Owner compliance with medication administration in small animal practice in New Zealand

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I hereby certify that the thesis has not been submitted for a higher degree at any university or institution and work embodied in this thesis is my work unless noted otherwise in the acknowledgements.

Thomas F. Odom

Dedicated to my lovely daughter Mira. And to Stella, a very difficult patient.

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List of Abbreviations

>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
95% CI	95% Confidence interval
AIC	Akaike information criterion
AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
ANOVA	Analysis of variance
BID	*bis in die* (twice daily administration)
eDEMs	Electronic drug event monitors
EMD	Electronic monitoring device
IQR	Inter-quartile range
MUVTH	Massey University Veterinary Teaching Hospital
MEMS	Medication event monitoring system
MPR	Medication possession ratio
MCT	Medium chain triglyceride
NZ	New Zealand
NZVA	New Zealand Veterinary Association
PDL	Proportion of days covered

OIE	World Organisation for Animal Health
SID	*semel in die* (once daily administration)
TID	*ter in die* (thrice daily administration)
URL	Uniform resource locator
WHO	World Health Organization

1 Introduction to the thesis

Medication compliance is a critical aspect of veterinary care for both cats and dogs. Despite its importance, research suggests that non-compliance is a common problem in veterinary medicine. Understanding the factors that influence medication compliance in cats and dogs is crucial for improving veterinary care and ultimately, the health and wellbeing of these animals. In this thesis, the various factors that impact medication compliance in these pets will be explored.

Presented here are the results of a cross-sectional survey of cat and dog owners, investigating their demographic data and their opinions on medicating their pets. Chapter 2 of the thesis is a review of the current literature relating to medication compliance in small animal practice and its importance within the greater context of human medicine.

Chapters 3 and 4 represent two original investigations to characterize medication compliance in cats and dogs in New Zealand. These chapters have been written in the format of manuscripts for peer review and publication. These are titled: Prescribing oral antibiotics for home administration by clients to their cats is associated with medication non-compliance and Factors associated with medication non-compliance in dogs.

Chapter 5 discusses the overall findings, the implication the findings have for medication compliance within New Zealand and future research options. References cited in the text are listed in Chapter 6. The final section is of appendices.

2 Compliance in veterinary medicine: a review

2.1 Introduction

The compliance of clients with veterinary instructions for medicating their pets is an important issue in small animal veterinary practice (Maddison, 2011). As observed in human medicine, pet owner compliance with medication regimes may have impacts on the health and wellbeing of the patient (Ramio-Lluch *et al.,* 2020). In human medicine, patient compliance with prescribed drug therapy is associated with lower mortality than non-compliance (Aronson, 2007). Compliance with human medication regimens is also correlated with clinical outcome (Farmer, 1999). As pet owners themselves conduct the majority of pet medication administration, client compliance is fundamental to the successful clinical outcome for the patient (Cron *et al*., 2014).

Among the challenges of professional considerations for medication prescription, it is widely accepted within the veterinary profession that a proactive approach to minimising antimicrobial resistance must be taken (Weese *et al*., 2015). One of the major factors identified by the New Zealand Veterinary Association (NZVA) for appropriate selection of antibiotics in practice is the likelihood of client compliance with dosing instructions (New Zealand Veterinary Association, 2019). Improved compliance has the potential to result in improved clinical outcome for pets, less antimicrobial resistance, timely preventive medicine, a better quality of life for pets and owners, and improved animal welfare with less time spent on recurrent problems (Adams *et al*., 2005).

While many studies in the human literature have examined patient compliance (DiMatteo, 2004), there is a relative dearth of literature describing veterinary client compliance with medication administration. Overall, the available literature suggests that improving compliance with medication administration in pets requires a multifaceted approach that addresses the various factors that contribute to non-compliance. These factors or barriers to compliance have been minimally investigated (Wareham, Brennan and Dean, 2019). Identifying barriers to the owners' execution and completion of the veterinarian's instructions in a clinical setting may help to improve therapeutic outcomes. By improving communication and providing effective education and support, pet owners can be better equipped to care for their pets and ensure they receive the medication they need to maintain their health. This review will summarize some of the important literature to date on pet owner compliance with medication, including definitions, methodology and

factors associated with compliance in pets.

2.2 **Definitions**

Medication compliance, adherence, and persistence have been well defined in human medicine, but the usage of these terms is evolving (Aronson, 2007; Cramer *et al*., 2008). Understanding these terms is important for healthcare providers to accurately assess and address medication non-compliance in their patients. Compliance in a human medical context generally refers to the extent to which a patient follows the recommendations of their healthcare provider or the instructions on the medication label (Hugtenburg *et al*., 2013). This includes taking the medication at the prescribed dose, frequency, and duration. Compliance also involves following any additional instructions, such as taking the medication with food or avoiding certain activities while on the medication (Jimmy & Jose, 2011).

Compliance and adherence are largely synonymous in the human medical literature, with the latter increasingly being preferred over the former in human medicine due to a less paternalistic connotation (Aronson, 2007). Adherence is similar to compliance, but it focuses more on the patient's willingness and ability to take the medication as prescribed. Adherence takes into account factors that may influence a patient's behaviour, such as forgetfulness, fear of side effects, or difficulty understanding the instructions (Jimmy & Jose, 2011).

The term ‘concordance’ is sometimes used in place of compliance or adherence. It refers to an agreement between the prescriber and the patient on the use and purpose of the medication (Hugtenburg *et al*., 2013). While compliance and persistence were once generally synonymous in the literature, they are now recognised to have different meanings (Gwadry-Sridhar *et al*., 2009), with persistence now indicating how long a patient stays on the prescribed medication (Hugtenburg *et al*., 2013). Persistence is important because some medications require long-term use to be effective. If a patient stops taking the medication prematurely, they may not receive the full benefit of the treatment.

The term ‘adherence’ cannot be applied easily to veterinary medicine as it infers independence in decision making for the patient’s own health (Booth *et al*., 2021). Based on the considerations described above, and the agreed premise that animals cannot provide informed consent to treatment, compliance as defined by Hugtenberg *et al*. (2013) is the preferred term to apply to pet owners.

Non-compliance, also known as medication non-adherence, refers to a patient's

failure to follow the recommendations of their healthcare provider or the instructions on the medication label (Osterberg & Blaschke, 2005). Non-compliance can generally be described in three ways. Primary non-compliance refers to a situation where the patient fails to obtain or begin taking the medication. In human studies, primary non-compliance may range as high as 33% (Barragry, 2000; Gwadry-Sridhar *et al*., 2009). Non-conforming compliance refers to a patient who fails to use the medication as prescribed (wrong dosage, wrong frequency, wrong frequency of administration, wrong route of administration, improper timing of administration) (Barragry, 2000). Lastly, non-persistence is a form of non-compliance in which the patient prematurely discontinues their medication without being advised by a medical professional to do so (Jimmy & Jose, 2011). In the context of this review, the author suggests that for each consideration of non-compliance, "pet owner" is inserted in the place of "patient" to provide definitions for a veterinary context.

2.3 **Methods of reporting compliance**

There are several ways to describe medication compliance rates in human medicine, each of which provides different information about a patient's medication use. Proportion of Days Covered (PDC) calculates the percentage of time during a specified period that a patient has medication available based on prescription records. PDC is a commonly used method for measuring medication compliance and provides a comprehensive view of a patient's medication use over time. Medication Possession Ratio (MPR) calculates the ratio of the total number of days' supply of medication dispensed to the patient over a specified period to the total number of days in the same period. MPR is similar to PDC but takes into account the number of days' supply of medication dispensed, rather than the number of days medication was available to the patient. And adherence rate is a measure that calculates the percentage of medication doses taken as prescribed by the healthcare provider. Adherence rate is typically based on self-report or pill count and provides a measure of medication use at a specific point in time. Each of these measures provides different information about a patient's medication compliance rates, and healthcare providers may use one or more of these measures depending on the medication being administered and the goals of the treatment (Fairman & Motheral, 2000).

The approaches to the reporting of compliance in veterinary medicine vary from study to study, although pet owner compliance is usually presented as a compliance rate. This may represent the percentage of prescribed doses given over the course of the medication, the percentage of days on which the correct number of doses was given, or the percentage of doses given on time (Adams *et al*., 2005). Data may also be represented as a percentage of patients who demonstrated a particular level of

compliance (e.g., percentage of patients who complied completely) (Adams *et al*., 2005). For example, compliance may be defined as "good" when at least 80% or 90% of the medication is administered correctly. When comparing veterinary studies, it is important to determine how compliance is measured as results may vary depending on methodology used and where the defined cut-offs are (Maddison, 2011). Compliance rates for medication in human medicine range from 4% to 100% across hundreds of studies (DiMatteo, 2004), with wide variations across conditions studied.

2.4 **Non-compliance**

Non-compliance in human medicine has been extensively studied (DiMatteo, 2004; Hugtenburg *et al*., 2013), and tools exist to screen patients for barriers to compliance (Svarstad *et al*., 1999). Non-compliance can be represented by under-dosing, missing doses of medication, or stopping the medication completely (Chapman, 2018). Previously identified major barriers to compliance to medication therapy in humans include the complexity of the medication regimen (the number of medicines and the frequency of administration) and the failure of the patient to understand the importance of compliance with prescription instructions (Aronson, 2007). Another identified reason for poor compliance in human medicine is inadequate communication between the physician and the patient (Chapman, 1996). Table 2-1 contains a more complete list of predictors associated with poor compliance in humans. Poor compliance has been reported to be observed in 30% to 50% of all human patients regardless of disease or prognosis (Gwadry-Sridhar et al., 2009).

Table 2-1

Major predictors of poor compliance in human medicine. Adapted from Osterberg and Blaschke (2005).

Predictor
Poor patient-provider communication or relationship
Lack of patient knowledge about a medicine
Patient's lack of insight into the illness
Patient's lack of belief in the need for treatment
Treatment of asymptomatic disease
Treatment of chronic disease
Presence of psychological problems or cognitive impairment **in the patient**
Low literacy of the patient
Inadequate follow-up or discharge planning
Presence of barriers to care or medications
Missed appointments
Side effects of medication
Complexity of treatment or varying dosing schedules
Cost of medication
Long term drug regimens

A meta-analysis of medical treatment in humans found non-compliance averaged 24.8% (DiMatteo, 2004). It has been reported that non-compliance in small animal veterinary practice may not be as large a problem as it is in human medicine (Adams *et al*., 2005). Barriers to compliance are underreported in veterinary medicine but are suggested to include the inconvenience of the dosing schedule (Bomzon, 1978; Booth *et al*., 2021), misunderstanding instructions and forgetfulness (Adams *et al*., 2005), side effects of the medication (Morris, Dobson and Bostock, 1993), packaging and characteristics of the drug itself (Barragry, 2000), and physical and social risk (Maille and Hoffmann, 2013).

Measuring compliance

Methodologies for measuring compliance in human clinical practice are well described (Farmer, 1999). Measurement of compliance can be performed directly or indirectly. Direct methods include observation of administration and measurement of drug levels in blood and/or urine (Jimmy & Jose, 2011). While direct approaches have been shown to be the most effective methods of measuring compliance (Fairman & Motheral, 2000; Farmer, 1999; Jimmy & Jose, 2011), they are largely impractical in veterinary medicine. Therapeutic drug monitoring, for example, is only available for a relatively limited number of medications in veterinary medicine (Maddison, 2011) and comes at a direct cost to pet owners that human patients may not encounter. Indirect measurement of compliance may be performed in several ways. In veterinary medicine, medication monitoring through the use of pill counts or electronic monitoring devices (EMDs) and self-reporting via interview or survey have been previously reported (Adams et al., 2005; Barter, Maddison and Watson, 1996; Bomzon, 1978). In general, approaches that involve contacting patients (whether in person, by telephone, online, or by mail) add complexity to a project (Fairman & Motheral, 2000) as access to patients' personal information, navigating inaccurate or incomplete patient data, and time spent on follow-up all contribute to increased labour involved with the investigation. Other indirect measures of compliance, including prescription counts, are progressively less applicable in the veterinary setting.

Table 2-2

Methods of measuring compliance in veterinary medicine		
Direct methods	**Advantages**	**Disadvantages**
Therapeutic drug monitoring	Objective; plasma levels of some drugs such as anticonvulsants and digoxin can be measured to assess therapeutic levels	Invasive; not available for most medications; expensive; no reports in veterinary literature describing this technique to measure compliance
Indirect methods		
Pill counts	Objective, quantifiable, and easy to perform. Frequently used and judged to be a reasonable measure of compliance	Should be performed by the investigator and not the pet owner; client may hoard or dump pills significantly altering data

Client self-reports	Simple; inexpensive; the most useful method in the clinical setting; similar to compliance measured by pill count	Results easily distorted by the client; error in reporting increases in time between visits; overestimate compliance
Clinician estimation	Simple; inexpensive; easy in the clinical setting	Demonstrated to be unreliable
Electronic monitoring devices	Regarded as the gold standard for measuring compliance; precise data regarding dates and times of dosing can be collected	Expensive, not suitable for prolonged or complex regimens; only works when client uses the container properly
Dispensing records and refill rates	Objective; easy to obtain data	Client must obtain medication from veterinary practice
Therapeutic outcome	Simple; generally easy to perform	Can be affected by multiple variables, thereby complicating correlation with compliance

Table 2-2 describes the advantages and disadvantages of the different methods of measuring compliance in veterinary medicine. Two veterinary studies (Barter, Maddison and Watson, 1996 and Adams *et al*., 2005) compared the methods used to assess client compliance with instruction for antibiotic administration to dogs. Methods assessed in these two studies included return medication (pill) count, client self-report of missing doses, electronic medication monitoring, and veterinarian prediction. Both studies found that client self-reporting and return pill counts tended to overestimate compliance while veterinarian estimation of owner compliance did not correlate with EMD counts in either study. Pill counts and client self-reporting of missing doses were insensitive measures of compliance (Adams *et al*., 2005) and EMDs were found to be expensive and problematic in both studies. Veterinarians' estimation of which clients will be compliant has been shown to be largely inaccurate (Adams *et al*., 2005; Barter Watson and Maddison, 1996; Verker, von Stokrom and Endenburg, 2008). This inability to predict who amongst their clients would be compliant is a situation that also exists in human medicine (Chapman, 1996).

2.5 Compliance in veterinary literature

In veterinary medicine, there have been few studies primarily examining compliance for owners administering medication to their pet. Most studies investigating the factors influencing pet owner compliance are not found in peer-reviewed literature but rather are derived from internal pharmaceutical company-derived data (Maddison, 2011). A recent systematic review of factors affecting dog and cat owner compliance with medication treatment recommendations found that the evidence available regarding factors affecting client compliance with pharmaceutical treatment recommendations in dogs and cats was limited and of poor quality (Wareham, Brennan and Dean, 2019). Lacking in the literature is a descriptive analysis of the challenges that owners face and the barriers to compliance.

2.6 Dogs: an overview

There is little published data on dog owner compliance in veterinary medicine. Most studies have included small cohorts and evaluated owner compliance with administration of short-term antimicrobials to dogs (Abood, 2007). Defining and measuring compliance in scientific studies is complicated by the use of different methodology and reporting standards. And although a variety of methods have been used, problems generating valid and reliable data still exist (Adams *et al*., 2005). The studies specific to dogs are discussed here.

2.6.1 *Reported compliance rates in dogs.*

A pilot study in South Africa of 26 dogs prescribed oral ampicillin showed that 73% of owners failed to follow the veterinarian's instructions when it came to medication administration, as determined by pill counts (Bomzon, 1978). Another small study in Australia of 22 dogs prescribed oral amoxicillin-clavulanate used EMDs to measure compliance and reported low scores for number of container openings, interval timing, and doses per day (27%, 32%, and 56-59%, respectively) (Barter, Watson and Maddison, 1996). A Norwegian study of pet owner compliance with short-term oral antibiotic administration to dogs and found only 44% (42/95) of owners were 100% compliant with instructions from the veterinarian based on owner self-reported pill counts (Grave & Tanem, 1999). Compliance in this study increased to 88% however when the compliance level was measured at 80% or higher.

A telephone survey of pet owners in the Netherlands reported a 55% (22/40) compliance rate with administration of various prescribed oral antibiotics (Verker,

von Stokrom and Endenburg, 2008). Cats were reportedly included in this study, but they were not identified or separated from dogs in the data analysis. Another study of pet owners in Germany using EMDs examined compliance with once vs. twice daily administration of an oral antibiotic and found 73% (32/51) of owners were highly compliant (gave at least 90% of their pet's medication) (Amberg-Alraun *et al*., 2004). The methodology for this study was not provided.

Booth *et al*. (2021) examined owner compliance in canine epilepsy via prescription analysis. This study included 94 dogs from the UK and reported an overall median compliance of 56% with oral anti-seizure medications, although only 21% of owners were 100% compliant. Lastly, a survey conducted with Canadian pet owners examined compliance with oral antibiotic administration to 90 dogs (Adams *et al*., 2005). This study used 4 different methods to measure the compliance of pet owners, including EMDs. Compliance rates were relatively high in this study, though lower than what the clients self-reported. Of the clients in this study, 78% had a pill count of zero at the end of the study although other factors measured, such as dosing interval and number of doses per day, makes overall total compliance more difficult to determine.

2.6.2 *Dosing frequency and regimen complexity*

Several studies have examined compliance with oral antibiotic administration to dogs. Bomzon (1978) reported on oral administration of thrice-daily ampicillin to dogs. Though the study was small (n=26), it was concluded that the mid-day medication was impractical and contributed to the relatively high degree of non-compliance (73%). Further to this, Barter, Watson and Maddison (1996) demonstrated improvement in compliance with BID vs. TID dosing of oral antibiotics, though these differences were not statistically significant. Adams *et al*. (2005) found clients giving oral antibiotics once or twice a day were more likely to be 100% compliant than those giving thrice-daily medication. Similarly, Amberg-Alraun *et al*. (2004) reported the best compliance with SID dosed antibiotics vs BID and TID. The effect of dosing frequency on compliance has also been examined with topical medications. Boda, Liege and Remy (2011) found that SID administration of an otic solution produced significantly better compliance than BID dosing of a similar product. Booth *et al*. (2021) also demonstrated that non-compliance increases with multiple daily dosing, a trend which is also described in human medicine (Claxton, Cramer and Pierce, 2001). However, this study also demonstrated that patients on polytherapy of antiseizure medication had higher compliance rates than those receiving monotherapy, suggesting an association with compliance and severity of

disease.

2.6.3 *Time spent with the veterinarian and information delivered.*

In human medicine, it is well documented that improved patient education and enhancing communication between the physician and the patient are key and effective strategies in assisting the patient's ability to follow the recommended therapeutic regimen (Osterberg and Blaschke, 2005). Grave and Tanem (1999) demonstrated that compliance was significantly improved when the pet owner felt the veterinarian had spent enough time with them in the consult. This time spent with the client was thought to influence the pet owners' willingness and ability to comply with the recommended therapy. Amberg-Alraun *et al*. (2004) reported a benefit to owner compliance when information sheets were delivered with the medication. The highest compliers in this study received printed information about bacterial infections and therapy with antibiotics with their prescription. Verker, von Stokrom and Endenburg (2008) suggested two factors that improved pet owner compliance with medication instruction: the repeating of important information and the verbal explanation of the effects of the medication. In this study, clients who were given the most important instructions more than once were compliant 77% of the time, compared to 46% for the owners given this information only once. Clients given an explanation of the effect of the medication were almost twice as likely to be compliant as owners not given such an explanation. These studies suggest the positive effects of professional communication with pet owners to increase their compliance with veterinarians' recommendations.

2.6.4 *Predicting compliance*

A common method for assessing compliance in medical practice is the physician's judgment of the patient's behaviour (Farmer, 1999). However, this subjective and indirect measure of compliance has been called into question regarding its validity. Studies in human medicine have found that physicians are no better than chance at estimating patient compliance (Maddison, 2011). Indeed, several studies have confirmed the inability of veterinarians to predict compliance. Barter, Maddison and Watson (1996) found no significant correlation between the veterinarian's estimate of the owner's likely compliance and the electronic monitor data used to measure compliance in the study. Adams *et al*. (2005) agreed that veterinarians were unable to predict client compliance in a study using EMDs to monitor medication administration. Verker, von Stokrom and Endenburg (2008) also found that

veterinarians were poor at estimating the likelihood of owner compliance and in fact overestimated compliance. This study also illustrated that the importance of compliance was rarely communicated to clients directly by veterinarians. In order to improve compliance with pet owners it may be necessary to discuss it with them but also treat them all as potentially noncompliant (Maddison, 2011).

2.7 **Cats: an overview**

The majority of veterinary literature examining medication compliance has described the phenomenon in dogs. However, some of the findings of veterinary studies may be applicable across species. Taylor *et al*. (2022), for example, reported that most owners found information given to them about how to administer medication useful, and around half of them sought this information on the internet. This survey demonstrated the importance of the delivery of information to clients about medicating their animals, a finding replicated in dogs (Amberg-Alraun *et al*., 2004; Verker, von Stokrom and Endenburg, 2008). The evidence available regarding factors affecting medication compliance with treatment recommendations for cats is scarce and of limited quality (Wareham, Brennan and Dean, 2018). Many suggested factors associated with compliance in cats are extrapolated from dogs or humans. The studies specific to cats are described here.

2.7.1 *Disease Severity*

Casey & Bradshaw (2008) examined owner compliance measures for 85 cats presenting to UK veterinarians for behavioural problems. The authors were able to demonstrate a strong positive correlation between the change in severity score of the behavioural problem (as rated by the clinician) and the compliance score, concluding that owner compliance is an important factor in treatment outcomes for behavioural therapy in cats. Severity of disease has been shown to affect patient compliance in human medicine (DiMatteo, Haskard and Williams, 2007), but previous studies in dogs have not shown an association (Adams *et al*., 2005; Grave and Tanem, 1999).

2.7.2 *Dosing frequency and regimen complexity*

In human medicine, treatment adherence is inversely related to dosing frequency (Claxton, Cramer and Pierce, 2001; Aronson, 2007). Dosing frequency and/or regimen complexity have previously been demonstrated to affect compliance in

dogs (Adams *et al*., 2005; Barter, Watson and Maddison, 1996; Boda, Liege and Remy., 2011). These factors have also been investigated in cats to a limited degree, with inconsistent results. In an examination of adherence to veterinary recommendations for flea control, Lavan *et al*. (2020) found that cat owners purchasing product with a longer duration of action protected their cats for up to 17% longer each year. Thus, the convenience of a less frequent dosing regimen equated to an improvement in actual treatment success. But Caney (2013) produced UK-based online survey results showing that owners of hyperthyroid cats did not rank a relatively simple once-daily treatment as important, and that 62% of owners in the survey stated that pilling their cat twice a day was not a problem. The author thus suggested owner factors were not a barrier in BID dosing of thyroid medications. Murphy *et al.* (2022) produced a questionnaire from 54 referral clients demonstrating that while chronic medication adherence was high in this cohort of owners, BID dosing was the highest frequency of medication administration most owners could achieve. The authors of this study conceded that the small sample size in the study and the referral nature of the practices were potential limitations.

2.7.3 *Palatability and ease of administration*

In human medicine, compliance with medication instructions declines when the formulation is difficult to administer (Khor *et al*., 2011). Stein *et al*. (2022) found that method of administration was of similar preference to cost when examining influencers of cat owners for medicating their pet. Traas *et al*. (2009) found that administration of pills to cats was physically challenging or caused cats to avoid interaction with the owners. In this study of 90 cats, owner perceived acceptability scores were higher for medium-chain triglyceride (MCT) oil or film strip than gelatine capsules, suggesting that non-capsule options may be better for administration. Prior palatability evaluations in cats (Khor *et al*., 2011) have shown that owner compliance is better with oral palatable suspensions, though owners prefer tablets for long term management of their pets.

In a survey of Finnish cat owners, Siven *et al.* (2016) found that free choice acceptance and ease of dosage administration are still problematic in feline medication. The authors reported on the results from an e-survey on the difficulties in administration of oral formulation to cats. In an evaluation of consumption success, owners were unable to give doses as prescribed for one-fourth of the prescriptions. In a finding consistent with Khor *et al*. (2011), the authors found that most owners preferred a solid dosage form of medication for cats. The authors also reported that drugs registered for cats were significantly more palatable than drugs

for other species and liquid formulations were more palatable than solid formulations.

Despite these findings, Taylor *et al.* (2022) reported that cat owners rated tablets as significantly harder to administer than liquids. In this random survey of over 2500 cat owners from 57 countries, over half of cat owners reported that medicating their cats had changed their relationship with them, and 77% reported that their cat had tried to scratch or bite them when medicating. This survey also reported "taste of the medication" as the most reported reason by owners for difficulty in medicating their cat. Curtis (2008) suggested that the daily handling ritual for administering medications to cats (oral meds) may add stress.

Finally, in a survey of New Zealand veterinarians (Gargiulo *et al*., 2013), respondents claimed that compounded products improved the ease of administration and owner compliance. This study examined the use of extemporaneous compounding performed by the veterinarian within the clinic, not products produced through a compounding pharmacy under the supervision of a pharmacist. The authors did not report on the alteration of medicines to improve acceptance or palatability and suggested that the primary driver for in-house compounding by veterinarians was cost.

2.7.4 *Antimicrobials and compliance*

Non-compliance with antibiotic therapy is associated with treatment failure and antimicrobial resistance (AMR) in humans (D'Ambrosio *et al*., 2022). Burke *et al.* (2016) examined the use of cefovecin, a long-acting 3rd generation cephalosporin injectable antibiotic, in a UK population of cats seeking general practice care. In this study, the most common body system treated was skin. The authors found that the most commonly cited reason for prescribing cefovecin over alternative antimicrobials was an inability to orally medicate the cat. While the convenience of this antibiotic to the owner is undeniable—the brand name is Convenia—its common usage raises questions about antimicrobial stewardship. The NZVA traffic light antimicrobial principle is used to promote judicious and effective antimicrobial use while limiting potential selection of key mechanisms for resistance (New Zealand Veterinary Association, 2019). Under these prescribing guidelines, 3rd generation cephalosporins are considered "red-light" antimicrobials: a class of drug deemed of highest importance in human medicine and thus reserved for treatment of refractory conditions. While it has been suggested that cefovecin can be considered a first-line or "green-light" antibiotic where compliance is likely to be poor (Van

Vlaenderen *et al*., 2011), the use of this agent as a substitute for other, more narrow spectrum oral antibiotics deserves scrutiny.

Weese *et al*. (2021) examined prescribing habits of veterinarians in North America for 673 cats diagnosed with bacterial urinary tract disease. The authors described cefovecin as the most commonly prescribed antibiotic for all upper and lower urinary tract infections and called attention to the fact that this cephalosporin antibiotic is broader spectrum and longer duration than what is needed for the treatment of the cats in this study. The authors also found that the use of fluoroquinolones, another "red-light" drug, increased over the two years of the study, and suggested that owner preference should not be a deciding factor when choosing a short course of a lower-tier drug for the treatment of a bacterial disease.

Finally, Stein *et al*. (2022), in a survey of North American cat owners on attitudes towards antimicrobials, reported that a low proportion of clients (21%) in the survey thought antimicrobial use in pets posed a risk to humans. Few cat owners in this study appeared to recognize the AMR risks associated with antimicrobial use in pets. These pet owner preferences may significantly impact AMS. The results of this study emphasize cat owners' reluctance to administer oral medications and that veterinarians prescribing habits may be influenced as a result.

2.8 **Summary**

The veterinary literature highlights the variability in pet owner compliance and also the need for a more analysis of compliance rates by species and medication type. The majority of studies examining medication compliance have described dogs, and compliance studies in cats remain underperformed. Studies specifically examining the barriers to owner compliance in veterinary medicine are few, and no studies about owner compliance in New Zealand have been performed. The aims of this research program were to investigate:

1. To describe compliance rates with medication administration in dogs and cats in New Zealand.
2. To identify and describe barriers to medication compliance as reported by pet owners in dogs and cats in New Zealand.
3. To provide context to lack of compliance and reported barriers in administration of antimicrobial drugs in dogs and cats in New Zealand.

3 Prescribing oral antibiotics for home administration by clients to their cats is associated with medication non-compliance.

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3.1 **Abstract**

AIMS: To identify factors associated with non-compliance of cat owners with veterinary recommendations for medication administration to their pets, and to describe client-reported barriers and aids to the administration of medications in a New Zealand primary care practice.

METHODS: A cross-sectional survey of compliance with veterinary medication recommendations by cat owners was performed from January 9, 2019, to July 18, 2020, using a convenience sample of cat owners who were prescribed medication for their pet by Massey University Veterinary Teaching Hospital veterinarians during or following elective veterinary examination. Data were analysed using descriptive and analytic statistics.

RESULTS: Administration of oral antibiotics was significantly associated with non-compliance ($P<0.05$). Clients with limited pet ownership experience were less likely to be non-compliant. 24% (16/66) of pet owners reported challenges in administering medication to their pet. The most common reason cited by clients reporting challenges was a resistant pet.

CONCLUSIONS AND RELEVANCE: The inability of clients to orally medicate their cat may have implications for clinical outcomes and antimicrobial stewardship. Alternatives to direct administration of oral medications in cats should be considered. Demonstrating technique for the client may improve compliance and clinical outcome.

KEY WORDS: Antimicrobials, antibiotics, AMR, compliance, adherence, persistence, cat, pet owner, New Zealand, medication, survey

3.2 **Introduction**

The compliance of clients with veterinary instructions for medicating their pets is an important issue in small animal veterinary practice (Wareham, Brennan and Dean, 2019). In the human medical context, compliance generally refers to the extent to which the patient follows the prescriber's recommendations (Hugtenburg *et al.*, 2013). This includes whether the medication is correctly self-administered, the accuracy of the dose given, and whether or not a medication is taken at the time intervals specified in the prescription (Wareham, Brennan and Dean, 2019). In the case of pet owners, an understanding of medication compliance is more complex as it requires an understanding of the behaviours of the owner and the animal, and the interactions between the two (Halls, 2018).

As animal owners are responsible for the administration of most medications to their pets, their compliance is fundamental to the successful clinical outcome for the patient (Cron *et al*., 2014). Poor compliance is likely to compromise efficacy and encourage antimicrobial resistance. Current veterinary data suggest compliance rates between 22% and 80% in pets (Hague, Durham, and Menzies-Gow, 2021). These levels of compliance can have a significant impact on the management of long-term disease. For example, as few as 21% of owners of dogs with epilepsy were reported to be fully compliant with medication administration (Booth *et al*., 2021). Poor compliance with frequent, long-term application of topical medications has also been reported in cats with glaucoma (McLellan and Teixeira, 2015). Non-compliance can be manifested as under-dosing, missing doses of medication, or stopping the medication completely (Chapman, 2018).

The peer reviewed literature describing veterinary client compliance with medication administration (Wareham, Brennan and Dean, 2019) or the barriers to the administration of medications to their pets is scarce (Thombre, 2004; Maille and Hoffman, 2013; Taylor *et al.* 2022). Prior studies in veterinary medicine have suggested compliance is improved when the pet owners feel the veterinarian has spent enough time with them in the consultation (Grave and Tanem, 1999), information sheets were delivered with the prescription (Amberg-Alraun et al., 2004), and when important information and the explanation of the effects of the medication occurs and is repeated during the consultation (Verker, van Stokrom and Endenburg, 2008). Several studies have suggested that the complexity of the medication regimen has an impact on compliance (Amberg-Alraun *et al.,* 2004; Adams *et al.* 2005; Boda, Liège and Rème, 2011). Few studies have investigated

owner-related human factors associated with poor compliance (Maille and Hoffmann, 2013; Taylor *et al*. 2022). As observed in human medicine, pet owner compliance with medication regimes may impact the health and well-being of the patient (Ramio-Lluch *et al.,* 2020; Booth *et al*., 2021). Improved pet owner compliance has the potential to improve clinical outcomes for pets, reduce antimicrobial resistance, ensure timely preventive medicine, ensure a better quality of life for pets and owners, and improved animal welfare with less time spent on recurrent problems (Adams *et al*., 2005).

Cats present a unique challenge for medication administration. They are, by their nature, more discriminating than dogs and thus more difficult to medicate (Thombre, 2004). They are less accustomed to being restrained than dogs and may be more likely to display fearful behaviour or resistance when medicated (Siven *et al*., 2017). Their temperament, combined with their owner's potential fear of injury from the cat, may make them more challenging to consistently medicate than a dog (Murphy *et al*., 2022). A majority of clients report that their cat will spit a tablet out, and up to 45% of cats will attempt to bite or scratch their owners while being medicated (Taylor *et al*., 2022). Previously reported medication consumption failures have been related to the individual behaviour of the cat (Sivén *et al*., 2017). While free-choice acceptance has been shown to increase compliance (Thombre, 2004; Cron *et al*., 2014), poor palatability of medication can be inhibitory to the success of the treatment regimen (Sivén *et al*, 2017, Murphy *et al*., 2022). Medicating cats may also cause them to avoid interaction with their owners thus damaging the owner-cat relationship (Traas *et al*., 2010; Taylor *et al*., 2022). While the veterinarian's ability to predict which clients will be compliant has previously been shown to be unreliable (Verker, van Stokrom and Endenburg, 2008; Adams et al., 2005; Barter, Maddison and Watson, 1996), the suspected ability of the client to successfully medicate their cat may still influence the veterinarian's selection of available medications, thus potentially affecting the therapeutic outcome (Mateus et al., 2011; Beco *et al*., 2013; Mateus *et al*., 2014; Weese *et al*., 2021).

Studies specifically examining the barriers to owner compliance in veterinary medicine are few, and none addressing New Zealand cat owners have been performed. Of the few peer-reviewed publications investigating medication compliance, most have focused on dogs, or cats and dogs collectively, with little to no estimation of the significance of contributions of different risk factors for non-compliance (Wareham *et al.* 2019). Most studies performed in cats have been limited to investigations of the palatability or acceptability of oral medications (Thombre, 2004; Cron *et al*., 2014; Khor *et al*., 2012; Sivén *et al*. 2017) despite concerns regarding compliance for cats on frequent or long-term therapies

(McLellan and Teixeira, 2015). To improve compliance and outcomes for cats, it may be helpful to identify barriers to the owners' following through on the veterinarian's instructions in a clinical setting. (Wareham, Brennan and Dean, 2019; Taylor *et al.,* 2022). This study aimed to identify factors associated with the non-compliance of cat owners with veterinary recommendations for medication administration to their pets, and to describe client-reported barriers and aids to the administration of medications in a New Zealand primary care practice.

3.3 **Materials and Methods**

3.3.1 *Ethics and Data Protection*

This project was evaluated by peer review as low risk for human participants. Consequently, it was not required to be reviewed by a Human Ethics committee in New Zealand but was registered with the Massey University Human Ethics Committee (Human Ethics Notification 4000020081). Data collection was carried out in accordance with the low-risk notification and informed owner consent was obtained. Data were deidentified immediately after enrolment by providing clients with their animal's patient number to complete the survey.

3.3.2 *Study Design*

A prospective cross-sectional study of compliance with veterinary medication recommendations by cat owners was performed from January 9, 2019, to July 18, 2020, using a convenience sample of cat owners who were prescribed medication for their pet by the Massey University Veterinary Teaching Hospital veterinarians during or following elective veterinary examination.

3.3.3 *Enrolment*

Clients were invited to participate in this study if their cat had been seen by veterinarians of the MUVTH Community Practice service and had been prescribed oral or topical medication. As part of informed consent, prospective participants were advised that the investigators were examining medication compliance and the aids and barriers they may have experienced in administering medication to their

cats. They were further advised that the findings of the study would be used to educate and assist pet owners' completion of the treatment instructions. Clients were given their MUVTH patient number to allow prescriptions to be matched to individual patients without exposing the identity of the client to the researchers. Clients were advised that they were free to withdraw from the study at any time.

3.3.4 *Inclusion and Exclusion Criteria*

The owners of cats that were prescribed oral or topical medication by the MUTVTH Companion Animal Community Practice were included in the study following client consent. Cats who were prescribed medication by specialist veterinarians at the practice were excluded. Patients who died or were euthanized between the time of consent and the time of data collection were excluded. Patients who were administered their prescribed medication in-hospital by staff were excluded.

3.3.5 *Questionnaire Construction*

An online questionnaire was developed using proprietary software (Qualtrics XM, Seattle Washington; www.qualtrics.com) in three parts: firstly owner demographic information, secondly questions relating to the administration of medications to their pet, and thirdly identification of challenges associated with medicating their pet. The survey included questions with binary, categorical or semiquantitative response options. Questions relating to medication compliance used Likert scales, while questions relating to challenges and barriers allowed for multiple selections and free-text entry. The survey was piloted with five staff members employed at MUVTH to refine questions in an iterative process to ensure valid questions (Dean, 2015). The survey may be found in the Appendix.

3.3.6 *Dissemination of Questionnaires*

Cat owners seen through the MUVTH Community Practice service that consented to participate in this study were given a unique URL link to the online survey for the project at the time of the initial medication prescription. Owners were advised to complete the survey at the end of the prescription period. Participating clients were contacted by a staff member two weeks later either in-person at a recheck appointment or via telephone or email after a course of medication had been administered. The research team member in contact with the client was not

involved in the blinded analyses of results.

3.3.7 *Statistical Analysis*

Data from the online survey tool was imported as a spreadsheet CSV file into R statistical software (Version 3.6.1, R Development Core Team 2020, R Foundation for Statistical Computing, Vienna, Austria) for data cleaning and analyses. Entries that did not meet the inclusion criteria and responses that were not sufficiently complete for the evaluation of outcomes were excluded from further analysis.

Descriptive statistics were summarised for all quantitative study variables. The distribution of continuous variables was evaluated for normality by the Shapiro-Wilk test. For continuous data that was normally distributed the mean and standard deviation were calculated. For data that was not normally distributed, median and interquartile range values were calculated. For the Likert-scale questions, median and mode are reported.

Univariable logistic regression analyses were performed to assess factors associated with non-compliance and medication administration to cats. The binary outcome measure, non-compliance (yes/no), was defined as failing to give the prescribed medication for the duration of the prescription, failing to give the prescription at the prescribed intervals, or failing to give the prescription. Non-compliance was identified by comparing the directions in the prescription with the recorded responses of the client. Any deviation from the veterinarian's instruction within the prescription period was identified as non-compliance.

Explanatory variables encompassing client, animal, veterinary visit, and medication factors were explored for their contribution to the outcome. An initial univariable logistic regression was performed for each potential explanatory variable, and *p* values were calculated using the Wald Test. Each predictor variable returning a $p < 0.20$ from the univariate modelling was considered for inclusion in a multivariable model. A stepwise backward elimination procedure was then performed whereby predictive values with the least significant *p* value were successively removed until all variables in the final model had a Wald's *p* value ≤ 0.05. A set of basic diagnostic statistics including fitted and standardized residuals and leverage was examined for adherence to model assumptions. No influential points were detected. The models were compared using ANOVA of deviance function in R, and the model with the lowest Akaike information criterion (AIC) was chosen (Field *et al.* 2021). The findings are presented as odds ratios (OR) and confidence intervals (95%CI) for each

predictive variable.

3.4 **Results**

3.4.1 *Survey Response*

Owners of cats receiving prescriptions during the study period were invited to participate. Cats that died or were euthanized while participating in the study were excluded. 66 respondents met the criteria to participate in the study.

3.4.2 *Descriptive Data, Predictive and Outcome Variables*

The frequency of owners' responses to a survey on medication administration to their cats in New Zealand are summarized in Table 1. The proportion of surveyed client cat owners that were noncompliant with medication instructions was 39% (26/66), resulting in an absolute compliance rate of 61% (40/66).

Respondents were most commonly female, aged between 51 and 60 years, New Zealanders of European ethnicity, and educated to a university level. Seventy-one percent (47/66) reported prior experience ownership of multiple pets of multiple species. Only 11% (7/66) had no prior experience managing pet illness, and 21% (14/66) reported they had training in animal health. Fifty-three percent (35/66) had prior experience with orally medicating pets, and another 29% (19/66) reported they had experience with both oral and topical routes of medication administration. Sixty-three percent (42/66) of respondents administered the medication themselves. All respondents answered that they had a good understanding of the reason the medication was prescribed, with 94% (62/66) responding either “extremely well” or “very well”.

Eighty-five percent (56/66) of respondents strongly agreed that the veterinarian had spent enough time explaining the reason for the prescription, and 86% (57/66) strongly agreed that the veterinarian had explained the reason for the medication well. Most clients were shown how to administer the medication by a veterinarian (47%; 31/66), although 39% of clients (26/66) reported that “nobody” showed them how to give the medication(s).

Almost all (97%; 64/66) of the cats in this study were prescribed at least one oral medication. Medication classes prescribed (as reported by the client were: oral anti-

inflammatory/pain reliever (53%; 35/66), oral antimicrobial (35%; 23/66), oral behavioral (9%; 6/66), oral anti-hypertensive (6%; 4/66), and "other oral medication" (17%; 11/66). The frequency of administration was predominantly once a day (47%; 31/66) or twice a day (38%; 25/66). Only 35% (23/66) of clients reported giving medication directly into their cat's mouth, while 65% (43/66) reported administering the medication with food, with a treat, or a combination of these methods.

Twenty-four percent (16/66) of clients reported challenges giving the prescribed medication. All of these respondents (16/16, 100%) listed "My pet was resistant to my efforts to medicate him/her" as at least one of their reasons. Owner-reported aids in medicating their cats were grouped into the following categories: food (44%; 28/66), training (14%; 9/66), behavioural modification (9%; 6/66), restraint (8%; 5/66), product (13%; 8/66), and nothing (11%; 7/66). Twenty-nine percent of the cats in this study were prescribed multiple medications.

Cat owners in this study were asked to report what went well with medication administration. The most common response (43%; 28/66) was the use of food to hide the medication. Some respondents (8%; 5/66) described various methods of restraint used and several described using a particular method in order to avoid being scratched or bitten. Very few (5%; 3/66) reported the use of a low-stress handling technique. Twelve percent (12%; 8/66) of respondents commented positively on the taste of a particular brand of flavoured suspension and how the cat's acceptance of that medication vastly aided in their administration. Several owners commented on altering the medication—cutting or crushing the tablet--to aid in assisting delivery.

The breed and sex of the study cats are summarized in Table 3-2. As a result of the limited sample size, cats were grouped into two breed categories for subsequent analyses: purebred (11/54, 20%) and domestic (short, medium, or long hair; 43/54, 80%). The clients did not state the breed of 12 cats. The median weight of cats in the study was 4.52kg (IQR 1.34; n=53). The median age of cats in the study was 9.6 years (IQR 9.8; n=53). Table 3-1 is a frequency table showing the response counts for the survey questions.

Table 3-1

Frequency table of owners' responses to a survey on medication administration to their cats in New Zealand. Data were available for 66 cats.

Variable Name	Category	Count (%)
Client factors		
Prior experience with pet ownership	First cat	4 (6)
	Multiple cats	15 (22)
	Multiple pets, multiple species	47 (71)
	Total	66 (100)
Prior experience with pet illness	This pet	11 (17)
	Other pets of the same species	15 (23)
	Multiple species	19 (29)
	Training in animal health	14 (21)
	No experience	7 (11)
	Total	66 (100)
Prior experience with medicating pets	No	2 (3)
	Yes, oral medication	35 (53)
	Yes, eye or ear medication	10 (15)
	Yes, all routes	19 (29)
	Total	66 (100)
Client gender	Male	9 (14)
	Female	57 (86)
	I prefer not to answer	0 (0)
	Total	66 (100)
Client age group	<30 years old	14 (21)
	31-40 years old	16 (24)
	41-50 years old	10 (15)
	51-60 years old	18 (27)
	>60 years old	8 (12)
	Total	66 (100)
Client ethnic group	NZ European	50 (76)
	Other European	10 (14)
	Māori	3 (5)
	Asian	3 (5)
	Total	66 (100)
Client educational qualification (highest attained)	High school	14 (21)
	University	30 (46)
	Postgraduate	18 (27)
	Other	4 (6)
	Total	66 (100)
Client annual income	<$14,000	9 (14)
	$14,000-$48,000	12 (18)
	$48,000-$70,000	10 (15)
	$70,000-$100,000	3 (5)
	>$100,000	7 (11)
	Missing	25 (38)
	Total	66 (100)

Client disability	Yes	1 (15)
	No	65 (85)
	I prefer not to answer	0 (0)
	Total	66 (100)
Who administered medication to the cat	Myself	42 (64)
	Myself plus others	21 (32)
	Other	1 (2)
	Total	66 (100)
Client understanding of the reason medication was prescribed	Extremely well	45 (68)
	Very well	17 (26)
	Moderately well	4 (6)
	Slightly well	0 (0)
	Not well at all	(0)
	Total	66 (100)
Veterinary Visit Factors		
The veterinarian spent enough time explaining	Strongly agree	56 (85)
	Somewhat agree	8 (12)
	Neither agree nor disagree	2 (3)
	Somewhat disagree	0 (0)
	Strongly disagree	0 (0)
	Total	66 (100)
The veterinarian explained the reason for the medication well	Strongly agree	57 (87)
	Somewhat agree	6 (9)
	Neither agree nor disagree	3 (5)
	Somewhat disagree	0 (0)
	Strongly disagree	0 (0)
	Total	66 (100)
Who showed how to give the medication(s)	Veterinarian	31 (47)
	Veterinary Student	9 (14)
	Nobody	26 (39)
	Total	66 (100)
Medication Factors		
Medication class prescribed as reported by the client	Anti-inflammatory/pain relief (oral)	35 (53)
	Antimicrobial (oral)	23 (35)
	Behavioural (oral)	6 (9)
	Blood pressure (oral)	4 (6)
	Other oral medication	11 (17)
	Topical medication	5 (8)
	Total medications (oral & topical)	84[1]
Frequency of medication	Once a day or every 24 hours	31 (47)
	Twice a day or every 12 hours	25 (38)
	Three times a day or every 8 hours	4 (6)
	Other	6 (9)

	Total	66
Oral medication prescribed	Yes	64(97)
	No	2(3)
	Total	66
How was oral medication administered	Directly into the cat's mouth	23 (35)
	With regular cat food	13 (20)
	With a treat	13 (20)
	Combination of methods	17 (25)
	Total	66 (100)
Missed doses of oral medication	Yes	14 (21)
	No	52 (79)
	Total	100 (100)
Topical medication prescribed	Yes	14 (21)
	No	52 (79)
	Total	66 (100)
Challenges with topical medication	Yes	5 (36)
	No	9 (64)
	Total	14 (100)
Missed dose of topical medication	Yes	7 (50)
	No	7 (50)
	Total	14 (100)
The owner reported challenges giving prescribed medication.	Yes	16 (24)
	No	50 (78)
	Total	66 (100)
Owner-reported aids in medicating cats	Food	28 (44)
	Training	9 (14)
	Behavioural modification	6 (10)
	Restraint	5 (8)
	Product	8 (13)
	Nothing	7 (11)
	Total	63 (100)

[1]Clients reported that 19/66 (29%) cats received multiple medications.

Table 3-2

The breed and sex of cats of owners that participated in a survey on compliance with medication administration in New Zealand. Data were provided for 54/66 (82%) cats.

Breed	**Male**	**Female**	**N (%)**
Domestic short hair	16	22	38 (70)
Domestic medium hair	1	3	4 (8)
Burmese	2	1	3 (6)
Persian	0	2	2 (4)

Birman	1	0	1 (2)
British Shorthair	1	0	1 (2)
Devon Rex	1	0	1 (2)
Domestic longhair	0	1	1 (2)
Himalayan	0	1	1 (2)
Maine Coon	0	1	1 (2)
Siamese	1	0	1 (2)
Total	24	30	54 (100)

3.4.3 *Univariate and Multivariable Logistic Regression*

The results of the univariate logistic regression are presented in Table 3-3. Due to data sparseness all variables were combined into three or less categories. Several continuous variables (age of cat and weight of cat, for example) were categorized into terciles. Several variables (experience of client administering medication, for example) were eliminated prior to screening due to insufficient variation in data. Other variables (client income, for example) were eliminated prior to screening due to missingness of data. Univariate screening identified the following as inclusion variables for consideration in the multivariate model: weight of cat (kg), client experience with pet ownership, type of medication prescribed (anti-inflammatory, antimicrobial, "other"), the prescription of multiple medications, frequency of medication as reported by the client, pet resisting medication, restraint used as an aid in medicating, and prescription of a topical medication). The results for variables that failed to meet the inclusion criteria are included in the Appendix.

The results of the multivariable logistic regression are reported in Table 3-4. A confounding check was performed to examine the effect of client age. Client age was included in the final model as a variable to test the interaction amongst the remaining variables; no significant effect was found. The results of this confounding check are included in the Appendix. In the final multivariable model, client experience with pet ownership and medication with oral antimicrobials were associated with non-compliance.

Table 3-3

Variables with a *p*-value < 0.20 were selected for initial inclusion in the multivariate logistic regression model based on univariate logistic regression of associations between non-compliance and animal, client, veterinary visit, and medication factors. Data were collected from an online survey on owner compliance with medication administration to cats in New Zealand (n = 66) between 2019 and 2020.

Variable Name	**Category**	**Est.[1]**	**SE[2]**	**OR[3]**	**95%CI[4]**	***p*[5]**
Weight of cat	<3.9 kg	Ref				
	>3.9 and <4.8 kg	-0.96	0.71	0.38	0.09-1.49	0.17
	>4.8 kg	-0.57	0.69	0.57	0.14-2.15	0.41

Client experience with pet ownership	None	Ref				
	Multiple cats	-0.61	0.77	0.55	0.34-4.73	0.43
	Single cat	-1.85	1.11	0.16	0.39-5.04	0.09
Medication class	No	Ref				
	Anti-inflammatory	1.37	0.57	3.92	1.33-12.81	0.017
Medication class	No	Ref				
	Antimicrobial	1.76	0.57	5.8	1.97-18.53	0.002
Medication class	No	Ref				
	Other	-1.21	0.64	0.30	0.08-0.98	0.06
Multiple medications	No	Ref				
	Yes	2.33	0.63	10.24	3.17-38.34	<0.001
Med frequency[6]	Once	Ref				
	Multiple	0.81	0.52	2.24	0.81-6.38	0.12
Pet resisted medication	No	Ref				
	Yes	1.16	0.64	3.18	0.94-11.83	0.07
Medication aid	No	Ref				
	Restraint	1.92	1.16	6.82	0.92-139.46	0.10
Topical medication	No	Ref				
	Yes	0.80	0.62	2.22	0.67-7.77	0.19

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable [6]highest medication frequency per client

Table 3-4

Results of multivariable logistic regression of associations between non-compliance and factors. Data were collected from an online survey on medication administration to pets in New Zealand (n=66) between 2019 and 2020.

Variable Name	**Category**	**Est.[1]**	**SE[2]**	**OR[3]**	**95%CI[4]**	***p*[5]**
Client experience with pet ownership	None	Ref				
	Multiple cats	-1.57	1.08	0.21	0.021-1.52	0.148
	Single cat	-2.74	1.32	0.06	0.003-0.66	0.038
Medication class	No	Ref				
	Antimicrobial	1.84	0.67	6.27	7.77-25.83	0.006
	Other	-1.84	0.91	0.15	0.02-0.82	0.04
Owner age	<30 years	Ref				
	31-50 years	-0.03	0.92	0.97	0.016-6.09	0.97
	>50 years	1.17	1.01	3.21	0.45-25.62	0.25

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable

3.5 **Discussion**

Overall, 61% of New Zealand cat owners at a single clinic in this study complied with medication instructions. Comparative feline data are scant, but these results compare to 66.4% compliance reported for an international online survey of 2507 cat owners predominantly located in the United Kingdom, North America and Europe (Taylor *et al*., 2022). However, compliance among these clients was lower than the 73.1% medication compliance found for a small survey of 46 Finnish cat-owning clients at nine different clinics (Sivén *et al*., 2017) and considerably lower than the 92.6% reported for a multi-institutional study of 54 owners whose cats were prescribed medication for cardiovascular disease (Murphy *et al*., 2022).

One of the aims of this study was to identify factors associated with the non-compliance of owners with veterinary recommendations for medication administration to cats. Administration of oral antimicrobial drugs was significantly associated with non-compliance in the multivariable model. While overall compliance rates with antibiotic administration have been previously measured in dogs (Verker, van Stokrom and Endenburg, 2008; Adams *et al*., 2005; Amberg-Alraun *et al*.; 2004, Grave & Tanem, 1999; Barter, Watson and Maddison, 1996; and Bomzon, 1978); this is the first study to identify antimicrobials as a risk factor for non-compliance in cats.

Pets that are difficult to dose orally may lead to poor owner compliance, exacerbating fluctuations in tissue and plasma concentrations of an antimicrobial (Stegemann *et al*., 2007). Non-compliance with oral antimicrobial therapy has been associated with reduced treatment efficacy and increased treatment cost in dogs (Van Vlaenderen, Nautrup and Gasper, 2011). In this study, antimicrobials were prescribed for longer periods than other classes of medication examined. It may be difficult for clients to perceive benefit from the effect of antimicrobials as the prescription course continues. It's also possible that clinic veterinarians are prescribing antimicrobials for courses that extend past clinical resolution of symptoms or are prescribing for patients who may not require oral antimicrobial therapy. Compliance in human medicine has been shown to decline with longer treatment periods (Greenberg, 1984). Evidence exists that the antimicrobial prescribing habits of veterinarians are influenced by extrinsic factors unrelated to efficacy, including perceived owner compliance and ease of administration (Mateus *et al.,* 2014). Human compliance is also known to be lower in perceived less important situations (DiMatteo, Haskard and Williams, 2007). A recent survey of knowledge and attitudes of cat owners around antimicrobials and antimicrobial stewardship demonstrated that clients ranked method of administration

significantly higher than the importance of a drug for treating human infections, and very few considered the use of antimicrobials in pets to pose a risk to humans (Stein *et al*., 2022). Empowering the entire veterinary team to communicate the importance and benefits of the prescribed medication may be essential in developing a sense of priority when administering antimicrobial agents appropriately.

Among the factors explored with univariate analyses, oral medication, including anti-inflammatory, antimicrobial and other orally administered drugs, was significantly associated with non-compliance, suggesting that this route of administration is problematic for cat owners and their pets. The palatability of oral medications has been a focus of research for feline medication (Thombre, 2004). Sivén *et al*. (2017) specifically explored the administration of oral medication to cats in a clinical setting and found those drugs formulated specifically for cats were more palatable. In the current study, very few medications prescribed in this study were labelled specifically for cats, and even fewer were flavoured suspensions. Flavoured suspensions formulated for cats are significantly more palatable for cats. It has been previously reported that owners prefer solid forms of oral medication (Sivén *et al*., 2017). In contrast, an international survey of 2507 non-client cat owners reported that most preferred liquid oral medications and respondents reported that tablets or capsules were significantly harder to administer (Taylor *et al.,* 2022). In a recent study, a common reason for reported difficulty medicating cats consistently was the (poor) taste of the medication (Murphy *et al*., 2022). For those resistant cats, where formulation and palatability may have played a role in non-compliance, there are limited options available in New Zealand with regard to ease of administration and palatability with this class of drugs. Further exploration of the physical characteristics of oral medication for cats was beyond the scope of the current study but warrants further large-scale investigation in a veterinary hospital or clinic setting.

Client experience with pet ownership was associated with non-compliance in the multivariable model. This protective effect (OR 0.06) of ownership of a single cat--as compared to multiple cats and/or multiple species--on non-compliance is curious. First-time cat owners may be more receptive to veterinary team direction. As is common with other university-based feline medication studies (Traas et al., 2010; Murphy et al., 2022), many of the participants in this study were trained in animal health or claimed prior experience in the medication of pets due to multispecies or muti-feline ownership. These clients and the veterinarians servicing them may have assumed they had sufficient skill for the medication of cats without further direction. Indeed, administration techniques were not modelled by the veterinary team for

almost 40% of pet owners in this study (those who declined instruction) and technique demonstration was more likely to have been shown to inexperienced cat owners. Those owners who took advantage of veterinary instruction were very satisfied with the amount of time the veterinarian spent explaining the reason for the medication, indicated that the veterinarian had explained that reason well, and understood why medication had been prescribed. Ineffective veterinary communications regarding these factors have been identified as barriers to compliance in dog owners (Grave and Tanem, 1999; Adams *et al.,* 2005; Verker, van Stokrom and Endenburg, 2008) and, more recently, in cats (Caney, 2013). The authors suggest that client instruction and demonstration should be provided for every feline patient, or access to standardized videos and other educational resources should be supplied (Chapman, 2018).

A univariate association was found between non-compliance and cats that required the administration of multiple medications. Previous studies in dogs have shown that owner compliance with instruction decreases as the complexity of the medication regimen increases (Boda, Liege, and Reme, 2011; Adams *et al*., 2005; Amberg-Alraun *et al*., 2004; Barter, Watson and Maddison, 1996). One study in dogs demonstrated that dogs receiving multiple anti-convulsant medications had higher compliance rates than dogs on a single medication (Booth *et al*., 2020), but to the authors' knowledge the effects of polypharmacy on compliance in cats is unreported. Negative behavioural responses frequently occur when owners attempt to administer oral medication to their cats. Therefore, it is reasonable to assume that uncooperative behaviour is exacerbated when multiple medications are given (Taylor *et al.,* 2022). Prior experience with pet illness and medicating pets was not associated with non-compliance in this study.

Another aim of this study was to describe client-reported barriers and aids to the administration of medications in a New Zealand primary care practice. Of the one-fourth of clients in the current study reporting challenges in medicating their cat, most indicated their cat resisted efforts to medicate them. One-third of these reported they could not give the medication with food, or the method of administration was difficult. Although objective evidence is lacking (Chapman, 2018), many medication consumption failures have been attributed to the individual behaviour of the cat (Sivén *et al*., 2016) or the risk of potential injury from the cat (Murphy *et al.*, 2022). Injury to the cat must be considered also, as there is evidence that, in some cases, oral medication can be traumatic to the feline oesophagus (Beatty *et al*., 2006). Although not reported in the current survey, veterinarians should consider this possibility in formerly compliant cats that become uncooperative. Further details as to why clients had difficulty medicating their cats

were lacking. An invitation to post anonymous survey participation interviews may yield additional data on the nature of medication resistance by the cats.

Cat owners in this study were also asked to report what went well with medication administration. Only a third of owners administered the medication directly into the cat's mouth, but almost half of the respondent's used food as an aid in medicating their cat. Multiple respondents reported using cheese or peanut butter as an aid to administration. While consumption success has rarely been evaluated in cats (Khor *et al*., 2012), free-choice acceptance of medication remains problematic with cats (Traas *et al.,* 2010; Sivén *et al*, 2016). Adding medication to food may increase intake success in some cats but ensuring complete and timely delivery of the entire dosage may prove difficult using this technique. Food may interfere with the rate of absorption of the drug (Adams *et al*., 2005). Several respondents commented positively on the taste of a particular brand of flavoured suspension and how the cat's acceptance of that medication vastly aided in their administration. One-fourth of owners described a particular technique as an aid in medicating their pet, such as using a pill-popper or low-stress handling. Some owners specifically recommended a form of restraint as an aid in medicating their cat. Restraint, however, was associated with non-compliance in the univariate analysis (OR 6.82).

Similar to other recent client-directed studies of feline medication compliance (Sivén *et al.,* 2017; Murphy *et al.,* 2022), the current study suffered from a small sample size. This constrained the number of variables that might reasonably be incorporated into a multivariable model of all possible factors associated with non-compliance. The study design, a blinded client survey, presented further limitations. Owner self-reporting in veterinary compliance studies may overestimate compliance compared to other measurement methods (Barter, Watson and Maddison, 1996; Adams *et al.,* 2005). As enrolment in the study was voluntary, more compliant owners may have been more likely to be respondents. The reliance on a convenience sample of pets may have led to an underrepresentation of noncompliant owners. While the survey was offered within two weeks of the MUVTH visit, the retrospective nature of the survey may have increased the risk of pet owner recall bias for self-reported data. The lack of an organized patient call-back routine to remind clients about rechecks after prescriptions may have decreased involvement in the study. Clients not completing the entire survey led to missing data. Finally, the clientele of the MUVTH is overrepresented with individuals with animal experience (veterinary students, nurses, veterinary educators) and, therefore, may have overestimated compliance when compared to the clientele of private practice clinics.

3.6 **Conclusion**

The results of this study confirm the need for approaches that improve client compliance with veterinary instructions for the medication of their cats. The pet owner's prior experience with pet ownership should be considered when prescribing medication to cats. Nevertheless, our findings underscore the importance of providing standardized instruction and guidance for all feline-owning owning clients. Poor compliance with oral antimicrobial medication administration may have consequence with regard to antimicrobial stewardship. Ensuring that oral medications prescribed for cats are palatable and safe to administer before patient discharge may assist in improving compliance in this species.

4 Factors associated with medication non-compliance in dogs.

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4.1 Abstract

AIMS: To identify factors associated with non-compliance of owners with medication administration instructions for their dogs, to evaluate associated factors, and to provide context to client-reported barriers and aids to the administration of medications in a New Zealand primary care practice.

METHODS: A cross-sectional survey of compliance with veterinary medication recommendations by dog owners was performed from January 9, 2019, to July 18, 2020, using a convenience sample of dog owners who were prescribed medication for their pet by the Massey University Veterinary Teaching Hospital veterinarians during or following elective veterinary examination. Data were analysed using descriptive and analytic statistics.

RESULTS: Increasing age of dogs was associated with better owner compliance (p<0.05). Pet owners that used "nothing" as an aid to medicating their dog were less likely to be non-compliant (p<0.05). Forty-seven percent (71/151) of pet owners reported that "nobody" showed them how to administer the medication. One third of dog owners (47/151) reported challenges in medicating their pet. The most common reason cited by clients reporting challenges was a resistant pet. Prior experience with pet ownership and managing pet illness were not found to be associated with compliance. Almost half of the clients in this survey were non-compliant (47%; 71/151).

CONCLUSIONS AND RELEVANCE: Age is a protective factor for compliance in dogs. Demonstration of medicating technique and discussion about available aids to medicating a pet may improve client compliance with medication instruction.

KEY WORDS: Compliance, adherence, persistence, dog, pet owner, New Zealand, medication, survey

4.2 Introduction

Medication administration is an essential aspect of pet healthcare, and it is crucial that pet owners follow the instructions of their veterinarian for the optimal response to treatment (Abood, 2006; Ramió-Lluch *et al*., 2020). However, the compliance with veterinary directions for medication administration to dogs has been an issue of concern for many years as it is often challenging for pet owners to ensure that their pets receive the correct dosage and adhere to the medication schedule (Wareham, Brennan and Dean, 2019).

Client compliance with medication administration to dogs refers to the extent to which dog owners or caregivers follow the instructions provided by a veterinarian or animal healthcare provider (Barragry, 2000; Grave and Tanem, 1999). In other words, it is the extent to which dog owners or caregivers give their dogs the medication in the right way, at the right time, and for the full duration of the prescribed course of treatment. Compliance thus refers to how closely a client follows their prescriber's recommendations. In human medicine, "adherence" is increasingly used instead, emphasizing patient independence and free will (Booth *et al*., 2021). However, in veterinary medicine, where owners provide treatment and care for sick animals, the term "adherence" is not as applicable, and "compliance" is used in this study due to the owners' intermediary role.

Pet owners who comply fully with the medication regimen will administer all prescribed doses to their pets at the right time intervals. Owners who are not fully compliant may miss doses, give doses at the wrong time, give the wrong dose, or stop the treatment early. Compliance is typically considered 'good' when at least 80% of the medication is administered correctly, although the optimal level of compliance varies depending on the disease and medication and is difficult to determine precisely (Maddison, 2011; Talamonti *et al*., 2015; Booth *et al*., 2020; Ramió-Lluch *et al*., 2020). Studies may report a percentage of patients who had perfect (100%) compliance (also referred to as “absolute compliance”), while others may report data as a percentage of patients who demonstrated a particular level of compliance (Adams *et al*., 2005). It is important to determine how compliance is defined when comparing studies, as results can vary significantly depending on the standard used (Wareham, Brennan and Dean, 2019). It has been theorised but not verified that non-compliance among clients in veterinary practice for small animals may not pose as significant of an issue compared to human medicine, with the

animal population studied often compared to paediatric medicine (Adams *et al*, 2005).

There have been few studies in veterinary medicine where potential factors affecting compliance were tested. Those published have suggested that compliance is improved when the pet owners feel the veterinarian has spent enough time with them in the consultation (Grave & Tanem,1999), when information sheets are delivered with the prescription (Amberg-Alraun *et al*., 2004), and when important information and the explanation of the effects of the medication is repeated during the consultation (Verker, van Stokrom and Endenburg, 2008). Several studies have suggested that the complexity of the medication regimen has an impact on compliance (Amberg-Alraun *et al.,* 2004; Adams *et al.* 2005; Boda, Liège and Rème, 2011). However, a recent systematic review of factors affecting owner compliance with medication treatment recommendations found that evidence available regarding factors affecting client compliance with pharmaceutical treatment recommendations in dogs and cats was limited and of poor quality (Wareham, Brennan and Dean, 2019). Few studies have investigated owner-related human factors associated with poor compliance (Maille and Hoffmann, 2013; Taylor *et al*. 2022). As observed in human medicine, pet owner compliance with medication regimes may impact the health and well-being of the patient (Ramio-Lluch *et al.,* 2020; Booth *et al*., 2021). Improved owner compliance has the potential to improve clinical outcomes for pets, reduce antimicrobial resistance, ensure timely preventive medicine, ensure a better quality of life for pet dogs and owners, and improve animal welfare with less time spent on recurrent problems (Adams *et al*., 2005).

To improve client compliance with medication administration to dogs, it is important to educate pet owners or caregivers about the importance of medication adherence and provide clear instructions on how to properly administer the medication (Maddison, 2011; Verker, von Stokrom and Endenburg, 2008). This may include demonstrating how to give the medication, explaining the proper dosage and frequency, and providing information on any potential side effects or interactions with other medications. In addition, veterinarians can use various tools and strategies to promote client compliance with medication administration, such as sending reminders about when to administer the medication, providing written instructions or visual aids, and offering follow-up appointments to check on the dog's progress and adjust the treatment plan if necessary (Barragry, 2000).

This study explored the challenges associated with medication compliance of clients with dogs, including the factors that affect medication compliance and the strategies employed by owners to improve compliance in canine patients. The aims of this

study were to identify factors associated with non-compliance of owners with medication administration instructions for their dogs, to evaluate associated factors, and to provide context to client-reported barriers and aids to the administration of medications in a New Zealand primary care practice. Based on the findings, the authors seek to provide insights into the importance of medication compliance in dogs, and offer recommendations for veterinarians and pet owners to ensure that their pets receive the best possible care.

4.3 **Materials and Methods**

4.3.1 *Ethics and Data Protection*

This project was evaluated by peer review as low risk for human participants. Consequently, it was not required to be reviewed by a Human Ethics committee in New Zealand but was registered with the Massey University Human Ethics Committee (Human Ethics Notification 4000020081). Data collection was therefore carried out in accordance with the low-risk notification and informed owner consent was obtained. Data were anonymized immediately after enrolment by providing clients with their animal's patient number to independently complete the survey.

4.3.2 *Study Design*

A prospective cross-sectional study of compliance with veterinary medication recommendations by dog owners was performed from January 9, 2019, to July 18, 2020, using a convenience sample of dog owners who were prescribed medication for their pet by the Massey University Veterinary Teaching Hospital veterinarians during or following elective veterinary examination.

4.3.3 *Enrolment*

Clients were invited to participate in this study if their dog had been seen by a veterinarian of the MUVTH Community Practice service and had been prescribed oral or topical medication. As part of informed consent, prospective participants were advised that the investigators were examining medication compliance and the aids and barriers they may have experienced in administering medication to their dogs. They were further advised that the findings of the study would be used to

educate and assist pet owners' completion of the treatment instructions. Clients were assigned MUVTH patient number to allow prescriptions to be matched to individual patients without exposing the identity of the client to the researchers. Clients were advised that they were free to withdraw from the study at any time.

4.3.4 *Inclusion and Exclusion Criteria*

The owners of dogs that were prescribed oral or topical medication by the MUVTH Companion Animal Community Practice were included in the study following client consent. Dogs who were prescribed medication by specialist veterinarians at the practice were excluded. Patients who died or were euthanized between the time of consent and the time of data collection were excluded. Patients who were administered their prescribed medication in-hospital by staff were excluded.

4.3.5 *Questionnaire Construction*

An online questionnaire was developed using proprietary software (Qualtrics XM, Seattle Washington; www.qualtrics.com), consisting of three parts: firstly owner demographical information, secondly questions relating to the administration of medications to their dog, and thirdly identification of challenges associated with medicating their pet. The survey included questions with binary, categorical or semiquantitative response options. Questions relating to medication compliance used Likert scales, while questions relating to challenges and barriers allowed for multiple selections and free-text entry. The survey is available in the Appendix. Five staff members employed at MUVTH were asked to complete the survey as a pilot study, and their feedback used as part of an iterative process to ensure valid questions in the final survey (Dean, 2015).

4.3.6 *Dissemination of Questionnaires*

Dog owners seen through the MUVTH Community Practice service that consented to participate in this study after an invitation by a staff member were given a unique URL link to the online survey for the project at the time of the initial medication prescription for their dog. Participating clients were contacted by a staff member two weeks later either in-person at a recheck appointment or via telephone or email after a course of medication had been administered. The research team member in contact with the client was not involved in the blinded analyses of results.

4.3.7 *Statistical Analysis*

Data from the online survey tool was imported as a spreadsheet CSV file into R statistical software (Version 3.6.1, R Development Core Team 2020, R Foundation for Statistical Computing, Vienna, Austria) for data cleaning and analyses. Entries that did not meet the inclusion criteria (e.g., rabbits) and responses that were not sufficiently complete for the evaluation of outcomes were excluded from further analysis.

Descriptive statistics were summarised for all quantitative study variables. The distribution of continuous variables was evaluated for normality by the Shapiro-Wilk test. For continuous data that was normally distributed the mean and standard deviation were calculated. For data that was not normally distributed, median and interquartile range values were calculated. For the Likert-scale questions, median and mode are reported.

Univariable logistic regression analyses were performed to assess factors associated with non-compliance and medication administration to dogs. The binary outcome measure, non-compliance (yes/no), was defined as failing to give the prescribed medication for the duration of the prescription, failing to give the prescription at the prescribed intervals, or failing to give the prescription. Compliance/non-compliance was identified by comparing the directions in the prescription with the recorded responses of the client.

Explanatory variables encompassing client, animal, veterinary visit, and medication factors were explored for their contribution to the outcome. An initial univariable logistic regression was performed for each potential explanatory variable, and *p* values were calculated using the Wald Test. Each predictor variable returning a $p < 0.25$ from the univariate modelling was considered for inclusion in a multivariable model. A stepwise backward elimination procedure was then performed whereby predictive values with the least significant *p* value were successively removed until all variables in the final model had a Wald's *p* value ≤ 0.05. A set of basic diagnostic statistics including fitted and standardized residuals and leverage was examined for adherence to model assumptions. No influential points were detected. The models were compared using ANOVA of deviance function in R, and the model with the lowest Akaike information criterion (AIC) was chosen (Field *et al.,* 2021). The findings for associations are presented as odds ratios (OR) and confidence intervals (95%CI) for each predictive variable.

Qualitative data from the free-text comments for the question with "What went well

with medication administration?" option was imported into NVivo v12.0 (QSR International Pty Ltd. 2018, Chadstone, Australia) and thematic analysis was performed to highlight key issues raised by respondents about their positive experiences and opinions towards the administration of medication to their pets. This process involved (i) reading through all free-text responses multiple times to gain familiarity with the data, (ii) reading through the individual responses again in detail, underlining keywords, phrases, and/or ideas exemplifying major themes, (iii) collating the coded data into potential themes by subjectively grouping responses with similar perceived meaning, and (iv) then re-reading and reflecting on the coded data to identify more in-depth meanings and to make any required amendments to the themes.

4.4 **Results**

4.4.1 *Survey Response*

Owners of 151 dogs agreed to participate in the study.

4.4.2 *Descriptive Data, Predictive and Outcome Variables*

The breed category, sex, weight, and age of study dogs are summarized in Table 4-1. Patient breed, weight, and sex data was available for 117/151 respondents. As a result of sample size, dogs were grouped into three categories based on weight: large breed (55/117, 47%), medium breed (27/117, 23%), and small breed (35/117, 30%). A complete listing of dog breeds in this study can be found in the Appendix. The median weight of dogs in the study was 23.0kg (IQR 22.0 kg). The median age of dogs in the study was 6.6 years (IQR 7.8 kg).

The frequency of owners' responses to a survey on medication administration to their cats in New Zealand are summarized in Table 4-2. The proportion of surveyed client dog owners that were non-compliant with medication instructions was 47% (71/151), resulting in an absolute compliance rate of 53% (80/150).

Respondents were most commonly female, aged between 51 and 60 years, New Zealanders of European ethnicity, and educated to a university level. Seventy-three per cent (110/151) of dog owners reported prior experience in ownership of multiple pets of multiple species. Only 10% (14/151) had no prior experience managing pet illness, and 11% (17/151) reported they had training in animal health. Forty-eight

per cent (72/151) of clients had prior experience with orally medicating pets, and another 37% (56/151) reported they had experience with both oral and topical routes of medication administration. Sixty percent (91/151) of respondents administered the medication themselves. All respondents answered that they had a good understanding of the reason the medication was prescribed, with 95% (144/151) responding they understood either "very well" or "extremely well".

Eighty-seven per cent (131/151) of respondents strongly agreed that the veterinarian had spent enough time explaining the reason for the prescription, and 86% (130/151) strongly agreed that the veterinarian had explained the reason for the medication well. Most clients were shown how to administer the medication by a veterinarian (41%; 61/151), although 47.3% of clients (71/151) reported that "nobody" showed them how to give the medication(s).

Most (88%; 132/151) of the dogs in this study were prescribed at least one oral medication. Medication classes prescribed (as reported by the client) were oral anti-inflammatory/pain reliever (n=95), oral antimicrobial (n=38), oral behavioral, "other oral medication" (n=15), and topical medication (n=32). Fifty-five (36.4%) clients were prescribed more than one medication for their dog.

The frequency of administration was predominantly twice a day (53%; 78/148). Only 31% (40/151) of clients reported giving medication directly into their dog's mouth, while 68% (89/131) reported administering the medication with food, with a treat, or a combination of these methods.

Thirty-one per cent (47/151) of clients reported challenges giving the prescribed medication. The most common problem (n=28) listed by respondents was "my pet was resistant to my efforts to medicate him/her". Other barriers identified by respondents include treatment duration, inability to give medication with food, inconvenient dosing regimen, number of medications prescribed, and the complexity of the treatment regimen. Several owners reported diarrhoea in their pets and associated this with the prescribed medication—which they then stopped. Multiple owners also reported altering the medication in some manner in order to administer. This included opening capsules, crushing tablets, and altering recommended administration schedules. Owner-reported aids in medicating their dogs were grouped into the following categories: food (n=81), technique (n=31), behavioural modification (n=5), positive reinforcement (n=7), product (n=3), and nothing (n=29).

Survey participants were asked what went well with medication administration and were encouraged to offer any tricks or techniques that they employed that made medicating their pet easier. These responses were collected via free text entry with a total of 147 respondents. Several common themes emerged from these answers. The majority of these respondents (55.1%; 81/147) reported that food or a treat was helpful in assisting oral medication. These food-related responses ranged from putting the medication directly into the food to finding a special food or treat to help deliver the medicine. Twenty-six respondents (17.7%) described a particular technique as helpful. Eight of these respondents mentioned some form of restraint as a positive influencer. Fifteen respondents (10.3%) reported an attribute of the medication itself as a positive feature. For example, the inclusion of a measured syringe for liquid suspensions was noted as a helpful inclusion by several respondents. Fourteen respondents (9.5%) described behavioural modification or a particular dog attribute that assisted them in administering medication. Twelve respondents (8.2%) reported the use of multiple aids. Twenty respondents (13.7%) reported that there were no tricks or techniques that improved the administration, with responses such as "I just put it in his mouth" and "it was straightforward" predominating.

Table 4-1

Demographic data on dogs of respondents to a survey on compliance with medication administration in New Zealand. Data were available for 117/151 dogs.

Breed grouping	**Small breed dogs** (<10kg)	**35 (30%)**
	Medium breed dogs (>10kg and <20kg)	27 (23%)
	Large breed dogs (>20kg)	55 (47%)
Sex of dog	Neutered males	43 (36.7%)
	Spayed females	45 (38.5%)
	Intact males	13 (11.1%)
	Intact females	16 (13.7%)
Weight of dog		2.2 to 73kg (median) 23.0, IQR 22.0))
Age of dog		2 to 16.5 years (median 6.6 years, IQR 7.8)

Table 4-2

Frequency table of responses to a survey on compliance with administration instructions for the medication to dogs in New Zealand. Data were available for 151 dogs.

Variable Name	Category	Count (%)
Client factors		
Prior experience with pet ownership	First dog	24 (16)
	Multiple dogs	17 (11)
	Multiple pets, multiple species	110 (73)
	Total	151 (100)
Prior experience with pet illness	This pet	28 (19)
	Other pets of the same species	28 (19)
	Multiple species	63 (42)
	Training in animal health	17 (11)
	No experience	15 (10)
	Total	151 (100)
Prior experience with medicating pets	No	4 (3)
	Yes, oral medication	72 (48)
	Yes, eye or ear medication	14 (9)
	Skin	5 (3)
	Yes, all routes	56 (37)
	Total	151 (100)
Client gender	Male	36 (24)
	Female	115 (76)
	Prefer not to answer	0 (0)
	Total	66 (100)
Client age group	<30 years old	23 (13)
	31-40 years old	18 (12)
	41-50 years old	40 (27)
	51-60 years old	46 (30)
	>60 years old	23 (15)
	Prefer not to answer	1 (0.7)
	Total	151 (100)
Client ethnic group	New Zealand European	112 (74)
	Other European	18 (12)
	Maori	11 (7)
	Asian	8 (5)
	Prefer not to answer	2 (1)
	Total	151 (100)
Client educational qualification (highest)	High school	35 (23)
	University	66 (44)
	Postgraduate	34 (23)
	Other	14 (9)
	Prefer not to answer	2 (1)
	Total	151 (100)
Client annual income	<$14,000	11 (7)
	$14,000-$48,000	11 (7)
	$48,000-$70,000	19 (13)
	$70,000-$100,000	24 (16)

	>$100,000	17 (11)
	Prefer not to answer	69 (46)
	Total	151 (100)
Client disability	No	149 (99)
	Yes	1 (1)
	Prefer not to answer	1 (1)
	Total	151 (100)
Who administered medication to the dog	Myself	91 (60)
	Myself plus others	57 (38)
	Other	3 (2)
	Total	151 (100)
Client understanding of the reason medication was prescribed	Extremely well	106 (70)
	Very well	38 (25)
	Moderately well	7 (5)
	Slightly well	0 (0)
	Not well at all	0 (0)
	Total	151 (100)
Veterinary visit factors		
The veterinarian spent enough time explaining	Strongly agree	131 (87)
	Somewhat agree	15 (10)
	Neither agree nor disagree	2 (1)
	Somewhat disagree	2 (1)
	Strongly disagree	0 (0)
	Total	150 (100)
	Missing	1
The veterinarian explained the reason for the medication well	Strongly agree	130 (89)
	Somewhat agree	18 (12)
	Neither agree nor disagree	1 (1)
	Somewhat disagree	1 (1)
	Strongly disagree	0 (0)
	Total	150 (100)
	Missing	1
Who showed how to give the medication(s)	Veterinarian	61 (41)
	Veterinary Student	18 (12)
	Nobody	71 (47)
	Total	150 (100)
	Missing	1
Medication factors		
Medication class and route prescribed as reported by the client	Anti-inflammatory/pain relief (oral)	95 (63)
	Antimicrobial (oral)	38 (25)
	Behavioral (oral)	8 (5)
	Other oral medication	40 (27)
	Topical medication	32 (21)
	Multiple medications (oral & topical)	55 (36)
Frequency of medication	Once a day or every 24 hours	43 (29)
	Twice a day or every 12 hours	78 (52)
	Three times a day or every 8 hours	12 (8)

	Other	15 (10)
	Total	148 (100)
	Missing	3
Length of prescription as reported by the client	Two days	4 (3)
	Three days	5 (3)
	Four days	5 (3)
-	Five days	21 (14)
	Six days	0 (0)
	Seven days	27 (18)
	8 to 14 days	38 (25)
	15 to 21 days	6 (4)
	22 to 28 days	3 (2)
	42 to 364 days	13 (9)
	Ongoing	23 (15)
	Not specified	6 (4)
	Total	151 (100)
Oral medication prescribed	Yes	132 (88)
	No	19 (12)
	Total	151 (100)
How was oral medication administered	Directly into the dog's mouth	40 (31)
	With regular dog food	30 (23)
	With a treat	39 (30)
	Combination of methods	20 (15)
	Other	2 (2)
	Total	131 (100)
	Missing	1
Challenges with oral medication	Yes	47 (31)
	No	103 (69)
	Total	150 (100)
	Missing	1
Missed doses of oral medication	Yes	39 (30)
	No	93 (70)
	Total	132 (100)
	Missing	19
Topical medication prescribed	Yes	45 (30)
	No	105 (70)
	Total	150 (100)
	Missing	1
Challenges with topical medication	Yes	12 (27)
	No	33 (73)
	Total	45 (100)
Missed dose of topical medication	Yes	19 (42)
	No	26 (58)
	Total	45 (100)
Medicating pet was a difficult experience for client or pet	Strongly Agree	8 (17)
	Somewhat Agree	19 (41)
	Neither agree nor disagree	8 (17)
	Somewhat disagree	7 (15)
	Strongly disagree	4 (9)

	Total	46 (100)
Owner-reported aids in medicating dogs	Food	81 (55)
	Technique	26 (18)
	Medication attribute	15 (10)
	Behavioural modification	14 (10)
	Multiple aids used	12 (8)
	No/Nothing	20 (14)
	Total	147

4.4.3 *Univariate and Multivariable Logistic Regression*

The results of the univariate logistic regression analyses are presented in Table 4-3. Univariate screening identified the following as inclusion variables for the multivariate model: breed category of dog, sex of dog, age of dog, client experience with medicating pets, who administered medication to the pet, prescription of oral antimicrobials, multiple medications prescribed, highest medication frequency as reported by the client, highest medication frequency as reported by the veterinarian, who showed the client how to give the medication, owner reported aids to medicating their pet (technique/training, restraint, nothing). The results for variables that failed to meet the inclusion criteria are included in the Appendix.

The results of the multivariable logistic regression analysis are reported in Table 4-4. Due to missingness and model errors, it was not feasible to include all variables identified in the multivariable analysis. Models for dog-associated factors and medication-associated factors were investigated separately. In the final multivariable model, age of the dog, and "nothing" as an aid to medication were associated with non-compliance.

Table 4-3

Variables with a *p*-value <0.25 were selected for initial inclusion in the multivariate logistic regression model based on the results of univariate logistic regression analyses of associations between non-compliance and animal, client, veterinary visit, and medication factors. Data was collected from an online survey on owner compliance with medication administration to dogs in New Zealand (n = 151) between 2019 and 2020.

Variable Name	**Category**	**Est[1]**	**SE[2]**	**OR[3]**	**95%CI[4]**	***p*[5]**
Breed category	Large	Ref				
	Medium	3.24	0.83	25.60	5.99-181.01	<0.001
	Small	3.16	0.80	23.50	5.90-158.95	<0.001

Sex of dog	Fem/spayed	Ref				
	Female	3.87	1.14	48.00	7.21-975.66	<0.001
	Male	3.94	1.17	51.20	7.32-1065.4	<0.001
	M/neutered	3.79	1.06	44.44	8.33-827.12	<0.001
Age of dog (years)		-0.10	0.05	0.90	0.82-0.99	0.03
Client experience administering medication	All routes	Ref				
	Eye/ear	-0.30	0.60	0.74	0.22-2.45	0.62
	None	0.80	1.19	2.23	0.27-46.60	0.50
	Oral	-0.85	0.37	0.43	0.21-0.88	0.02
	Skin	1.09	1.15	2.97	0.41-60.13	0.35
Who gave medication to pet	Myself	Ref				
	Other	0.27	1.43	1.31	0.05-33.76	0.85
	Myself & Others	0.48	0.34	1.62	0.83-3.20	0.16
Medication class	No	Ref				
	Antimicrobial	0.60	0.39	1.82	0.86-3.93	0.12
Multiple medications	No	Ref				
	Yes	0.44	0.35	1.56	0.79-3.10	0.20
Highest med frequency per vet		0.30	0.25	1.36	0.83-2.27	0.22
Who explained medication	Veterinarian	Ref				
	Nobody	-0.60	0.35	0.55	0.27-1.10	0.09
	Student	0.28	0.55	1.33	0.46-4.05	0.61
Who explained: categorized	Veterinary team	Ref				
	Nobody	-0.42	0.34	0.66	0.34-1.27	0.22
Medication aid	No	Ref				
	Technique	0.83	0.46	2.29	0.95-5.82	0.07
Medication aid	No	Ref				
	Restraint	-0.95	0.70	0.39	0.08-1.41	0.18
Medication aid	No	Ref				
	"Nothing"	-1.42	0.67	0.24	0.05-0.80	0.03

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable

Table 4-4

Results of multivariable logistic regression analyses of associations between non-compliance and dog factors and medication factors. Data were collected from an online survey on medication administration to dogs in New Zealand (n=151) between 2019 and 2020.

Variable	**Category**	**Est[1]**	**SE[2]**	**OR[3]**	**95%CI[4]**	***P*[5]**
Dog age		-0.10	0.05	0.90	0.82-0.99	0.030
Medication aid	No	Ref				
	Nothing	-1.42	0.67	0.24	0.05-0.81	0.030

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable

4.5 **Discussion**

The proportion of surveyed client dog owners that were noncompliant with medication instructions was 47% (71/151). Compliance in this study was defined as 100% or absolute and, using this as a basis for comparison to other studies reporting data in a similar manner, this proportion of non-compliance among dog-owning clients is lower than values reported in previous studies in dogs (56% to 89%) (Bomzon, 1978; Barter, Watson and Maddison, 1996; Grave and Tanem, 1999, Verker, von Stokrom and Endenburg, 2008, Booth et al., 2020). Other canine studies (Adams et al, 2005, Amberg-Alraun, 2004) have reported compliance rates as median values making comparison of the current findings with those studies challenging. The clientele of the MUVTH is overrepresented with individuals with animal experience (veterinary students, nurses, veterinary educators) and, therefore, may have overestimated compliance when compared to the clientele of private practice clinics.

This study aimed to identify factors associated with the non-compliance of owners with veterinary recommendations for medication administration to dogs by examining client factors, animal factors, veterinary visit factors and medication factors. A significant association ($p<0.05$) was found between age of the dog and non-compliance, with increasing age having a protective effect on compliance, an animal factor that has not be previously reported. There could be several possible explanations for this finding. Firstly, similar to humans, older animals are more likely to have medical conditions that require medication (Senior Care Guidelines Task Force, 2005). This could lead to a higher awareness and understanding among owners about the importance of medication compliance for their older pets. Additionally, the potential chronic nature of treatments in older animals and the standard of geriatric care for dogs may provide more opportunities for client interaction with the veterinary team (Abood, 2006). The majority of dogs in this study (61%) were over 5 years old, with one third over 10 years old (mean=6.8 years). During these veterinary interactions, verbal explanations of the medication effects and repeating important medication information to the client may contribute to improved compliance (Verker, van Stokrom and Endenburg, 2008). This suggests that treatment compliance in animals can be enhanced by scheduling regular follow-up visits to ensure correct implementation of the treatment by the owner. Adjusting the therapy based on the animal's response and actively involving the owner in the treatment plan are also recommended strategies. Furthermore, older animals with acute or chronic conditions may pose a greater social risk to clients who are non-compliant (Maille & Hoffman, 2013). Owners may feel a desire to showcase a pet in good health, and neglecting the care of a dependent animal could be viewed as

worse than not taking care of oneself.

In human medicine, the relationship between age and compliance is complex and may be closely associated with the specific disease being treated. Most studies suggest that medication adherence increases with age in humans (Park *et al*., 1999). Older patients also tend to have greater illness severity (Kim *et al*., 2019), which can be predictive of compliance (DiMatteo, Haskard and Williams, 2007). Similarly, in dogs, the specific disease being treated may influence owner compliance (Grave and Tanem, 1999). Diseases commonly associated with geriatric animals, such as canine osteoarthritis, may significantly impact a client's daily routine and serve as a strong motivator for compliance (Maddison, 2011).

A significant association (p<0.05) was also found between non-compliance and the aids that clients used to assist in medication administration. Failing to employ different methods (i.e., "Nothing") as an aid to medication administration was negatively associated with non-compliance. In other words, respondents who did not report using any aids to medicate their dog were found to be more compliant. This could reflect a lack of explanation or demonstration on the part of the veterinary team. Prior studies in dogs have demonstrated that time spent with the veterinarian (Grave & Tanem, 1999; Verker, von Stokrom and Endenburg, 2008) and, specifically, repeating he most important instructions and verbal explanation of the effect of the medication (Grave & Tanem, 1999; Verker, von Stokrom and Endenburg, 2008) improved compliance. While most respondents in this study were satisfied with the time spent by the veterinarian and the degree to which the medication was explained, the depth of information delivered in these visits likely varied. The use of printed or video instructional tools for client education remains inconsistent within the MUVTH. Pet owners may have been unaware of the options or methods available to assist them in medicating their animal. The choice of "nothing" as an aid to medicating their pet may also reflect the owner's general inability to do so. The most frequently reported barrier to medication administration in this study was a resistant pet. Owner's may have employed multiple techniques only to find none of the suggested methods were successful. Further investigation into this factor is warranted to determine what, if any, options these pet owners would elect to employ if given the opportunity.

We may also interpret the simplicity of application as a factor of the medication itself: the clients didn't need to alter or hide the medications to successfully administer them to their dogs. Many owners rely on food to administer medications to their pets (Maddison, 2011), and over half of the clients in this study used food or a treat as an aid in administering their dog's medication. Emphasizing the popularity

of this practice, instructions not to give medication with food resulted in a low compliance rate (22%) in one veterinary study (Adams *et al*., 2005). Thus, the palatability (or another quality) of the medication in this study may have impacted the clients' ability to administer it. As an example, 63% (95/151) of dogs in this study were prescribed and anti-inflammatory/pain reliever. The nonsteroidal anti-inflammatory drugs prescribed in the MUVTH are provided as a flavoured tablet or suspension, likely contributing to the ease of administration of that class of medication. Free text answers from this cohort of owners who reported not using an aid in medicating their dogs may also provide some insight to this finding. The temperament of the dog was commonly mentioned as a positive attribute, describing the animal as "calm" or "relaxed". Dogs are reportedly less discriminating pets than cats (Thombre, 2004), and fear of injury from the animal is not a reported barrier to compliance in the dog as it is in the cat (Murphy *et al*., 2022). Some owners said their dog would "eat anything". Other owners took a more direct approach, stating the process was straightforward or "I just gave it". Several directly commented that the demonstration by the veterinary team was instructive enough and precluded the use of any aids, simply stating "I did as shown".

Almost half of the dog owners (47%; 71/151) in this study replied "nobody" when asked who showed them how to administer the prescribed medication. The effect of demonstrating medication administration to pets by the veterinary team on compliance has not previously been examined. Incorrect techniques when delivering oral medication could limit efficacy. Poor technique may limit the appropriate dose the animal receives, decrease the bioavailability of the medication, or cause injury to the pet or owner (Chapman, 2018). Curiously, however, this finding was not associated with non-compliance in the current study. Pet owners have been shown to misremember this information (Adams *et al*., 2005), but a closer look at the free text from this question may be more informative. The majority of dog owners reporting nobody showed them how to give the medication noted that they did not require instruction due to prior training or personal confidence in the technique. Thus, the question design may have contributed to misleading results as these clients opted out of the offered demonstration. Prior studies in veterinary medicine have focused on the delivery of oral or written information on prescribed medicines and how to administer them (Adams et al., 2005; Amberg-Alraun, 2004; Verker, von Stokrom, 2008), but none have modelled the technique for owners. The in-clinic demonstration of medication to pets may be a future area of investigation for improvement of non-compliance.

Dog owners in this study were also asked to report what went well with medication administration. A majority (55%) responded that adding it to food or a treat was a

positive influence in medicating their dog. While this is a popular tactic and likely improves the success of administration, ensuring complete and timely delivery of the entire dosage may prove difficult using this technique. If the dog is anorectic or the dosing schedule does not align with mealtimes, then they owner may not be able to consistently medicate their pet. Some medication may not be labelled for use with food. Food may also interfere with the rate of absorption of the drug (Adams *et al*., 2005). Six respondents reported that they altered the medication (crushed a tablet, for example), in order to mix with their dog's food, a tactic that may be inappropriate. Reliance on food may impact compliance in these situations. In one study, instructions to give medication without food resulted in a low compliance rate (22%) (Grave and Tanem, 1999), a result also seen in human medicine (Maddison, 2011).

Fourteen respondents (9.5%) described an attribute of their dog that made medicating them easier. For example, a calm or food-motivated animal was reported as improving the medication experience. Interestingly, five respondents identified their dogs as Labradors and, as such, were inherently easy to medicate. No other dog breeds were mentioned by name in this question's responses. Some survey participants claimed some form of restraint as a positive influence on medicating their pet. A majority of these responders commented that the inclusion of a second person was helpful in assisting administration. More respondents (8) used physical restraint as a medicating aid than positive reinforcement (7). Only three clients mentioned the instruction they received from the veterinary team as a positive factor in medicating their pet, and only one respondent mentioned their training in animal care.

Client factors such as prior experience with pet ownership and pet illness did were not a factor in non-compliance in this study. Experience medicating pets produced enough of an association with non-compliance to be included in the multivariate analysis, but the results were not significant (p=0.08).

Challenges in medicating their pet were reported by 31% (47/151) of dog owners in this study. The primary reason listed was that the dog resisted efforts to medicate them (76%; 36/47). Difficulty getting the pet to take the medication is a reported barrier to compliance in dogs (Maddison, 2011). It has been previously suggested that length of treatment is also a barrier to compliance (Maddison, 2011), but treatment duration was an uncommon factor listed by owners in this study (4%; 2/47). Busy lifestyles or convenience have also been suggested as barriers to compliance in previous literature (Bomzon, 1978; Maddison, 2011). However, only 4% (2/47) of respondents associated that the convenience of the dosing regimen

was a challenge for them in medicating their dog, and this was not significantly associated with non-compliance in this study.

The study design, a blinded client survey, presented several limitations. Although the sample size was modest (n=151), this should be adequate to achieve reliability and confidence in the results obtained. While self-reporting is an indirect measure of medication compliance, it has been shown to be as effective as other indirect measures, including pill counts and refill rates (Khdour *et al*., 2012) and is the most practical approach for studies in veterinary medicine (Barter, Maddison and Watson, 1996). More precise estimates of medication adherence can be gained via direct methods (e.g., observation, drug or metabolites blood concentrations), however, such methods are expensive, burdensome or invasive, (Osterberg, 2006), or not applicable to veterinary medicine (Barter, Watson and Madison, 1996). Owner self-reporting in veterinary compliance studies may overestimate compliance compared to other measurement methods (Barter, Maddison and Watson, 1996; Adams *et al.,* 2005). As enrolment in the study was voluntary, more compliant owners may have been more likely to be respondents. The reliance on a convenience sample of pets may have led to an underrepresentation of noncompliant owners. While the survey was offered within two weeks of the MUVTH visit, the retrospective nature of the survey may have contributed to pet owner recall bias for self-reported data. The lack of a more standardised patient call-back routine to remind clients about rechecks after prescriptions may have decreased involvement in the study. Question design not forcing answers and clients not completing the entire survey led to missing data.

4.6 **Conclusions**

This is the first study to associate age with compliance in dogs. With an overall compliance rate of 53%, the results of this study confirm the need for approaches that improve client compliance with veterinary instructions for the medication of their dogs. Our findings underscore the importance of providing standardized instruction and guidance for all dog-owning clients, including the demonstration of medication administration. Ensuring that oral medications prescribed for dogs are palatable and easy to administer before patient discharge may assist in improving compliance in this species.

5 Conclusions

Compliance is an important issue in human and veterinary medicine. As well as identifying associations with non-compliance in cats and dogs, our survey has also provided basic information on certain demographic aspects of clients who medicate their pets. The results provide a valuable dataset for small animal practitioners in New Zealand and provide a platform from which to direct future study to improve compliance in small animals.

With an overall compliance rate of 60% and 53% in cats and dogs, respectively, the results of this study confirm the need for approaches that improve client compliance with veterinary instructions for the medication of their pets. This level of compliance in New Zealand does not compare favourably with other countries where this has been examined.

The results of this study confirm the need for approaches that improve client compliance in pet cats. This survey demonstrated an association between non-compliance and the administration of oral antibiotics in feline patients. Poor compliance with oral antimicrobial medication administration may risk poor clinical outcomes and also may have consequence with regard to antimicrobial stewardship. The inability of pet owners to medicate their cat and/or the presumption of non-compliance on the prescribing veterinarian's part may lead to overuse of available long-acting broad-spectrum antimicrobials. Further investigation into antibiotic prescribing preferences for cats in New Zealand is warranted.

The pet owner's prior experience with pet ownership should be considered when prescribing medication to cats. Our findings underscore the importance of providing standardized instruction and guidance for all feline-owning owning clients. Ensuring that oral medications prescribed for cats are palatable and safe to administer before patient discharge may assist in improving compliance in this species.

Cat owners in this study generally avoided direct administration of oral medication into their cat's mouth, with only one-third of clients attempting this. Medication palatability, using food as a delivery vehicle, and specific technique were all suggested by owners as aids in medicating their cat, while restraint was found to be negatively associated with compliance. Further investigation into improving the palatability and ease of administration of oral medication to cats should be undertaken.

The results of this survey demonstrated that client compliance improves with the age of the dog. Client factors such as prior experience with pet ownership and pet illness did not affect compliance in this study. Our findings underscore the importance of providing standardized instruction and guidance for all dog-owning clients, including the demonstration of medication administration. Veterinarians may wish to empower their teams to re-emphasize instruction and demonstration of medication administration to younger canine patients. Ensuring that oral medications prescribed for dogs are palatable and easy to administer before patient discharge may assist in improving compliance in this species. Given the variable pharmacokinetics of different medications, veterinarians should instruct clients on whether food should be used as an aid in medicating their pets.

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7 Appendix

7.1 Results of univariate analysis for cat variables

Variable Name	Category	Est.[1]	SE[2]	OR[3]	95%CI[4]	*p*[5]
Breed category	Domestic	Ref				
	Purebred	0.23	0.68	1.26	0.33-5.01	0.73
Sex of cat	Female	Ref				
	Male	-0.16	0.56	0.86	0.28-2.57	0.78
Weight of cat	<3.9 kg	Ref				
	>3.9 and <4.8 kg	-0.96	0.71	0.38	0.09-1.49	0.17
	>4.8 kg	-0.57	0.69	0.57	0.14-2.15	0.41
Age of cat	<7.1 years	Ref				
	>7.1 and <11.8 years	0.22	0.67	1.25	0.34-4.73	0.74
	>11.8 years	-0.01	0.70	0.88	0.22-3.48	0.85
Client experience with pet ownership	None	Ref				
	Multiple cats	-0.61	0.77	0.55	0.34-4.73	0.43
	Single cat	-1.85	1.11	0.16	0.39-5.04	0.09
Client experience with pet illness	Health Training	Ref				
	None	0.30	0.95	1.35	0.20-8.86	0.75
	All other	0.30	0.64	1.35	0.39-5.04	0.64
Client gender	Female	Ref				
	Male	-0.84	0.86	0.43	0.06-2.06	0.33
Client age	<30 years	Ref				
	31-50 years	-0.11	0.71	0.90	0.23-3.75	0.88
	>50 years	0.67	0.69	1.95	0.52-7.94	0.33
Client education	High school	Ref				
	Postgraduate	-0.22	0.76	0.80	0.18-3.63	0.77
	University	0.41	0.67	1.50	0.41-5.94	0.55
Medication class	No	Ref				
	Anti-inflammatory	1.37	0.57	3.92	1.33-12.81	0.017
Medication class	No	Ref				
	Antimicrobial	1.76	0.57	5.8	1.97-18.53	0.002
Medication class	No	Ref				
	Other	-1.21	0.64	0.30	0.08-0.98	0.06
Multiple medications	No	Ref				
	Yes	2.33	0.63	10.24	3.17-38.34	<0.001
Highest medication frequency per vet	Once	Ref				
	Multiple	0.03	0.53	1.03	0.36-2.88	0.96
Highest medication frequency as per client	Once	Ref				
	Multiple	0.81	0.52	2.24	0.81-6.38	0.12
Vet spent enough time	Strongly Agree	Ref				
	All Others	-0.580	0.74	0.56	0.11-2.25	0.43
How well did vet explain	Strongly Agree	Ref				
	All Others	0.25	0.63	1.29	0.37-4.43	0.69
Who explained medication instructions	Veterinarian	Ref				
	Nobody	2.7e-16	0.55	1.00	0.35 2.97	1.00
	Student	0.40	0.80	1.50	0.30-7.51	0.61
Pet resisted medication	No	Ref				
	Yes	1.16	0.64	3.18	0.94-11.83	0.07
Medication aid	No	Ref				

	Food	-0.55	0.57	0.57	0.18-1.76	0.33
Medication aid	No	Ref				
	Technique/training	-0.41	0.77	0.67	0.13-2.90	0.60
Medication aid	No	Ref				
	Behavioural modification	-0.38	0.92	0.68	0.09-3.89	0.68
Medication aid	No	Ref				
	Restraint	1.92	1.16	6.82	0.92-139.46	0.10
Medication aid	No	Ref				
	Product	-0.18	0.79	0.83	0.16-3.85	0.82
Medication aid	No	Ref				
	Nothing	0.08	0.82	1.08	0.19-5.50	0.92
Oral medication how given	Combo	Ref				
	Directly	0.14	0.77	1.15	0.26-5.57	0.85
	Food/Treat	-1.02e-15	0.76	1.00	0.23-4.77	1.00
Topical medication	No	Ref				
	Yes	0.80	0.62	2.22	0.67-7.77	0.20
Challenge giving topical	No	Ref				
	Yes	0.18	1.13	1.20	0.13-12.82	0.87

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable

7.2 Results of multivariate analysis for cat variables with confounding check

Variable Name	Category	Est.[1]	SE[2]	OR[3]	95%CI[4]	*p*[5]
Client experience with pet ownership	None	Ref				
	Multiple cats	-1.57	1.08	0.21	0.021-1.52	0.148
	Single cat	-2.74	1.32	0.06	0.003-0.66	0.038
Medication class	No	Ref				
	Antimicrobial	1.84	0.67	6.27	7.77-25.83	0.006
Medication class	No	Ref				
	Other	-1.84	0.91	0..15	0.02-0.82	0.04
Owner Age	<30 years	Ref				
	31-50 years	-0.03	0.92	0.97	0.016-6.09	0.97
	>50 years	1.17	1.01	3.21	0.45-25.62	0.25

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable

7.3 Breeds of dog participating in the survey

Breed	Breed Category	N
Afghan Hound	LG	1
Australian Terrier	SM	2
Belgian Shepherd	LG	1
Bichon Frise	SM	3
Border Collie	MED	4

Bulldog-English	MED	2
Cairn Terrier	SM	1
Collie	MED	4
Corgie	MED	1
Crossbreed	7LG/4MED/3SM	14
Dachshund	SM	1
Dalmatian	LG	1
Doberman Pinscher	LG	1
Fox Terrier	SM	7
Golden Retriever	LG	5
German Shepherd Dog	LG	6
Havanese	SM	1
Huntaway	LG	5
Siberian Husky	MED	2
Italian Greyhound	SM	2
Jack Russell Terrier	SM	1
King Charles Cavalier Spaniel	SM	1
Kelpie	MED	1
Labradoodle	MED	1
Labrador Retriever	LG	10
Lowchen	SM	1
Malamute	LG	2
Maltese	SM	1
Mastiff	LG	5
Miniature Schnauzer	SM	2
New Zealand Heading Dog	MED	1
Pointer-English	MED	1
Pomeranian	SM	3
Poodle (miniature)	SM	3
Poodle (standard)	MED	1

Rhodesian Ridgeback	LG	2
Rottweiler	LG	2
Shetland Sheepdog	SM	1
Shi Tzu	SM	2
Spitz	SM	1
Springer-English	MED	1
Staffordshire Terrier	LG	5
Vizsla	MED	3
West Highland Terrier	SM	1
Wheaten Terrier	MED	1
Total		**117**

7.4 Results of univariate analysis for dog variables

Variable Name	Category	Est.[1]	SE[2]	OR[3]	95%CI[4]	*p*[5]
Breed category	Large	Ref				
	Medium	3.24	0.83	25.60	5.99-181.01	<0.001
	Small	3.16	0.80	23.50	5.90-158.95	<0.001
Sex of dog	Female spayed	Ref				
	Female	3.87	1.14	48.00	7.21-975.66	<0.001
	Male	3.94	1.17	51.20	7.32-1065.4	<0.001
	Male neutered	3.79	1.06	44.44	8.33-827.12	<0.001
Weight of dog (kg)		<0.001	0.02	1.00	0.97-1.03	0.99
Age of dog (years)		-0.10	0.05	0.90	0.82-0.99	0.03
Client experience with pet ownership	Multi pets/species	Ref				
	Multi same species	-0.53	0.54	0.59	0.19-1.66	0.32
	Single same species	0.33	0.46	1.40	0.57-3.54	0.47
Client experience with pet illness	AH[6] trained	Ref				
	Multiple Species	0.46	0.56	1.57	0.54-4.86	0.41
	None	0.64	0.73	1.90	0.46-8.34	0.38
	Same pet	0.36	0.62	1.42	0.43-4.97	0.57
	Same species	-0.23	0.63	0.79	0.22-2.79	0.71
Client experience with administering medication	All routes	Ref				
	Eye/ear	-0.30	0.60	0.74	0.22-2.45	0.62
	None	0.80	1.19	2.23	0.27-46.60	0.50
	Oral	-0.85	0.37	0.43	0.21-0.88	0.02
	Skin	1.09	1.15	2.97	0.41-60.13	0.35
Client gender	Female	Ref				
	Male	14.62	882.74	2.24e+06	<0.001-NA	0.99

Client age categories	31-40	Ref				
	<30	14.48	882.74	1.94e+06	<0.001-NA	0.99
	41-50	14.57	882.74	2.12e+06	<0.001-NA	0.99
	51-60	14.10	882.74	1.33e+06	<0.001-NA	0.99
	>61	14.83	882.74	2.75e+06	<0.001-NA	0.99
Client ethnicity	NZ European	Ref				
	Asian	<0.001	1.59	1.67	0.05-54.45	0.75
	Maori	<0.001	1.55	0.57	0.02-17.21	0.72
	Other European	<0.001	1.50	1.42	0.05-40.43	0.81
Client salary	>$100,000	Ref				
	<$14,000	-0.56	0.07	0.57	0.14-2.07	0.41
	$14,000-$48,000	-0.56	0.07	0.57	0.14-2.07	0.41
	$48,000-$70,000	0.11	0.05	0.90	0.32-2.50	0.84
	$70,000-$100,000	-0.09	0.05	0.92	0.35-2.37	0.86
Client education	University	Ref				
	High school	15.51	1029.12	5.44e+06	<0.001-NA	0.99
	Other	15.85	1029.12	7.68e+06	<0.001-NA	0.99
	Postgraduate	15.57	1029.12	5.76e+06	<0.001-NA	0.99
Who gave the medication to pet	Myself	Ref				
	Others	0.27	1.43	1.31	0.05-33.76	0.85
	Myself plus others	0.48	0.34	1.62	0.83-3.20	0.16
Client understands reason for medication	Extremely well	Ref				
	Moderately well	0.15	0.84	1.16	0.21-6.53	0.86
	Very well	0.26	0.39	1.30	0.61-2.79	0.50
Medication class	No	Ref				
	Anti-inflammatory	0.04	0.35	1.04	0.52-2.07	0.91
Medication class	No	Ref				
	Antimicrobial	0.60	0.39	1.82	0.86-3.93	0.12
Medication class	No	Ref				
	Behavioural	-0.53	0.75	0.59	0.12-2.50	0.48
Medication class	No	Ref				
	Topical	0.27	0.41	1.30	0.59-2.93	0.51
Medication class	No	Ref				
	Other	0.09	0.38	1.09	0.52-2.29	0.81
Multiple medications	No	Ref				
	Yes	0.44	0.35	1.56	0.79-3.10	0.20
Highest med frequency per veterinarian		0.30	0.25	1.36	0.83-2.27	0.22
Highest med frequency per client		-0.15	0.26	0.85	0.51-1.44	0.56
Veterinarian spent enough time explaining	Strongly agree	Ref				
	Neutral	0.62	1.43	1.06	0.04-27.27	0.97
	Somewhat agree	-0.23	0.57	0.80	0.25-2.42	0.69
	Somewhat disagree	0.06	1.43	1.06	0.04-27.28	0.97
How well did vet explain the reason for medication	Strongly agree	Ref				
	Neutral	-15.52	1455.4	1.82e-07	NA-1.2e+122	0.99
	Somewhat agree	-0.31	0.52	0.07	0.03-2.03	0.55
	Somewhat disagree	15.61	15455.4	6.03e+06	9.4e-123-NA	0.99
Who explained medication	Veterinarian	Ref				
	Nobody	-0.60	0.35	0.55	0.27-1.10	0.09
	Student	0.28	0.55	1.33	0.46-4.05	0.61

Who explained: categorized	Veterinary team Nobody	Ref -0.42	0.34	0.66	0.34-1.27	0.22
Challenge giving medication	No Yes	Ref 0.08	0.35	1.08	0.53-2.16	0.83
Pet resisted medication	No Yes	Ref -0.02	0.38	0.98	0.46-2.08	0.96
Medication aid	No Food	Ref 0.35	0.35	1.42	0.72-2.81	0.31
Medication aid	No Technique	Ref 0.83	0.46	2.29	0.95-5.82	0.07
Medication aid	No Behavioural modification	Ref -0.41	0.60	0.67	0.19-2.11	0.50
Medication aid	No Restraint	Ref -0.95	0.70	0.39	0.08-1.41	0.18
Medication aid	No Product	Ref -0.40	0.60	0.66	0.19-2.11	0.50
Medication aid	No “Nothing”	Ref -1.42	0.67	0.24	0.05-0.80	0.03
Oral medication	No Yes	Ref 0.15	0.51	1.16	0.43-3.21	0.77
Oral medication: how was it given	Treat Combo Directly With food	Ref 0.68 -0.25 -0.32	0.66 0.54 0.57	1.97 0.78 0.74	0.55-7.49 0.27-2.26 0.23-2.28	0.30 0.65 0.60
Missed oral dose	No Yes	Ref 0.04	0.38	1.04	0.49-2.20	0.92
Topical medication	No Yes	Ref 0.35	0.36	1.42	0.70-2.90	0.33
Challenge giving topical medication	No Yes	Ref 0.28	0.68	1.32	0.35-5.27	0.69

[1] Coefficient estimate; [2] standard error; [3] odds ratio; [4] 95% confidence interval; [5] p-value for variable [6]animal health trained

7.5 Survey form completed by clients participating in the study

Start of Block: Consent

Q51 Dear Sir/Madam, we are asking for your help and cooperation in conducting a study that will assess the compliance level of pet owners who give their pets medication. Examining the aids and barriers to administering medication to pets may help improve therapeutic outcomes and identify specific problem areas to for veterinarians to focus on in order to assist pet owners’ completion of the veterinarian’s instructions. As your pet has been prescribed medication today, you have been identified as a potential participant in this study. Your participation would involve a

short survey after the expected end of the course of medication you are going home with today. The survey will ask you about your experiences with medicating your pet. This survey is online, and you will be provided with a link for completion (via email or text). You may also complete the survey in person if you wish—this can be done if you are scheduled for a recheck appointment with us. **By signing this form, you agree to participate in the study.** If you have any comments or questions, please do not hesitate to contact Thomas Odom (contact details below). We truly appreciate your willingness to participate in this research. Yours sincerely, Thomas Odom, DVM

○ I consent to participation (1) _____

○ I choose not to participate in this study (2)

End of Block: Consent

Start of Block: Demographic questions

Q1 What is your gender?

○ Male (1)

○ Female (2)

○ Prefer not to answer (3)

Q2 What age group do you fit into?

- ○ 18-20 years old (1)
- ○ 21-30 years old (2)
- ○ 31-40 years old (3)
- ○ 41-50 years old (4)
- ○ 51-60 years old (5)
- ○ 61-70 years old (6)
- ○ 71 years or older (7)

Q3 Which ethnic groups do you belong to? (check all that apply)

- [ ] New Zealand European (1)
- [ ] Other European (2)
- [ ] Maori (3)
- [ ] Cook Island Maori (4)
- [ ] Samoan (5)
- [ ] Tongan (6)
- [ ] Niuean (7)
- [ ] Chinese (8)
- [ ] Indian (9)
- [ ] Other (please specify) (10) _____

Q5 Which statement best describes your total annual income? (Check all that apply)

- [ ] Zero income (1)
- [ ] up to $14,000 (2)
- [ ] $14,001 to $48,000 (3)
- [ ] $48,001 to $70,000 (4)
- [ ] $70,000 and over (5)
- [ ] Received pension (NZ superannuation, or equivalent overseas pension) (6)
- [ ] Received work and income benefit (either job seeker support, sole parent support, or supported living payment) (7)

Q6 What is your highest qualification?

- ○ none (1)
- ○ High School qualification (such as NCEA levels 1-3, school certificate, sixth form certificate, higher leaving certificate, university entrance) (2)
- ○ University qualification (degree, diploma, certificate) (3)
- ○ Postgraduate degree (4)
- ○ Trade certificate (5)
- ○ other (please specify) (6) _____

Q7 What is your prior pet ownership experience?

- ○ This is my first pet (1)
- ○ I have owned one pet before, of the same species (2)
- ○ I have owned multiple pets before, but only of this species (cats ONLY, for example) (3)
- ○ I have owned multiple pets of multiple species before (dogs AND cats, for example) (4)

Q8 What is your prior experience with pet illness? (Check all that apply)

- [ ] I've had to manage illness with this pet before (1)
- [ ] I've had to manage illness with other pets of this species before (2)
- [ ] I've had to manage illness in pets of multiple species before (3)
- [ ] I have training in animal health (please specify) (4) _____
- [ ] I have no prior experience in managing illness in pets (5)

Q9 One of the purposes of this study is to identify any potential barriers to medicating pets, and to help overcome those barriers. Do you have any physical disability or impairment that may hinder your ability to medicate your pet?

- ○ yes (1)
- ○ no (2)
- ○ prefer not to answer (3)

End of Block: Demographic questions

Start of Block: Medication Questions

Q35 Which member of your family/household gave MOST of the medication to your pet?

- Myself (1)
- Myself and/or one other person (2)
- Myself and/or two other persons (3)
- Myself and/or three other persons (4)
- Other (please specify) (5) _____

Q29 How well do you understand the reason(s) why your veterinarian recommended the prescribed medication?

- Extremely well (1)
- Very well (2)
- Moderately well (3)
- Slightly well (4)
- Not well at all (5)

Q38 Can you recall the name of the disease or condition that your pet was diagnosed with?

_____

Q37 Most of the time, how often did you give your pet the prescribed medication?

- ○ Once a day or every 24 hours (1)
- ○ Twice a day or every 12 hours (2)
- ○ Three times a day or every 8 hours (3)
- ○ Other (please specify) (4) _____

Q36 I gave the prescribed medication to my pet for _____ days/weeks:

- ○ how many days (1) _____
- ○ how many weeks (2) _____

Q47 Did you miss any doses of the prescribed medication?

- Missed most doses (1)
- Missed frequent doses (2)
- Missed some doses (3)
- Missed hardly any doses (4)
- Did not miss any doses (5)

Q39 I feel like the veterinarian spent enough time explaining the medication to me.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q40 I feel like the veterinarian explained the reason for the medication well.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q41 Who showed you how to give your pet their medication?

- Veterinarian (1)
- Veterinary Student (2)
- Other Staff member (3)
- Nobody (4)
- other (please specify) (5) _____

Q42 Were there any challenges giving the prescribed medication to your pet?

- yes (1)
- no (2)

Skip To: Q44 If Were there any challenges giving the prescribed medication to your pet? = no

Q43 Listed below are some common reasons why medication administration to pets is challenging. Did any of these apply to you? (Check all that apply):

- ☐ Method of administration was difficult (1)
- ☐ My pet was resistant to my efforts to medicate him/her (2)
- ☐ Label instructions were unclear (3)
- ☐ Treatment duration (4)
- ☐ I did not see a benefit to the medication (5)
- ☐ Complexity of treatment was difficult for me (6)
- ☐ Number of different medications prescribed (7)
- ☐ Medication was physically difficult for me to administer (8)
- ☐ Instructions from veterinary team were unclear (9)
- ☐ Unable to give medication with food (10)
- ☐ Dosage frequency was inconvenient for my lifestyle (11)
- ☐ Other (please specify) (12) _____

Q46 Medicating my pet was a difficult experience for myself and/or my pet.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q44 We are also interested in <u>what went well</u> with medication administration. Were there any tricks or techniques that you employed that made medicating your pet easier?

_____

Q45 If you were prescribed oral medication for your pet, how did you give it most of the time? (Pick one)

- ○ With my pets regular food (1)
- ○ With a snack or a 'treat' (2)
- ○ Directly into my pets mouth (3)
- ○ A combination of these methods (4)
- ○ An oral medication was not prescribed (5)
- ○ Did not end up giving any (6)
- ○ Other (please specify) (7) _____

Q49 Were you prescribed a topical medication?

- ○ Yes (1)
- ○ No (2)

Skip To: Q48 If Were you prescribed a topical medication? = No

Q50 If you were prescribed a topical medication, did you encounter any challenges administering it?

○ Yes (please clarify) (1)
_____

○ No (2)

Q48 **Please make any additional comments that you may have on the questionnaire, this study, or specific questions in the space provided below. Your input is welcomed.**

_____

End of Block: Medication Questions

7.6 Ethics approval

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 04 September 2018

Dear Dr Thomas Odom

Re: Ethics Notification - **4 0 0 0 0 2 0 0 8 1** - **Owner compliance with medications in small animal practice in New Zealand**

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:
"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director - Ethics, telephone 06 3569099 ext 85271, email humanethics@massey.ac.nz."

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

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