the use of long-acting cefovecin injections.

Contraindications also were considered, such as the adverse effects of fluoroquinolones on growing animals (C10). The risk of adverse effects of TMS (C11, V7) in dogs was a concern for some veterinarians; they seemed unaware that this risk could be decreased by using short durations of treatment.

3.5 | Antimicrobial drug factors

It just has to get to the place that I'm trying to get to ... then you just choose based on a few other things like cost, ease of administration, volume of administration ...

Factors relating to the antimicrobial drugs themselves were very important in veterinarians' choices (Table 3). Practical considerations were paramount; the ease of achieving the correct per kilogram dose rate was mentioned by multiple veterinarians as a strong influence on the drug prescribed (A1, A2, A3, A7, A10, C11). Patient body weights

TABLE 1 Overview of factors influencing veterinarians' choices of antimicrobial drug, dose, and duration.

Case factors	Veterinarian factors
<ul style="list-style-type: none">• Clinical features of case• Likely pathogen(s)• Animal temperament and environment• Potential for direct adverse effects	<p>Selecting <i>drug and dose</i>:</p> <ul style="list-style-type: none">• Knowledge and past experiences• Concern about AMR• Access to continuing veterinary education (CVE) and relevant, reliable prescribing resources• Communication skills, confidence, relationship with owner• Energy and emotional state• Habit and familiarity
<p><i>Antimicrobial drug factors</i></p> <ul style="list-style-type: none">• Ease of dosing (size/volume, route, divisibility, palatability, duration of action)• Cost to pet owner• Spectrum of activity• Penetration of affected tissue• Non-antibacterial effects	<p>Selecting <i>duration</i>:</p> <ul style="list-style-type: none">• Knowledge and past experiences, awareness of duration guidelines• Fear of relapse• Uncertainty about the relationship between treatment duration and AMR risk• Beliefs about “finishing the course”• Attitudes to other approaches to duration of therapy
<p><i>Pet owner factors</i></p> <ul style="list-style-type: none">• Capability, opportunity, and motivation to give oral medications• Financial constraints• Relationship with veterinarian• Expectations of receiving a particular medication• Understanding of AMR	<p><i>Veterinary practice and colleague factors</i></p> <ul style="list-style-type: none">• The “dispensary cycle”: colleagues' prescribing habits and “what's on the shelf”• Influence of veterinary colleagues• Influence of broader veterinary community• Influence of veterinary specialists• Financial considerations• Clinic charging policies• Prescribing resources in the clinic• Clinic culture• Time pressure• Capacity to follow up with owner
	<p><i>External factors</i></p> <ul style="list-style-type: none">• Antimicrobial label information• Information provided in culture and susceptibility reports• Pharmaceutical company marketing

in CA practice can vary markedly, from a 100 g newborn kitten to a 100 kg adult giant breed dog. Veterinarians described challenges at both ends of the weight spectrum, whether because of the need to split tablets into fractions (A1, A2) or needing several tablets to make up a single dose (A11). Capsules were noted to be difficult to divide (A10) for smaller animals. Lower-volume veterinary practices also struggled to maintain an inventory of antimicrobials in a wide range of dose sizes, particularly when supplier minimum order quantities were large (C11).

The palatability of PO antimicrobial formulations was another prominent practical consideration (A4, A7), especially for cats. Palatability was cited as a reason to use amoxiclav, which is available as a palatable liquid (A5), and doxycycline, which is available in a flavored paste for cats (A4), over other options. Poor palatability also was mentioned as a reason not to comply with antimicrobial use guidelines. For example, TMS is recommended as an empirical treatment for sporadic urinary tract infections in dogs and cats, but was felt to be impractical in cats because of its bitter flavor (A6).

Dosing route and frequency were important determinants of drug selection. Most systemic antimicrobial regimens used in CA outpatient practice require at least once daily PO dosing (most commonly twice daily) for at least 3 days. Only 1 antimicrobial (cefovecin) is currently

available as a single, long-acting injection that lasts for this duration. Hence, where a combination of animal temperament (C7, C8, O1), environment (C9, O2), and owner factors (O1, O2, O3) pointed to difficulties with PO administration (A9), the simplicity of an injection of cefovecin was appealing to some participants, and more likely to outweigh any concerns about AMR risk (O1, O3). Some veterinarians would use this option without a second thought (A8), whereas others would struggle with it (D12). One practice had stopped stocking cefovecin, and the staff had developed innovative ways to assist pet owners who could not administer antimicrobials PO (P19). Participants expressed a wish that pharmaceutical companies would develop more user-friendly formulations of low-importance antimicrobials (A9), such as long-acting injections, palatable pastes and liquids, and transdermal medications, as well as topical treatments for otitis externa that do not contain antibacterial drugs (P22).

The cost of the antimicrobial to the owner was mentioned frequently (A3, A4, A10, A15). Veterinarians said they had sometimes not prescribed their preferred antimicrobial drug, to minimize cost (A11, A12).

Veterinarians mentioned the antimicrobial's spectrum of activity (A13) and the ability of the drug to reach the affected tissue (A14) influenced their drug choice, as did nonantibacterial effects, such as immunomodulation (A15, A16).

TABLE 2 Case factors (C) influencing veterinarians' choice of antimicrobial drug, dose, and duration in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
Clinical features of case, expected pathogen(s)	C1	If it's been ... on antibiotics and relapsed , or something that's really severe , I think [I'd give a longer course of antimicrobials]. Probably also just the dog's or cat's clinical status ; if it's bright and happy and not systemically unwell, I'd be a lot more light-handed , whereas the dog that I had with pneumonia ... was quite flat ... <i>Veterinarian R, 28F^a, regional CA practice, high interest in AMR/AMS</i>
	C2	I would tend to use a broader-spectrum [antimicrobial] for a [gastroenteritis] issue or peritonitis issue because ... it could be anything . I mean, it could be <i>E. coli</i> , could be [<i>Staphylococcus</i>], [<i>Streptococcus</i>]. So you're going to use a broad-spectrum [antimicrobial]. If it's a skin thing , you can be a bit more selective because it's going to be a [<i>Staphylococcus</i>] or a [<i>Streptococcus</i>] mostly. So, I will tend to narrow my choice of spectrum. <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
	C3	Some colleagues will say, "Let's stick it on [enrofloxacin], metronidazole, and amoxiclav just to cover all bases ." Which is not something I would tend to do, unless I have some kind of culture, or unless something was about to die and the owners didn't have money and it was the only thing I could think of. <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	C4	Cats that have had frequent urinary tract infections, like the older cats—if I've been seeing one for its third UTI in the last six months—I might reach for enrofloxacin straight away, and do a longer course . <i>Veterinarian F, 30F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Information about the bacteria	C5	[The antimicrobial I would choose for a UTI] depends whether I've got cocci or whether I've got rods . I run a lot on the morphology of what I've got. So, if I've just got cocci, then then I'd be using [amoxicillin-clavulanate] before I'd go anywhere else ... [For a UTI with rods] my first antibiotic of choice ... would be enrofloxacin. <i>Veterinarian S, 66M, regional CA practice, low interest in AMR/AMS</i>
	C6	If I got [culture and susceptibility test] results back, then I would probably swap over [from initial empirical amoxicillin-clavulanate] depending on what that comes back as. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
Animal temperament and environment	C7	I tend to reserve [long-acting cefovecin] if it's like a really, really fractious animal ... when I have a lot more aggressive dogs that kind of screws up me being able to dole out oral antibiotics at all. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	C8	[Whether I use long-acting cefovecin] will really be decided by the cat's behavior ... like whether it's going to stress the cat more than anything to try and medicate it twice a day. <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	C9	If [the owner] said, "No, he's an outdoor cat , there's no chance I'll be able to catch him twice a day, I would go with [long-acting cefovecin]." <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Potential for direct adverse effects	C10	I tend to be a bit less gung-ho about giving antibiotics to younger animals and certainly [I'm more selective in] the types of antibiotics I'm giving ... both [to reduce the disruption to] ... normal flora, so gut, skin, whatever. But also other direct effects like enrofloxacin on [growing] bone and joints. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	C11	Sometimes we do [keep stock of TMS], not much. I don't want to cause dry eye . I use it every now and then for urinary tract infections, but I find the dose a bit awkward with the tablets. And I think you normally buy like a bottle of 200 or something ... I don't use them much. <i>Veterinarian N, 29F, rural CA practice, moderate interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

3.6 | Owner factors

I don't want to save the world from antibiotic resistance, but cause an old lady to break a hip

A range of owner factors were important in veterinary antimicrobial choices (Table 4). The owner's capability, opportunity, and motivation to administer medication to their animal were important factors in the veterinarian's choice of antimicrobial agent. Owners who were

disabled or frail (O1, O3), too busy or simply blasé (O2), or could not catch their outdoor cat (C9) caused some veterinarians to offer an injection of cefovecin, even when their preferred choice was a PO antimicrobial. Veterinarians felt this choice was justified to ensure the animal received a complete course (D10, D11).

Some participants felt that 5 to 7 days was the upper limit for the duration most pet owners could reliably dose their animal, either because of memory (O4, O5) or time (O5) limitations, or because the animal would become more avoidant (O5). Owners admitting to

TABLE 3 Antimicrobial drug (A) factors influencing veterinarians' choices of antimicrobial drug, dose, and duration in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
Ease of dosing (formulation, size/volume, route, divisibility, palatability, duration of action)	A1	Sometimes [your preferred antimicrobials] are not available to you or what you have on hand ... [or available] in certain sizes. So, metronidazole tablets, the smallest we have is 200 milligrams, and if I've got a little kitten or puppy that needs something like that, it's really hard to cut a tablet into eighths , otherwise it's got to be intravenous and ... you have to hospitalize them to do that ... things like that can be really hard. <i>Veterinarian E, 24F^a, regional CA practice, moderate interest in AMR/AMS</i>
	A2	What's the easiest way I can divide this tablet and not give them too much ? ... [If I need to give 300 milligrams] ... Okay, let's give a 500 milligram tablet and divide it ... [into] three quarters , things like that ... do play on my mind. I do get clients that, especially if they're old , they struggle to divide tablets up and ... I do try to divide it for them, but then it often crumbles ... So things like that do come into play. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	A3	I would probably choose amoxicillin-clavulanate as my first-line [empirical treatment for the dog UTI]. Because I'm suspecting <i>E. coli</i> , I guess. And it's cheap and easy to give and the ... tablet sizing is quite easy. So, it's generally my first go-to antibiotic for everything . <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
	A4	Palatability is a big thing. Pretty much the only thing I can give as a liquid is [amoxicillin-clavulanate] palatable drops. You can get [enrofloxacin] but you can't give [enrofloxacin] to cats. So that limits things as well. And if you go and get something compounded , it is hellishly expensive ... and could take five days to come in, and you need it now ... If there were more liquid formulations ... that'd be nice. <i>Veterinarian M, 28F, regional CA practice, low interest in AMR/AMS</i>
	A5	Most clients are hopeless at medicating their cats with tablets, in particular. Even liquids as well ... the only medications that I would say that our clients consistently, successfully give to cats are probably the transdermals and pastes and things ... flavored pastes like doxycycline they're a bit more successful with. But in terms of your tablets and liquids, it's pretty hit and miss . It's mostly miss! [laughs] <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	A6	TMS is a difficult one, because obviously, it's a good one to use as a first-line [empirical antimicrobial]. But it is also very difficult to dose in cats. It's difficult to administer because it tastes like shit ... So I don't really use it ... unless I absolutely have to. <i>Veterinarian V, 36F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	A7	If there's not an easy size , flavoring , or whatever, it's going to be a lot harder for vets to use those [medications]. [Pharmaceutical manufacturer] did something a couple years ago, all their tablets were hideous tasting ... generic ... their cephalexin ... tablets ... were horrible and trying to get them into animals was a nightmare! At some point, they did flavor them and that's made a massive difference to how much we can now easily use those drugs. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	A8	If it is a cat that isn't going to be easily handled , obviously I will go down the track of [a long-acting cefovecin injection] ... and I wouldn't think twice about it. <i>Veterinarian J, 32F, metropolitan CA practice, high interest in AMR/AMS</i>
	A9	Everyone wants simplicity , you don't want to struggle with your cat to put things down [its throat]. You start cursing your vet if you get scratched and bitten , so I think there should be something easier ... If there was something like [long-acting cefovecin] but it wasn't [cefovecin] ... maybe an injection of a longer-acting penicillin or a longer-acting doxycycline ... or a gel that you could put under the skin, that would be good. <i>Veterinarian B, 31M, metropolitan CA practice, high interest in AMR/AMS</i>
Cost to pet owner	A10	... as long as it's a responsible choice then probably, [I consider] cost to the client and ... the formulation of the tablet we have on the shelf, like, Is it a tasty tablet? ... Or is this a capsule that they can't break in half ? ... Things like that. <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	A11	Cost does come into it ... There are dogs, especially large ones that I would love to put on cephalexin because the amoxiclav dose, they'd have to eat two or three tablets twice a day . It's not feasible . But the cephalexin is extremely expensive for the client ... I definitely have that as a conundrum . <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	A12	Sometimes you say, "Well, I think clindamycin will work really well here, but it's four times the price of amoxiclav. This person has no money . I'm going to give them the amoxiclav." ... [Cost] is probably a bigger factor than it should be ... I rarely use [long-acting cefovecin] in a dog, just because it's really expensive . <i>Veterinarian M, 28F, regional CA practice, low interest in AMR/AMS</i>
Spectrum of activity	A13	I do kind of try and have a list of possible bacteria and then pick a spectrum from that. So, in reptiles [enrofloxacin] is actually quite good because it's often a Gram-negative [pathogen]. <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>

TABLE 3 (Continued)

Factor	Quotation code	Quotation, participant code, and demographics
Penetration of affected tissue	A14	[I think] more about penetration and less about spectrum [of activity] because I don't know exactly what bacteria I'm treating ... then you just choose based on a few other things like cost, ease of administration, volume of administration . <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
Non-antibacterial effects	A15	I probably wouldn't use anything other than metronidazole for diarrhea . Mostly I use metronidazole because it has that sort of anti-inflammatory type effect. I can give it IV. It's easy to send home on and it's cheap . <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
	A16	Well [we use] that one [metronidazole] for ... inflammatory bowel disease ... [to reduce] inflammation in guts and also doxycycline for eyes is the other one ... where I'm not actually massively worried about the infection ... It's something that ... I've been advised to do by specialists and ... it seems to work, so we do it. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

having leftover antimicrobial doses (O4) was evidence of noncompletion of previous antimicrobial courses.

Owner financial constraints interacted with the differing costs of antimicrobials (discussed in the previous section) to guide drug choice (O6, O7, O8, O9). When financially constrained owners also had large dogs, requiring a higher antimicrobial dose, the effect was compounded (O6). Cost constraints could be so severe that the veterinarian feared the owner might choose no treatment at all, leading to animal welfare concerns (O6). Conversely, sometimes the expense of an antimicrobial drug helped the veterinarian convince a pet owner to accept a cheaper alternative (O7, O8, O9), that may be less convenient, but more appropriate.

A trusting, friendly relationship with a good client can assist in persuading the owner to give PO antimicrobials rather than giving a more convenient, long-acting injection (O10). Conversely, a difficult or distrustful relationship encouraged defensive prescribing, which could mean using a broader-spectrum antimicrobial than necessary (O11, O14) or a longer duration of treatment, or both (P19).

Some veterinarians described the difficulty of dealing with explicit owner expectations or requests for a long-acting antimicrobial injection rather than a PO formulation (O12, O13, O14), particularly when the owner had seen the injection used for a similar presentation (O12, O13). Less experienced veterinarians were sometimes reluctant to appear to the owner to contradict the previous drug choice of a more senior veterinarian (O12), preferring instead to repeat their colleague's selection.

In addition to influencing the choice of drug, owner expectations could influence the duration of treatment chosen. If the owner expressed unwillingness to return for a revisit, the veterinarian might select a longer course (O13, O15).

An owner's preexisting understanding of AMR could assist with avoiding cefovecin use (O16), allowing a more productive discussion of the reasons to opt for a PO medication instead.

3.7 | Veterinarian factors

3.7.1 | Selecting drug and dose

I probably overuse [amoxicillin-clavulanate] because it seems safe. Like you can use it in pregnant dogs. You can use it in young dogs. And I feel like it covers 90% of problems.

Many factors relating to the veterinarian were important in their choice of antimicrobial drug and dose (Table 5A). Frequent empirical use of broad-spectrum antimicrobial treatment, particularly amoxiclav, was described by multiple participants (V1, V2, V3) to “cover all bases” (V4), with 1 participant unable to see any reason to select a narrower spectrum antimicrobial (V3). The broad-spectrum treatment gave veterinarians a sense of safety (V1, V2, D7), reinforced by treatment success (V1, V2, V9) and low rates of overt adverse effects (V2). Safety and treatment success became especially important when the veterinarian felt vulnerable, such as during a “run of bad clients who were grumpy” (V5).

Conversely, even a single experience of treatment failure (V6) or serious adverse effects (V7) with a particular antimicrobial could make a veterinarian “unreasonably nervous” (V7) and disproportionately influence their long-term prescribing habits.

Although many participants were unaware of antimicrobial importance ratings and some said they did not consciously consider AMR risk when selecting an antimicrobial (V10), many conveyed concern about AMR (V11, V23, D7) and a sense of an antimicrobial hierarchy, using words such as “stronger” (V9) or “heavier-duty” (O11) to describe higher importance antimicrobials that they generally avoided prescribing. Fluoroquinolones were frequently mentioned in this category because of the high risk of AMR (V8, V9, V11), that had been “drilled” into them at university (V8, V11). A few participants also mentioned cefovecin in this category, but awareness of AMR risk from this drug was less prominent than for fluoroquinolones, and

TABLE 4 Pet owner (O) factors that influence veterinarians' choice of antimicrobial drug, dose, and duration in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
Capability, opportunity and motivation to give oral medications	O1	I only tend to use [long-acting cefovecin] if it's a really, really, really fractious animal, and it would benefit this animal to be on antibiotics rather than missing a bajillion doses or having that owner's head bitten off . Or it's a client that's quite disabled or has difficulty tableting a dog or cat that's otherwise fine to tablet ... If I have an old arthritic lady where it's a pain for her to get to the clinic I'll be like, "Look, we do have [long-acting cefovecin]. I don't like using it because [it] encourages resistance . It has its pros and cons and it is quite expensive . If you are okay to go ahead with that, then we can." <i>Veterinarian D, 25F^a, regional CA practice, high interest in AMR/AMS</i>
	O2	If the client is afraid of handling the cat or if they're busy and if they seem like they're not going to remember , they're too blasé or whatever, then my feeling would be, "Well at least he has this [long-acting cefovecin] in his system ." <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	O3	Which is the lesser of two evils ... the risk of me creating some antibiotic resistance in this German Shepherd, or this old lady falling over and breaking her hip [trying to give the dog antimicrobial tablets]? ... A 90 year-old lady with a German Shepherd, I might say, the safest option is [long-acting cefovecin]... I don't want to save the world from antibiotic resistance, but cause an old lady to break a hip! ... I try and work out ... whatever [antibiotic will give] the best outcome for that particular patient and client, and somewhere on the list, the world . <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	O4	Three days [of antimicrobial treatment] for most people is not that difficult ... There are many things I've sent home on longer courses that don't get the full course , as much as we try and tell them it's important . I know that, because ... they'll come back and say, "Oh, I've still got these tablets leftover from the last course ..." ... Three to five days would be the perfect window ... the majority [of owners] would be OK up to a week . But beyond that, I'm skeptical of how many actually [continue giving antimicrobials]. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	O5	I mean, I'm useless at taking a multivitamin! And I suspect that if I can put a little bit of the fear of God into an owner about antimicrobial resistance , that they can probably follow those instructions for three to five days . I suspect any longer than that ... they are going to forget or they're going to have other commitments that impair them, or the animal is going to become savvy to tablets in a meatball. <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>
Financial constraints	O6	My clients are a little bit more cost-constrained ... and have much larger dogs ... whereas when I was in [my first job], they were basically ... Cavoodle, city-type [dog breeds]; I didn't have to worry about having to dose 1000 milligrams of [cephalexin] or something ... Cost does influence my prescribing a lot more than I care to acknowledge. When I think about it, I can't use any of those [antimicrobials] because a client can't afford that ... if I don't give this—not necessarily the antibiotic that the client wants—but if I pick the cheaper of the two, that's the only way they're going to afford to do it . Otherwise, they're just not going to [treat] it, and they're not going to euthanize it. So, they're just gonna leave it to suffer . And ... it's definitely something I [feel] responsibility for. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	O7	I'd say maybe one [owner] every few months, will just say that they can't [tablet their cat] and then I will have no qualms in giving [long-acting cefovecin] a go. But most of them, if you say [long-acting cefovecin is] going to be double the cost of tablets , then they'll try [the tablets]. <i>Veterinarian F, 30F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	O8	... there's a massive cost difference as well [between a long-acting cefovecin injection and amoxicillin-clavulanate tablets] and for most clients, that's adequate [to convince them]. In our setting anyway, cost is a reasonably good deterrent . <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	O9	Occasionally an owner will want something [an antimicrobial] liquid , and I'll give it to them. But it's so expensive that I say, well, if you can get the tablets down , it's gonna cost you \$5. If you want the liquid, it's gonna cost you \$30, please yourself! <i>Veterinarian H, 68M, regional mixed practice, high interest in AMR/AMS</i>
Relationship with veterinarian	O10	[If the owner said they would prefer not to give tablets] I'd probably tell them to suck it up and do it! [laughter] ... I guess I need to preface that with, my clients are incredibly compliant and really good at things. We have an incredible clientele ... compared to other clinics locally, my clients are very, very good. <i>Veterinarian Q, 43F, regional CA practice, high interest in AMR/AMS</i>
	O11	I might have chosen a heavier-duty antibiotic than ... necessary. The reasoning that goes through my head in those instances is ... "It's just a really sick animal. And this [antimicrobial] will probably do it, but I just feel safer if I hit it with something a bit harder ." It's probably more ... the case of a difficult client

TABLE 4 (Continued)

Factor	Quotation code	Quotation, participant code, and demographics
		that you've had trouble with communicating with and you feel like you're still not really on the same page, and maybe there's a touch of worry that they're going to come back ... they're going to be pissed off and all that sort of thing. So let's make absolutely sure . <i>Veterinarian U, 39F, regional mixed practice, low interest in AMR/AMS</i>
Expectations of receiving a particular medication	O12	I didn't think [the cat] needed any [antibiotics] at all. And [the owner] was still like, "No, my wife said he has to have some ," and I said, "All right, I'll give you some [amoxicillin-clavulanate]." And he's like, "No, no, it has to be an injectable or she'll be very angry with me." There's that expectation, I've had [this] antibiotic before; I want it again ... They had an abscess done six months ago and it got [long-acting cefovecin], and so [my colleagues] were like, "Just give it again," because if for some reason it didn't go well, it would come back to bite me in the butt ... [My colleagues] use that drug quite a lot so it's harder for me to say , "I don't think it's the best option here," because then they'll be like, "Well, all those other much more experienced vets use it and ... it's always gone super well when it's had that." So obviously, when you've been [in practice for] six months it's, you know ... <i>Veterinarian E, 24F, regional CA practice, moderate interest in AMR/AMS</i>
	O13	[Clients] can definitely ... feel that we're not listening to ... not necessarily demands , but concerns about trying any other way of tableting. Because their previous experience ... [giving antimicrobial tablets] just didn't work , so, "Just go straight to the [long-acting cefovecin], I don't want to have to fluff around and then come back to you ..." <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	O14	God, if I don't give them what they want, they're going to scream at me . They might not directly scream at me, but they'll scream at someone . <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	O15	Part of that [decision] is client expectation as well. If you give a client, say, a week of [antibiotics] and the dog needed two weeks, then they'll be annoyed about having to come back , pay a recheck fee , pay for more antibiotics ... And they might make that clear to you as well; "I just want this thing sorted and I don't want to have to keep coming back!" Then I'm going to be more inclined to give them a course that [I'm] fairly confident that is going to really get on top of that infection. <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Understanding of AMR	O16	We tend to avoid using [long-acting cefovecin] where possible ... because of [antimicrobial] resistance , which most of our clients have heard of in some form they kind of know that word. So, we would definitely recommend ... that we stick to either a liquid form or a tablet form [of another antimicrobial]. And hide it in food, that sort of thing. <i>Veterinarian U, 39F, regional mixed practice, low interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

therefore more easily outweighed by the practicality of a long-acting injection (V11).

For some participants, continuing veterinary education had shaped their antimicrobial drug choices (V12), as had awareness of antimicrobial prescribing resources, including guidelines (V13). However, several participants were using resources from other countries (V14, V15), which can be less relevant because of differences in the drugs available, the prevalence of different pathogens, and AMR patterns.

Veterinarians also noted problems with the clarity and reliability of published antimicrobial dosages (V16), compounded by a sense of "information overload" (V17) and the inaccessibility of pay-walled scientific literature (V15).

Veterinarians with strong client communication skills (V18) and confidence (V19, V20) felt more able to resist client pressure to prescribe a particular antimicrobial, but an exhausted veterinarian dealing with a "difficult" owner (V21) was more likely to capitulate. Veterinarians also recognized that exhaustion and stress caused them to

default to suboptimal antimicrobial drug choices that demanded less cognitive energy (V22, V23, V24). Participants recognized that habit played an important role (P2, P10, V25, V26, V27) in their drug choices, particularly in stressful situations.

3.7.2 | Selecting duration of therapy

Am I treating it for long enough? Or am I treating it for too long? And where is the problem [of AMR] coming from? Is it treating too long, or not long enough?

Veterinarians felt treatment durations (Table 5B) were sometimes picked "out of the air" (D1), based on past experience (D2) or colleagues' suggestions. Many were unaware of any prescribing guidelines on duration and some were concerned about the lack of veterinary evidence for treatment durations (D1). Fear of relapse encouraged longer durations; 1 participant felt safer treating a

TABLE 5A Veterinarian (V) factors influencing choice of antimicrobial drug and dose in companion animals.

Factor	Quotation code	Quotation, <i>participant code and demographics</i>
Knowledge and past experience	V1	I probably overuse [amoxicillin-clavulanate] because it seems safe . Like you can use it in pregnant dogs . You can use it in young dogs . And I feel like it covers 90% of problems. <i>Veterinarian M, 28F^a, regional CA practice, low interest in AMR/AMS</i>
	V2	[Amoxicillin-clavulanate] is user-friendly, broad spectrum . Feels kind of safe ... I think you're like most likely to have a benefit using something broad-spectrum like that ... I rarely see any side effects , it's hard to overdose —if they do have too much, if the owner got the dose wrong, you get a [gastrointestinal] upset, that's about it! <i>Veterinarian E, 24F, regional CA practice, moderate interest in AMR/AMS</i>
	V3	I think that if I can get a better activity with the combination [amoxicillin-clavulanate] , then why am I staying with straight amoxicillin? <i>Veterinarian S, 66M, regional CA practice, low interest in AMR/AMS</i>
	V4	In that first year [of clinical practice], I would put so many cases on cephalixin plus metronidazole at the same time because I thought that would be broad spectrum and sort of cover all my bases ... I remember doing that willy nilly ... <i>Veterinarian F, 30F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V5	I'm sort of aware that [amoxicillin-clavulanate] is probably higher than I necessarily need for most urinary tract infections. But I guess I've found that it always clears them ... If I've had a run of bad clients who were grumpy because things didn't work. I'm like, "Nup ... I'm gonna go with the [antimicrobial regimen] that's always worked for me ." <i>Veterinarian N, 29F, rural CA practice, moderate interest in AMR/AMS</i>
	V6	Generally, when I see rods [bacilli] in the urine ... I'm probably going to reach for [enrofloxacin], rightly or wrongly, just because I haven't had much luck with [amoxicillin-clavulanate] when there's rods involved. So, based on past experience , I'd probably go for [enrofloxacin], unless it was a dog under 12 months [of age] . <i>Veterinarian M, 28F, regional CA practice, low interest in AMR/AMS</i>
	V7	Back in my real-world general practice days, probably [my first choice for a bacillary urinary tract infection] was TMS. Because it was cheap . So, for the clients who can't afford a culture and sensitivity, they can afford TMS. And it worked . And you don't have to worry if it's an intact male dog and probably TMS was my go-to in [those] days. And now, I have become unreasonably nervous [about using TMS] because of a handful of cases that have had side effects. <i>Veterinarian Y, 39F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V8	I think probably from university , they've kind of drilled it into us , "Don't ever use [enrofloxacin] unless you have a culture or it's a nasty prostatitis or something like that." "So there's a bit of a fear element of," Ooh, [enrofloxacin]! <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V9	I would generally use what I thought has the highest likelihood of success, that's necessary , if that makes sense. So even though I'm aware that [enrofloxacin] would probably work quite well, I wouldn't jump to that or any of the fluoroquinolones because it's unlikely it needs that. I tend to reserve those for more difficult cases . So [amoxicillin-clavulanate] and cephalixin, I know that most UTIs would respond to one or the other of those. The only reasons I might look at alternatives in terms of something stronger —for want of a better word—would be if it was a dosing issue . <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
Concern about AMR	V10	Do I consider resistance with it? Not consciously ... I'm certainly not thinking, if I use this, I might create a resistance issue. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V11	Then you have [enrofloxacin], but you don't really want to be using that ... I try and make that the last option ... from vet school, it's all drummed into you "Don't be using [enrofloxacin] unless you have to." From a resistance point of view, that's just something ingrained in me ... With cats it's more difficult . [Long-acting cefovecin] gets a fair bit of use . <i>Veterinarian E, 24F, regional CA practice, moderate interest in AMR/AMS</i>
Access to continuing veterinary education (CVE) and prescribing resources	V12	I had slipped across [from using amoxicillin] to using amoxicillin-clavulanate. And ... this CVE course I did ... said that there was no particular advantage to the clavulanate , because the probability of it working as a first-line treatment [in cystitis] was just as good for amoxicillin as it was for the mixture and ... I got the courage to go back to just using amoxicillin for cystitis, in the face of my colleagues that were using [amoxicillin-clavulanate]. <i>Veterinarian H, 68M, regional mixed practice, high interest in AMR/AMS</i>
	V13	I try to use the [University of Melbourne] website [which has antimicrobial prescribing guidelines for common conditions]. Sometimes I won't, or can't follow it exactly for whatever reason, but I do try. Especially if it's [a condition] that I haven't seen a lot of , that's not stock-standard, I will look up ... what I'm supposed to be doing ... <i>Veterinarian R, 28F, regional CA practice, high interest in AMR/AMS</i>
	V14	VIN [US website] and the BSAVA [UK] textbooks are probably the things that I use the most in clinic when I need an answer relatively quickly. If I've got a little bit of time up my sleeve, I often go home and [look up] online sources , most of them are either American or European . And that's probably where I get the bulk of my information. The other [source] that I go to in clinic is other vets ... especially if it's something that needs [treatment] to be started straight away. <i>Veterinarian J, 32F, metropolitan CA practice, high interest in AMR/AMS</i>
	V15	I want to be better . But I just don't have the time to read ... And I can't get into any [paywalled journal] articles. Because you need, like, "uni-ness" [a connection to a university] for subscribing to journals and such ... So, I

TABLE 5A (Continued)

Factor	Quotation code	Quotation, <i>participant code and demographics</i>
		pretty much base [my antimicrobial prescribing] on VIN [US website] or the Merck Manual ... But there's no journal articles . <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
	V16	I just want guidance! ... It's a little bit overwhelming ... just give me a dose! For example ... in Plumb's [Veterinary Drug Handbook] ... every time I look up doxycycline, I'm like, "You're not giving me a direct answer as to what I need to do here. You're giving me five different doses and different ways of dosing." And I'm like, can I do either and it'll be okay? <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	V17	I guess probably accessibility of the information as well ... we have information overload when it comes to publications. And it's fundamentally because we have such a breadth of knowledge that we need to maintain . <i>Veterinarian L, 32M, metropolitan CA practice, high interest in AMR/AMS</i>
Communication skills, confidence, relationship with client	V18	I didn't also realize how much of it's just ... being able to communicate that to clients , why they need to do things a certain way, why they have to dose it twice a day ... that definitely influences my decision [about which antibiotic to use]. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	V19	We usually just tell [owners] that they have to suck it up and do it [give oral antibiotics to their cats]! [laughs] There's just not a lot of room for argument . <i>Veterinarian Y, 39F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V20	I think there's probably more confident , more outgoing people out there who would have probably spoken up , like, "This is not what I was taught," or "I'd rather not use it." But ... for new grads , you always get worried that you're doing the wrong thing . <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	V21	If it's a client where we have written on their file "very difficult," I don't have the emotional, physical, or mental energy to ... debate this with this person. As long as I've said my spiel as to why I don't like prescribing [long-acting cefovecin] when you can probably tablet this animal, then fine. But ... I do it more to cover my own ass than really to practice good antibiotic stewardship. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
Energy and emotional state	V22	I'm sure you will see at the start of the vet's shift , there is less pattern recognition and the further you get towards the end of it, you're just eergh [tired sound], I think that plays a role. <i>Veterinarian A, 45F, metropolitan CA practice, high interest in AMR/AMS</i>
	V23	When I'm really stressed , and I've got a lot going on and I just want to get that case out of the way , I'm more likely to go to the [amoxicillin-clavulanate]. But when I don't have that much on my plate and I can talk to [the owner] and I think, "No I'm going to be a responsible vet today." ... and then I feel quite good about myself because I'm contributing less to antibiotic resistance. <i>Veterinarian N, 29F, rural CA practice, moderate interest in AMR/AMS</i>
Habit and familiarity	V24	I suppose [I'd choose] something that I'm used to or something I know the dose off the top of my head , especially if it's a busy, busy, evening clinic, I'm like, "Okay, let's just put them on cephalexin ... 20 mg/kg." Yeah, being honest about it, probably convenience for me as well. <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	V25	With so many vets, anything with diarrhea gets metronidazole because that's what they've always done! <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>
	V26	Habit! Habit, habit, habit! And it's hard to break it. You get complacent in your habits and you just get stuck in that thing. It's worked and the patient's alive! <i>Veterinarian B, 31M, metropolitan CA practice, high interest in AMR/AMS</i>
	V27	I think that's the primary thing is that it's something that you know , and you're comfortable with. <i>Veterinarian S, 66M, regional CA practice, low interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

urinary tract infection for 2 to 3 weeks, despite a colleague drawing their attention to evidence that 5 days would suffice (D4). Another noted that if a particular treatment duration had proven effective, it could become "just what you do," with little impetus to shorten it (D3).

Some veterinarians expressed uncertainty about whether under- or over-treating an infection contributed more to AMR (D6, D7). However, many believed that erring on the side of longer durations

(D5) and ensuring a patient finished all planned antimicrobial doses, even if they seemed better, was important (D9, D10, O2, O4). This approach was believed to decrease the risk of relapse (D5, D15) and of leaving behind AMR bacterial subpopulations (D6). Concern about owner compliance and "finishing the course" was the primary justification veterinarians gave for using long-acting cefovecin injections when there was any doubt about the owner's capability to administer PO medications (C9, D6, D10, D11). Another driver was concern for

TABLE 5B Veterinarian factors influencing choice of antimicrobial treatment duration (D) in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
Knowledge and past experience, awareness of guidelines	D1	I do just kind of make it up a bit. And ... I find it very hard to work out durations of things because there's no guidelines (sic) ... I feel like people are just picking numbers out of the air or based on, like, one study ... but [researchers] haven't worked out what a minimum and what a maximum [duration] is. <i>Veterinarian G, 26F^a, rural mixed practice, moderate interest in AMR/AMS</i>
	D2	I find you suddenly hear from humans [trials], "We're going much higher dose for only 3 days" and you go, is that something we need to adopt here? ... I find it a bit hard to know, how long is enough? ... I would say some of that is experience-based and just something I say, I think this is going to be all right with 5 days [of antibiotics], I think this is going to be all right with 7 days, I think this one will be all right with 10 days. That is not very scientific! <i>Veterinarian A, 45F, metropolitan CA practice, high interest in AMR/AMS</i>
	D3	I think a lot of it is anecdotal experience. You know, you've seen enough cases and they survived when you ... treated them with four to six weeks' of therapy. So that's just what you do . Rather than thinking, would one week be effective? <i>Veterinarian Y, 39F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Fear of relapse	D4	I was taught three weeks for urinary [tract infections], but ... one of our vets has said ... they don't need that long ... I have gone as short as two weeks with some, [but] I haven't gone as short as 5 days, which is what she was suggesting ... But I'm not game enough to go to five days ... that just doesn't seem long enough . Usually I'll either go a two- or three-week course . I guess for a first episode, maybe a two-week course. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	D5	I do have times where I probably do push the antibiotics longer than what may be strictly necessary, just as a safety net . <i>Veterinarian V, 36F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Uncertainty about relationship between treatment duration and AMR risk	D6	I don't know ... you certainly don't want to underdose but ... do you create resistance by having short durations? <i>Veterinarian G, 26F, rural mixed practice, moderate interest in AMR/AMS</i>
	D7	Am I treating it for long enough? Or am I treating it for too long? And where is the problem [of AMR] coming from? Is it treating too long or not long enough? <i>Veterinarian W, 39F, regional CA practice, moderate interest in AMR/AMS</i>
Concern about finishing the course	D8	... with any antibiotic use, I do want them to finish the course of whatever I give them. It's pretty pointless giving a course of tablets if it's only going to get three days of them. So I would rather give a [long-acting cefovecin] injection to a difficult animal, even though it may not be necessary for whatever the infection is, at least knowing that it's getting the full course of that. <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	D9	[Using a broad-spectrum antimicrobial] does make me feel a bit more secure , but it also makes me worry ... am I putting too much pressure on here? ... Resistance doesn't just miraculously occur ... there has to be a certain duration of pressure ... I go, "OK, I'm dispensing a broader spectrum than maybe is necessary , but I'll go the right dose and I'll go for a duration that I think is going to be effective, and then I'll very, very much encourage the people to finish the course ." <i>Veterinarian A, 45F, metropolitan CA practice, high interest in AMR/AMS</i>
	D10	[Long-acting cefovecin] is so user-friendly . It's really good . Cats are so hard to tablet , you can't sort of hide it in a piece of meat and things like that ... it's one injection that last seven (sic) days, it works for skin infections, it works for urinary tract infections, it's got a lot of uses ... What's the point of giving them ten days' worth of tablets , if the owners aren't even going to do it? ... And what's fair on the animal? ... I think a lot of people find suggestions on antimicrobial usage don't really fit with what you can realistically ... get the client to comply with. <i>Veterinarian E, 24F, regional CA practice, moderate interest in AMR/AMS</i>
	D11	If half the tablets are going to end up in the dog and half the tablets aren't , I feel like that's worse [than giving long-acting cefovecin]. <i>Veterinarian N, 29F, rural CA practice, moderate interest in AMR/AMS</i>
	D12	I still have a real problem in my head about using long-acting cephalosporins in cats. But then I look at little old ladies that get scratched to bits by their cats and think, there's the human issue with that and compliance issues with that animal. Are we better off just giving one injection and knowing it's been done? I really struggle with that. That's the biggest dilemma that I really have in small animal practice, is use of the long-acting antibiotics. <i>Veterinarian Q, 43F, regional CA practice, high interest in AMR/AMS</i>
Attitudes to other approaches to duration of therapy	D13	[When] the bacteria are winning the fight, the balance is in their favour. If we do something to tip it back the other way, the immune system's going to take over and sort it out. [When we give antibiotics] we're just giving the [patient] a bit of an advantage in the fight, to tip the balance back ... I think over the years I've used antibiotics too long . We had it sort of drummed into us that you had to complete the course . And I think probably used them too long. And of recent times I've tended to try and contract it down to some rational basis. <i>Veterinarian H, 68M, regional mixed practice, high interest in AMR/AMS</i>

TABLE 5B (Continued)

Factor	Quotation code	Quotation, participant code, and demographics
	D14	So probably [I'd treat the UTI for] five to seven days. But recently, we've been moving towards only treating while the symptoms are there . So ... once the signs have stopped—when the pollakiuria, stranguria, and hematuria ... resolves—[the owner] can probably just stop the antimicrobials ... they don't have to complete the course necessarily ... probably just to be on the safe side, I'd say give another dose [after clinical signs resolve], just to be sure. <i>Veterinarian V, 36F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	D15	The assumption there ... is that the symptoms are directly related to the level of infection ... my worry would be ... not actually completely resolving the infection . So, it's still there at some subclinical level. And then as soon as we stop the antibiotics, it's going to come back again ... My only other concern with that would be the reliance on the owner to appreciate what is a resolution of symptoms, which some clients I think would be amazing at, and some would be terrible at ... So that would be my other concern with it would be how reliable the owner is as a judge of those things. <i>Veterinarian T, 40 M, metropolitan CA practice, moderate interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

owner safety, particularly with frail owners who might get “scratched to bits” giving tablets to their cats (D12).

A few participants were aware of recommendations to minimize antimicrobial treatment duration and had adopted a “shorter is better” approach (D13), sometimes using clinical sign resolution as a guide (D14). However, 1 expressed concern about such an approach in outpatients because of variability in owners' observational skills (D15). Veterinarians who viewed antimicrobials as assisting the animal's immune system to “tip the balance” in favor of the patient (D13) appeared more comfortable with shorter durations.

3.8 | Practice and colleague factors

I know I should use a narrow-spectrum drug ... but in reality, I would probably use amoxiclav, because that's what we've got on the shelf.

Practice culture and colleagues substantially influence antimicrobial prescribing decisions (Table 6). A veterinarian's current co-workers strongly influence their antimicrobial drug selection, often by a mechanism we call the “dispensary cycle” (Figure 2). In many countries, veterinarians both prescribe and dispense medication, incurring costs for holding inventory of a range of antimicrobials and pressure to use them before expiration (P1). Our interviews indicated that the prescribing habits of veterinarians in a practice determine which antimicrobials are routinely kept in their dispensary (P1). In turn, the available drugs determine what veterinarians will prescribe (P1, P2, P3, P4, P5) and shape the habits of new graduates and locum veterinarians (P6, P5). This cycle amplifies the use of more popular drugs and limits less popular choices.

The dispensary cycle was best illustrated by the perpetuation of broad-spectrum amoxicillin-clavulanate use, which was available in every participant's practice, whereas narrower-spectrum amoxicillin was

rarely stocked (P1, P2, P3, P4, P5), hence rarely used, and sometimes forgotten about entirely as an option (P2). This situation occurred despite several veterinarians acknowledging that in many instances they should opt for amoxicillin instead of amoxicillin-clavulanate (P2, P3, P4). One experienced veterinarian noted he had “slipped” into using amoxicillin-clavulanate instead of amoxicillin because of his younger colleagues' preferences for the combination (V12) and was now trying to reverse that trend (P7), in the interests of AMS.

In other instances, the dispensary cycle could favor AMS. One veterinarian mentioned that a trend of dwindling cefovecin use in their practices resulted in the disposal of unused, expired products, prompting a policy to stop ordering the high-importance antimicrobial (P8).

More experienced colleagues, particularly those at a new graduate's first workplace, also had a direct influence on prescribing, recommending which antimicrobials to use, even if the choice was at odds with what they had learned at university (P9). This early influence could have long-lasting impact on drug selection (P9, P10).

Signals from the broader veterinary community also played a role in drug choice. For 1 participant, other veterinarians' comments on a social media group caused her to decrease her use of long-acting cefovecin (P11).

Veterinary specialists strongly influenced the antimicrobial choices of some general practice participants (A16) who felt that specialists “know way more than I do” (P12, P13). One experienced general practice veterinarian described this as a “god-like belief” in specialists (P14); another used biblical language to describe specialists' advice on antimicrobial duration (P13).

Participants' antimicrobial choices were not motivated by financial gain. Indeed, they were conscious of selecting a drug that minimized costs for owners (O6, O7, O8, O9), rather than improving clinic profits (P15, P16), even if they owned the practice (P15). Clinic charging policies also affected drug choice and duration. Fees for medication dispensing (P17), nurses administering medication to animals

TABLE 6 Practice and colleague (P) factors influencing veterinarians' choice of antimicrobial drug, dose, and duration in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
The “dispensary cycle”: colleagues' prescribing habits and “what's on the shelf”	P1	[Amoxicillin] I have used at times, but we don't always have that there. It's usually only if I have ordered it in for something else and if I happen to have some there I need to get rid of , I might use that, but otherwise it's amoxiclav or cephalixin based on, they're on the shelf, and they normally work ... I did certainly use [TMS] a lot more probably in my first 10 years of practice, when I was in mixed practice. And that was predominantly because it was on the shelf . We just don't keep it on the shelf [now] really ... that's the main reason we're not using it . <i>Veterinarian T, 40M³, metropolitan CA practice, moderate interest in AMR/AMS</i>
	P2	When I first started out, I probably did use just amoxicillin quite a lot more than what I do now ... the main reason I don't use [amoxicillin] so much these days is that I kind of ... forget that it exists and, you know, amoxiclav is so good for everything! [laughs] ... I know where the amoxiclav is on the shelf . I know it's always there. I know that I probably should choose something like amoxicillin . <i>Veterinarian W, 39F, regional CA practice, moderate interest in AMR/AMS</i>
	P3	I know I should use a narrow-spectrum drug like amoxicillin without the clavulanate ... but in reality, I would probably use amoxiclav because that's what we've got on the shelf . <i>Veterinarian R, 28F, regional CA practice, high interest in AMR/AMS</i>
	P4	Most of the places I've worked at have not had amoxicillin very accessible ... so usually [I use] amoxiclav ... I think amoxicillin is a better choice but it's not as available. We don't stock it in our clinic. We just don't have the ability to have a massive inventory . And we use amoxiclav so much . It's not ideal, but that is the reality. <i>Veterinarian V, 36F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	P5	I've got a locum ... that is really struggling to just use [amoxicillin]. “I just want to use amoxiclav. I just like it!” I'm like, “It's not necessary.” ... I think it's where you get used to doing something ... particularly for locums where they're moving between different clinics , they'll probably pick out a few things that they know will be there and will use them. <i>Veterinarian Q, 43F, regional CA practice, high interest in AMR/AMS</i>
	P6	I think a lot of medicine ... is habit-based. You've got a 10-minute consult; you don't have time to do this stuff properly. And then the [new graduate] vets do what the other vets in their clinic do . And the cycle continues. <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>
	P7	I haven't seen any reduction in the effectiveness of amoxicillin ... it wasn't really until I got a new graduate [veterinarian] and they started wanting [amoxicillin-clavulanate], that I ordered it. And then it was easier to grab that. But then I started ... saying, “... there's been no shift [in susceptibility to amoxicillin] —so why are we using the clavulanate? ” And actually a couple of them have started shifting in my direction ... we're ordering a lot more amoxicillin now and ... much less clavulanate. <i>Veterinarian H, 68M, regional mixed practice, high interest in AMR/AMS</i>
	P8	The first clinic I worked at we just wouldn't order [long-acting cefovecin] because they did the maths and they worked out they wouldn't use the bottle [before its expiry date]. So we just weren't allowed to order it in. <i>Veterinarian M, 28F, regional CA practice, low interest in AMR/AMS</i>
Influence of veterinary colleagues	P9	I think my early decision-making when it came to antibiotic prescription was more based on what my senior vets were telling me and less based on what I was taught at university. ... my indoctrination to it was, you know, just use this drug and nothing else . So ... whoever taught me or whoever I [worked] with in my first clinic , does play a big role in terms of what I'm comfortable with using ... regardless of what I might have been taught at [university] ... <i>Veterinarian D, 25F³, regional CA practice, high interest in AMR/AMS</i>
	P10	Most of that, I must admit, stemmed from my first ever job after [university], where you just gave whatever antibiotics your boss recommended for that particular case. And if it worked , that's my go-to for future cases . <i>Veterinarian U, 39F, regional mixed practice, low interest in AMR/AMS</i>
Influence of broader veterinary community	P11	And it wasn't until, in the [group for Australian veterinarians] on Facebook somebody was like, “Oh, I'm using [long-acting cefovecin], shame on me, ” and there's all the comments about it, that I realized that actually, it's one of those drugs that you should be limiting to just very specific cases. <i>Veterinarian W, 39F, regional CA practice, moderate interest in AMR/AMS</i>
Influence of veterinary specialists	P12	When I see that the specialist has sent me a summary of things, I'm like, what other drugs can I use for future cases? And I think that is because I have an inherent trust that they know way more than I do. And they know what they're doing . <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	P13	With skin infections, you're going to get a clinical cure in seven to 10 days. But the dermatologists have hammered into me : “thou shalt treat for 10 days past clinical cure, ” hence, three weeks ... it's just been hammered into me that that's what you are to do. So that's what I do ... [Veterinary specialists] know far more than I will ever know. <i>Veterinarian S, 66M, regional CA practice, low interest in AMR/AMS</i>
	P14	Maybe [I'd] talk to [veterinary] specialists and see what they're saying, but I don't give prima facie god-like belief to what they say ... they only see the weird stuff . They're not seeing the everyday stuff! <i>Veterinarian H, 68M, regional mixed practice, high interest in AMR/AMS</i>

TABLE 6 (Continued)

Factor	Quotation code	Quotation, participant code, and demographics
Financial considerations	P15	If anything, I probably, subconsciously or consciously, worry more about prices of things being too much . I'm not really thinking, "I'm gonna put this on a course of clindamycin or marbofloxacin because that's more expensive than [enrofloxacin] so we can make a bit more money on that." So, no, I can honestly say that that's not a consideration ... to make more money . <i>Veterinarian T, 40M, metropolitan CA practice, moderate interest in AMR/AMS</i>
	P16	To be honest, sometimes if I'm choosing between two, I'll ... see, how much is that going to cost? ... Sometimes, especially if it's a big dog, I think, "Oh my God, that's a lot of money ;" and ... go for the cheaper one ... So, I don't really think about what profit it's going to make for the clinic. <i>Veterinarian W, 39F, regional CA practice, moderate interest in AMR/AMS</i>
Clinic charging policies	P17	I didn't realize as a new grad how much money really plays a role in my decision-making. And that differs from clinic to clinic, because it just depends on what prices they set, what's their dispensing fee , things like that. <i>Veterinarian D, 25F, regional CA practice, high interest in AMR/AMS</i>
	P18	The cool thing about a three-day course of [antimicrobial] is it's once a day, so we can do one dose then and there. [If an owner can't tablet] I can be like, "Bring the dog in for two more days, my nurses will give a tablet free of charge ." <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>
	P19	If you give a client, say, a week of something and the dog needed two weeks, then they'll be annoyed about having to come back , pay a recheck fee , pay for more antibiotics ... they don't want to come back. And they might make that clear to you as well ... then you're going to be more inclined to kind of give them a course that you're fairly confident that is going to really get on top of that infection . <i>Veterinarian C, 33F, metropolitan CA practice, moderate interest in AMR/AMS</i>
Prescribing resources in the clinic	P20	I have seen in some clinics, they'll have ... a big [antimicrobial prescribing guidelines] poster ... where it says you've got a prostatic abscess, these are your options or you've got a skin condition, do it at this dose, and you've got these options. So, I think it's out there. I just don't know that we use it as much as we should . <i>Veterinarian M, 28F, regional CA practice, low interest in AMR/AMS</i>
Clinic culture	P21	And ... we've got lots of different treats and I've got information [resources for clients] on the fear-free tableting techniques , how to pill your cat or your dog ... The other thing I do—I've got a couple of real asshole cats, thankfully I've got beautiful clients and they will bring their cats in for just a daily injection of amoxicillin ... and it's two seconds. Sometimes we just go out to their car and do it in the car park . We will make it easy , if we can, for people. <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>
	P22	I really wanted to treat ear infections appropriately and we were having a lot of yeast ear infections coming in that didn't have any bacteria. I asked my boss if we could get [anti-fungal] just to kill the yeast and mix that with [corticosteroid] so that we didn't have to use any antibiotics at all . He was open to that and immediately got it in. And we were able to get all these dogs off antibiotics and on a yeast-only drop . <i>Veterinarian R, 28F, regional CA practice, high interest in AMR/AMS</i>
Time pressure	P23	The time and financial pressures that [general practice veterinarians] face are extremely challenging. They're often in a position where they just need to quickly and cheaply make the problem go away ... It's an unfortunate reality ... they deal with difficult clients every 10 or 15 minutes, who have \$40 or \$50 to make the problem go away. <i>Veterinarian Y, 39F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	P24	I've had 20-minute and 30-minute consultation times ... so I've never felt as much time pressure as I'm sure some other vets ... I think that's part of the reason why I've been able to communicate [with owners] the way that I have ... but I honestly don't know what my [antimicrobial prescribing] behavior ... would be like, even despite my knowledge and my values , if I was really burnt out and had worked a lot of hours and seen a huge volume of clients ... if I was pushed to that level of desperation . <i>Veterinarian R, 28F, regional CA practice, high interest in AMR/AMS</i>
Capacity to follow-up with owner	P25	[When I prescribe antibiotics, I will] call or get reception to call the owner the next day to make sure that there's been an immediate and impressive response . <i>Veterinarian P, 35F, metropolitan CA practice, high interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

(P18), and veterinary re-examination (P19) were identified as potential or actual barriers to optimal antimicrobial use.

Displaying antimicrobial prescribing guidelines (P20) in a practice and providing owners with information on topics such as administering

medications to cats (P21) and common infections that do not need antimicrobials were felt to help decrease suboptimal antimicrobial use. Clinic culture also played an important role, with clinic leaders who were open to change (P22) and teams engaged in AMS (P21) empowering

veterinarians to make more considered prescribing choices. Conversely, time pressure on consultations (P6, P23, P24) and owner financial limitations (P23) encouraged inappropriate antimicrobial use.

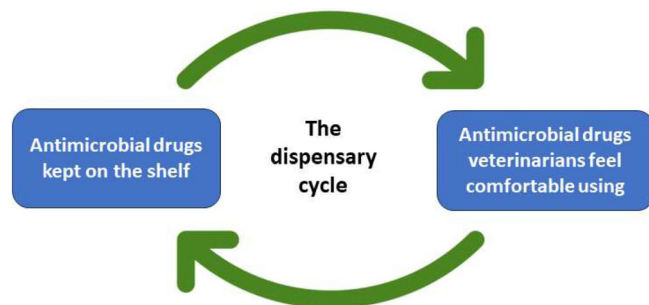


FIGURE 2 The dispensary cycle.

The capacity of the practice to communicate with pet owners was another influential factor. When a veterinary practice could follow up with owners soon after starting antimicrobial treatment, veterinarians felt confident using narrower spectrum antimicrobials (P25), knowing they could modify treatment in a timely fashion, if the initial choice proved ineffective.

3.9 | External factors

I think part of the problem is we are ... reliant on our [drug company] reps ... they come over with cake and pizza and they have this talk about a new drug ... it's a factor!

TABLE 7 External (E) factors influencing veterinarians' choice of antimicrobial drug, dose, and duration in companion animals.

Factor	Quotation code	Quotation, participant code, and demographics
Antimicrobial label information	E1	I completely ignore the dosing directions on packets . Because they say 12.5 to 13.5 milligrams per kilogram [for amoxiclav], and my understanding is that [with the label dose] you ... don't get as good penetration ... and the spectrum actually increases as you increase your dose, so you get better anaerobic and Gram-negative [bacterial] coverage at the higher doses . <i>Veterinarian P, 35F^a, metropolitan CA practice, high interest in AMR/AMS</i>
	E2	I do tend to go more off the dosages on the bottles , although there's some drugs [for which the label dose rates] are just plain wrong . <i>Veterinarian U, 39F, regional mixed practice, low interest in AMR/AMS</i>
	E3	I guess some of the vets in my clinic have the opinion that, "Well, [long-acting cefovecin has] been registered for this use , so ... we're going to use it as we need to." ... It's how you justify its use to yourself, I think, when you know it's probably not what we should be using, they're like, "Well, it shouldn't be available to us if we aren't supposed to use it," sort of thing. <i>Veterinarian E, 24F, regional CA practice, moderate interest in AMR/AMS</i>
Information in culture and susceptibility reports	E4	That's exactly it ... [When I get a culture and susceptibility report with lots of susceptible results], I don't know which antibiotic to choose. It might be great for that infection, but I might be carpet-bombing the gut and causing a resistance that I have no idea of. <i>Veterinarian B, 31M, metropolitan CA practice, high interest in AMR/AMS</i>
Pharmaceutical company marketing	E5	I think part of the problem is we are ... reliant on our [drug company] reps ... they come over with cake and pizza and they have this talk about a new drug ... it's a factor! I mean, how convenient is that [long-acting cefovecin] with a fractious cat ? You don't have to worry about it! I think ... we need to approach our relationships with those external stakeholders in a much more stringent way, because it is big money , it's Big Pharma ... I remember seeing [a drug company presentation] about [long-acting cefovecin] overseas, and it was like, " It's good for skin, good for teeth, good for urine! " [laughter], so ... you have to look at who is providing that resource. <i>Veterinarian B, 31M, metropolitan CA practice, high interest in AMR/AMS</i>
	E6	[Long-acting cefovecin] ... that is one that is certainly used without the necessary thought ... I think the [brand] name is no mistake ... that's clever marketing . And I think the convenience is over-sold . <i>Veterinarian Y, 39F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	E7	I always thought that [long-acting cefovecin] was just a ... super handy , super convenient form of antibiotic. And you could pretty much use it for anything , especially in cats, like UTIs or abscesses and everything ... was marketed as a really convenient drug ... but the info about it being ... one of those that you should reserve ... that never really was publicized . <i>Veterinarian W, 39F, regional CA practice, moderate interest in AMR/AMS</i>
	E8	But if I see [a guideline] produced by the [pharmaceutical] company ... then I wonder how many times [that company's drug] is going to be suggested as first-line treatment? <i>Veterinarian F, 30F, metropolitan CA practice, moderate interest in AMR/AMS</i>
	E9	No organization that has a vested interest in the sales of drugs should be allowed to provide guidelines for them. Not for drugs that will have an impact on the whole of society ... We're talking about critical medications that we will run out of. <i>Veterinarian L, 32M, metropolitan CA practice, high interest in AMR/AMS</i>

Note: Bold text added to highlight key phrases.

Abbreviations: CA, companion animal; F, female; M, male.

^aAge in years and gender.

Several external factors influenced veterinary antimicrobial prescribing choices (Table 7). Outdated or insufficient dosage information on some antimicrobial drug labels in Australia was a problem cited by veterinarians (E1, E2). Other participants were unaware that label doses could not always be relied upon to be clinically effective.

A drug's registration for a species and indication was interpreted by some veterinarians as an official endorsement of that application, with the attitude that "it shouldn't be available to us if we aren't supposed to use it" (E3).

Where microbiological culture and susceptibility testing were used, some participants felt the reports provided insufficient guidance, especially when a bacterium was susceptible to multiple antimicrobials (E4).

Veterinarians recognized that pharmaceutical companies influenced their antimicrobial choices. Pharmaceutical representatives routinely visit clinics to promote their products (E5). Veterinarians felt that clever branding and marketing (E6, E7) encouraged them to use antimicrobials less appropriately. One set of antimicrobial use guidelines funded by a pharmaceutical company was viewed with skepticism by some participants (E8, E9), whereas others were unaware of the funding source.

4 | DISCUSSION

Our study highlighted many factors that influence CA veterinarians' selection of antimicrobial drug, dose, and duration, many of which are unrelated to the animal and its clinical presentation. Some factors are amenable to intervention, to minimize suboptimal antimicrobial use.

With respect to personal and social factors, we found that 2 erroneous beliefs held by some veterinarians are a substantial barrier to AMS: that a predetermined duration of antimicrobial treatment must be completed; and that a longer duration of treatment decreases the risk of AMR because it is more likely to eliminate resistant pathogen subpopulations. Current evidence shows that shorter durations are generally as effective as longer durations, are less likely to cause adverse effects and less likely to select for AMR.^{29,30} Nevertheless, the "finish the course" mantra persists, leading to unnecessarily long durations of treatment and overuse of long-acting cefovecin injections. A stronger emphasis in veterinary education on minimizing antimicrobial treatment durations is needed. Additionally, because much of the evidence for shorter-duration antimicrobial treatment is from trials in human patients,³¹⁻³⁴ more animal trials to establish typical minimum effective durations would likely help convince veterinarians to adopt shorter regimens.

Although many of our participants expressed concern about AMR, they had inadequate awareness of prescribing guidelines, as shown by their case study responses, and tended to favor empirical use of medium- to high-importance, broad-spectrum antimicrobials, similar to their counterparts in the United Kingdom.¹⁸ This practice was partly driven by a sense of safety with broader spectrum drugs, because they "cover" more pathogens, and are perpetuated by what

we have termed the "dispensary cycle." The resulting (almost complete) replacement of amoxicillin with broader-spectrum amoxiclav on the shelves of Australian small animal practices²⁷ is not supported by local bacterial susceptibility patterns³⁵ nor local prescribing guidelines, that recommend amoxicillin without clavulanate for several common infections.²⁴ Practices aiming to promote appropriate antimicrobial use therefore should ensure they provide locally relevant prescribing guidelines and that all guideline-recommended antimicrobials are reliably available.

Veterinary colleagues markedly influenced our participants' antimicrobial choices. Notably, veterinary specialist advice had a powerful effect on general practitioner veterinarians and senior veterinarians had a long-lasting influence on new graduate colleagues, the latter of which has been recognized previously.^{18,19,36} To support AMS, we suggest that veterinary specialists be involved in delivering AMS education relevant to their subspecialty. We also suggest that veterinary schools equip new graduates with strategies for nonconfrontational discussions with colleagues about different treatment approaches.

The veterinarian-client relationship also impacted antimicrobial choices. Our previously published analysis of the decision to prescribe or withhold antimicrobials found that veterinarians were more inclined to prescribe if the pet owner was "difficult."²⁰ Our current analysis further demonstrated that a distrustful relationship with a pet owner can also lead veterinarians to defensively prescribe both broader-spectrum antimicrobials and longer durations of treatment than they might otherwise select. Building trust between clients and veterinarians within a practice may thus unexpectedly improve AMS.

At the clinic level, routine follow-up with owners of pets after they had begun a course of antimicrobials enabled lower-importance antimicrobial drug choices. We suggest that automated phone calls, emails, or text messaging may allow clinics to implement this practice at relatively low cost. Clinic videos and leaflets that assist pet owners with administering PO medications to cats were suggested by participants to decrease reliance on long-acting cefovecin injections. A recent global survey of cat owners showed that only half had been provided with information on how to administer PO medication at home and almost all of them found the information useful.³⁷ To our knowledge, such resources have not been included in past CA AMS trials³⁸⁻⁴⁰ and may be worth including in future trials.

More broadly, participants saw a role for pharmaceutical companies, drug regulatory authorities, and veterinary microbiology laboratories in steering them towards better antimicrobial choices.

The importance of the available antimicrobial formulations, in particular their ease of administration has been repeatedly highlighted by others.^{15,18,19,41,42} Our study suggests pharmaceutical companies could contribute to AMS by developing formulations of lower-importance antimicrobials, such as amoxicillin and TMS, that are more convenient to administer. Particular attention should be given to palatability and making it simple to achieve appropriate dose rates for a wide range of patient sizes. There might also be a place for increased scrutiny of antimicrobial marketing practices. Some veterinarians in our study felt that pharmaceutical company-sponsored information resources were encouraging suboptimal antimicrobial choices, a

concern that has been expressed previously by veterinarians in the United Kingdom.⁴³

Some veterinarians felt that drug regulatory authorities should play a stronger role in encouraging AMS, by not registering or restricting access to some antimicrobials. French government efforts to curb the unnecessary use of high-importance antimicrobials, such as cefovecin, by requiring antimicrobial susceptibility results before prescribing,⁴⁴ may be an example for other countries to follow. A cross-sectional survey of Australian veterinarians suggests such a move would be widely supported by the profession.⁴⁵ Furthermore, drug regulators should ensure that registered label antimicrobial doses are kept up-to-date, to avoid the confusion caused by outdated, subtherapeutic label doses⁴⁶ for amoxicillin and amoxiclav in dogs and cats.

Our participants also identified that many culture and susceptibility reports contain no AMS guidance, and simply list all tested drugs in alphabetical order. We suggest that veterinary microbiology laboratories could better support clinicians by adopting “cascade reporting,” that is, suppressing selected susceptibility results (eg, for high-importance antimicrobials) and arranging the remaining results in order of AMS preference. This type of reporting is well-established in human medical hospitals.⁴⁷ Another potential solution is to group susceptibility results by the drugs' antimicrobial importance ratings and explain that lower-importance drugs should be used preferentially. This approach has been adopted by veterinary diagnostic laboratories at the University of Melbourne (see Data S2) and the University of Sydney, but its effect on prescribing has not been evaluated.

One limitation of our qualitative study was recruitment bias. Because most participants self-selected in response to social media posts that mentioned antimicrobial use, it is not surprising that a large proportion (10/22) reported a high interest in AMR and AMS, and only a small proportion of participants had low interest (3/22). Purposively recruiting more veterinarians who were disinterested in AMS may have uncovered additional themes. Another limitation is that some findings will not be relevant in situations where veterinary antimicrobials are dispensed by a third party, rather than the veterinary practice itself. A strength of the study was the frankness shown by participating veterinarians. Because all interviews were conducted by a veterinarian, participants could assume that the interviewer understood the challenges and complexity of their work. Interpretation of the interview data was enhanced by the fact that all authors are veterinarians with clinical experience.

5 | CONCLUSION

Our study adds to the understanding of prescriber decisions about antimicrobial drug, dose, and duration of treatment. It identifies important reasons why many veterinarians continue to use antimicrobials of higher importance or for longer durations than necessary or both. These include ease of administration, difficult relationships with clients, the perceived safety of broad-spectrum choices, the “what's on the shelf” dispensary cycle, and the belief that finishing a

predetermined course is central to responsible antimicrobial use. It also supports several findings from previous qualitative studies undertaken in the United Kingdom and the Netherlands.

Our study also suggests the potential value of practical measures to enhance AMS in veterinary practice, such as improving veterinary education on the importance of minimizing treatment duration, enhancing antimicrobial susceptibility reports, providing more guidance to cat owners on giving PO medications and implementing routine, postconsultation follow-up messages.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Approved by The University of Melbourne Human Research Ethics Committee, Approval number 1955762.1.

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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