Published in final edited form as:
Prev Vet Med. 2010 February 1; 93(2-3): 193. doi:10.1016/j.prevetmed.2009.10.012.

Factors influencing heartworm, flea, and tick preventative use in patients presenting to a veterinary teaching hospital

Maureen C. Gates and
School of Veterinary Medicine, University of Pennsylvania, 3800 Spruce St. Philadelphia, PA 19104

Thomas J. Nolan

Abstract

The introduction of modern heartworm, flea, and tick preventatives has provided a safe and effective means of controlling companion animal endoparasites, but achieving good owner compliance remains an ongoing challenge for the veterinary profession. Based on a sample of patients from the veterinary teaching hospital at the University of Pennsylvania, this study retrospectively examined factors associated with preventative use and areas of potential weakness in client communication. Between 1999 and 2006, records of 5,276 canine and 1,226 feline patients were searched for signalment, survey results for heartworm, flea, and tick preventative use, date of visit, presenting complaint, vaccination history, and owner zip code. Data were analyzed using bivariate and multivariate techniques. Overall, only 13 - 23 % of patients were questioned about heartworm, flea, or tick preventative use during routine medical history taking. Patients with a prior history of parasites, younger patients, or those presenting with signs of cardiac disease were no more likely to be questioned about preventative use than healthy animals. Patients presenting to a specialty service were also less likely to be questioned. Approximately 74 - 79% of dogs and 12 – 38 % of cats in the sample were on preventative products at any given time. There was a distinct seasonality to preventative use corresponding to the heartworm transmission season from June through November in the northeastern United States. Only 50% of patients seen for a yearly physical examination in winter were reported to be using preventative products when surveyed later in the year, compared to the roughly 85% on patients in heartworm preventatives when they received their routine physical exam in spring. Month of presentation and neuter status were the only signalment factors significantly ($P<0.05$) associated with preventative use in the multivariate analysis. Findings from this study emphasize target areas for increasing owner compliance.

Keywords

Endoparasites; Chemoprophylaxis; Epidemiology; Canine; Feline

1. Introduction

The importance of modern heartworm, flea, and tick preventatives to the veterinary practitioner is as much in their ability to control endoparasites as to prevent clinical heartworm disease (Clark et al., 1992; Nolan et al., 1992; Horii et al., 1998; McTier et al., 2000). Given the zoonotic

Corresponding Author: Thomas J. Nolan, Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania, 3800 Spruce St Philadelphia, PA 19104, parasit@vet.upenn.edu Tel: 1-215-898-7895 FAX: 1-215-573-8115.

potential and high prevalence of many commonly identified parasites species, the Companion Animal Parasite council now advocates the use of such broad-spectrum heartworm preventatives as part of comprehensive parasite control programs (Blagburn et al., 1996; DeSantis et al., 2006; Schantz, 1994, 2003). However, achieving high owner compliance with giving the recommended monthly dose of preventative medications remains an ongoing challenge for the veterinary profession. Based on past surveys, between 48% and 59% of owned dogs in the United States receive monthly heartworm prevention, with the average number of doses dispensed only 5.4 per year (Cummings et al., 1995; AAHA, 2003). Nearly 40% of dog-owning clients in another study were unaware that most heartworm medications were also effective against intestinal nematodes (New et al., 1997).

In the busy practice setting, it is easy to overlook the degree of client education and adequate patient follow-up required to improve owner compliance with recommended protocols (Stull et al., 2007). According to the American Veterinary Medical Association household survey, approximately 83% of dogs and 64% of cats have at least 1 veterinary visit during the year (Shepherd, 2008). One possible explanation for poor owner compliance may be the difficulty in convincing clients of the need for preventative medications when parasites are perceived to be scarce in the pet's environment, such as during winter months. Researchers have also speculated that veterinarians are reluctant to discuss parasite control with clients because of a general lack of knowledge on the subject, inadequate time during appointments, and an increasing reliance on broad spectrum anti-parasitic drugs as an alternative to good client education (Harvey et al., 1991; Zajac et al., 2000).

There is clearly a need for the veterinary profession to be more pro-active in communicating the risks of parasitism and benefits of preventive medications to clients. While several epidemiological studies have provided estimates of preventative use, few have explored in detail the veterinary and patient based factors influencing owner compliance with monthly preventatives. In this study, a sample of patients presenting to the veterinary teaching hospital at the University of Pennsylvania was examined for trends in preventative use with the goal of identifying groups of patients that should be targeted to increase compliance. The primary focus was on dogs, but descriptive statistics on preventative use in cats were also estimated.

2. Materials and Methods

2.1 Data Collection

The study sample was 5,276 dogs and 1,226 cats that had a fecal analysis performed on presentation to the veterinary teaching hospital at the University of Pennsylvania (VHUP) from January 1999 through December 2006. These patients were selected based on the high clinical index of suspicion for endoparasites and thus the need to determine all components of the current de-worming protocol including monthly preventative medications. Repeat fecal examinations on the same patient were excluded. Survey questions regarding the use of heartworm, flea, and tick preventatives were introduced on the standardized VHUP patient history forms in 1999. Fourth year veterinary students were responsible for recording prophylactic medication use as part of taking the complete medical history of patients presenting to the hospital. Responses were coded into the medical records computer database by product name and whether it was used seasonally or year round. Given the limitations in this data, we defined poor compliance as patients who were not receiving any form of heartworm prevention during the year. Whether or not the patient was actually surveyed during the appointment was used as an indication that preventative medications were at least mentioned to clients, if not fully discussed.

Based on the assumption that heartworm testing and client education about parasite prevention occur most frequently during the yearly physical examination appointment, we wanted to

determine if season had an impact on the likelihood of the patient reporting preventative medication use at a later date in the year. The date of Rabies vaccination, used to provide an estimate of month in which the animal received its yearly physical examination, was available for 46 canine patients reporting heartworm preventative use and for 45 canine patients reporting flea/tick preventative use. Due to the small sample size, these patients were divided into 4 groups based on a three month time period: Jan-Feb-Mar, Apr-May-Jun, Jul-Aug-Sep, and Oct-Nov-Dec. This division was selected over strict calendar seasons because of the increase in advertising campaigns for preventative products during National Lyme Disease Awareness and Heartworm Awareness Month each year in April.

Information on patient signalment, including age, weight, American Kennel Club (AKC) breed group (Sporting, Hound, Working, Terrier, Toy, Non-Sporting, and Herding), sex, and neuter status, was obtained from the medical records database (American Kennel Club, 2008). The dogs breeds were further categorized as being small (0 -25 lbs), medium (26-50 lbs), or large (> 50 lbs) based on the average reported weight for the AKC breed. Mixed breed dogs were excluded from the size categories because there was no means of assessing what a normal body size would be without knowing the body condition score and without being able to predict the adult body weight of pediatric patients. The admitting service (Emergency, Medicine, Orthopedics, Cardiology, Neurology, Soft Tissue Surgery, Genetics, Dentistry, Dermatology, Ophthalmology, and Oncology) and primary presenting complaint (Healthy Animal, Parasite History, Diarrhea, Vomiting, Neurologic, Cardiac, Respiratory, Renal, Liver, and Other) were recorded when available. Based on the owner zip code, an estimate of median household income was obtained from the US Census Bureau (US Census Bureau, 2008).

2.2 Statistical Analysis

Descriptive statistics were calculated for the proportion of canine and feline patients using preventative products, the most commonly used brands, and duration of use (seasonal versus year round). Data from 1999 through 2006 were grouped together on the assumption that the seasonal nature and trends in preventative use did not change over the 8 year study period. The remaining analyses were generally limited to both canine patients and heartworm preventatives because of the infrequent use of preventative products in cats and the fact that the vast majority of pets receiving heartworm preventatives were also receiving flea and tick preventatives.

A preliminary comparison of age, weight, breed, sex, presenting complaint, and admitting service was made between patients that were surveyed and those that were not surveyed about preventative use. The purpose was to identify underlying patient or student related causes for failing to question so many animals about preventative use during history taking. Student T-tests were used to compare mean age and weight of patients, a χ^2 -test was used to compare the distribution of genders and breeds between groups, and contingency tables with odds ratios were used to determine the association between presenting complaint, admitting service, and the odds of a patient being surveyed about preventative use.

A bivariate analysis of the putative factors associated with heartworm preventative use was performed on the patients for which survey data was available. Odds ratios (ORs) were used as a measure of association between the independent variables and the outcome of interest, in this case the patient using preventatives for at least part of the year. The significance of the bivariate associations was determined using the Pearson χ^2 test or likelihood ratio χ^2 statistic. Exposures with a P value less than 0·20 that were not correlated with any other variable were included in the multivariate logistic regression model. The components of the final multivariate model were determined by an automated stepwise backwards model selection process, with the level of significance for a factor to remain set at 5%. Model performance was evaluated using the Hosmer-Lemeshow goodness-of-fit test and the area under the receiver operating characteristic (ROC) curve.

A Chi-square analysis was used to determine if the proportion of patients using preventative products was significantly different based on the month they received a routine yearly physical exam. Due to concerns over the small number of patients in each group, a calculation of the minimum sample size needed to demonstrate statistical significance based on a power of 0.8 was performed. All data in the study were analyzed by use of statistical software (Stata statistical software, Release 9.2, Stata Corp, College Station, Tex.) with p-values < 0.05 considered statistically significant.

3. Results

There were a total of 1,408 canine patients with available heartworm preventative data and 1,271 canine patients with flea and tick preventative data. Approximately 79.8% of the canine patients presented to VHUP were using heartworm preventatives when the fecal examination was performed. Of those patients, 76.3% reported using the products year round, 15% used the product seasonally, and the use was unknown for the remaining 8%. Heartgard Plus® (ivermectin/pyrantel pamoate) was the most common brand at 54%, followed by Interceptor® (milbemycin oxime) at 16%, Sentinel® (milbemycin oxime/lufenuron) at 5%, Revolution® (selamectin) at 2%, and others totaling 6%. About 95% of the dogs receiving heartworm preventatives were also receiving flea and tick preventatives. Approximately 74% of the canine population was using flea and tick prevention, but only 61% of these used the flea and tick products year round and 35% used them seasonally. Frontline® (fipronil), Advantage® (imidacloprid), and Revolution® (selamectin) were the most common brands used for dogs, representing 66%, 8%, and 1% respectively.

There were a total of 100 feline patients with heartworm preventative data and 138 feline patients with flea and tick preventative data. The use of chemoprophylactic products was less common amongst feline patients. Only 12% of cats were receiving heartworm preventative when the fecal exam was performed. Heartgard for Cats® at 58% and Revolution® at 33% were the most commonly used products. About 95% of the cats receiving heartworm preventative were also receiving flea and tick preventatives. Only 38% of the cat population was on flea and tick preventatives with 47% using the product year round and 34% using the products seasonally. Frontline® accounted for 59% of the feline use, Advantage® for 22%, and Revolution® for 14%.

Figure 1 illustrates the percentage of canine patients using heartworm preventative products by month, as well as the overall percentage that were surveyed regarding this preventative use. The peak month for heartworm preventative use was May with 93% of patients reporting at least seasonal use. The minimum occurred during March with 55% on heartworm preventatives and the difference was statistically significant ($z = 5.81$, $p<0.001$). The percentage of patients surveyed varied from a maximum of 23% in February to a minimum of 16% in June and October. The difference between the minimum and maximum was also statistically significant ($z = -3.99$, $p<0.001$). Based on the results in Table 1, there was a significant difference in gender and breed between patients that were surveyed about preventative use and those that were not surveyed. The monthly percentage of dogs using flea/tick products and the percentage of clients asked about this use was almost identical to those shown in Figure 1 for heartworm prophylactics (data not shown).

Using Emergency Service as the referent state, canine patients were significantly less likely to be surveyed about preventative use if they presented to one of the specialty services (Table 2). There was no significant difference in the odds of being surveyed when Orthopedics, Dentistry, and Medicine were compared to Emergency Service. Patients presenting to the Medical Genetics service had 21% lower odds of being surveyed than patients presenting to Emergency Service. It is worth noting that 95% of the Medical Genetics' patients were between the ages

of 6 and 8 months. Patients displaying any clinical signs on presentation to VHUP had similar odds of being surveyed to healthy animals, with the exception of patients displaying signs of liver disease. The odds of a patient being surveyed about preventative use if they displayed signs of cardiac disease were no different than those for healthy animals (OR=0.85, 95% CI: 0.57 – 1.26).

In the bivariate analysis, age, median household income, and being neutered were factors associated ($P<0.05$) with an increased likelihood of canine patients using heartworm and flea or tick preventatives, as shown in Table 3. It is worth noting that there was no significant difference in age between neutered and intact patients ($t = 1.42$, $p = 0.16$). The final multivariable model was based on 1,021 observations because some records were omitted due to missing information for one or more of the variables. Only neuter status and month of visit were retained based on the criteria of significance. The Hosmer-Lemeshow $\chi 2$ for goodness-of-fit was 17.04 ($P=0.029$) and the area under the ROC curve was 0.69, suggesting issues with model fit. Given concerns with the validity of the model, the results presented in Table 4 must be interpreted with caution.

The percentages of patients using heartworm or flea and tick products based on the time of yearly physical examination were not statistically different in the Chi-square analysis. However, based on Figure 2, it appears that patients seen in April, May, and June (A-M-J) are more likely to use preventative products than patients seen at any other time of year. Approximately 90% of patients seen in A-M-J were on heartworm preventative and 80% were on flea and tick preventatives, compared to the 50% of patients seen in October, November, and December (O-N-D) that were using preventative products. Assuming a 1 sided test with alpha of 0.05 and the desired power of 0.80, a sample of 145 patients would have been needed to establish statistical difference between groups.

4. Discussion

There are several definitions of owner compliance with heartworm prevention in the literature, which include missing one or more doses during the transmission season, starting heartworm preventatives more than two months after the start of the transmission season, and missing a single dose during year round administration (McCall et al., 1995; AAHA, 2003). It is important to distinguish between the use of heartworm preventatives for control of heartworms and their use for control of endoparasites. Even in the harsh climate of Canadian winters, the high prevalence of intestinal nematodes in companion animals has prompted researchers to recommend year round administration of broad spectrum parasiticides, such as those included in monthly heartworm prophylaxis (Blagburn et al., 2008). However, other studies suggest that to adequately control heartworm infections, preventative medications need only be given during transmission seasons, which for the northeastern United States lasts from approximately June through November (Knight and Lok, 1998). For the purpose of this study and based on the limitations of our data, we chose a conservative definition of poor owner compliance: patients not receiving any form of preventative medication during the year.

Owner compliance with heartworm, flea, and tick prevention appeared to follow perceived seasonal trends in heartworm transmission with the highest use reported from May through November. This may in part be explained by the extensive marketing campaigns by the drug companies in early spring and increased awareness during National Lyme Disease Month and Heartworm Awareness Month in April. There is no conclusive evidence that endoparasites follow seasonal trends in the Philadelphia area (Nolan and Smith, 1995). In a more recent and extensive survey of parasite prevalence across the United States, dogs actually appear to be at greater risk during fall and winter months (Mohamed et al., 2009). The efficacy of heartworm preventatives against endoparasites is important to many clients (New et al., 1997). Perhaps

the veterinary profession should refer to them as “parasite preventatives” to better emphasize their broad spectrum of activity. Strictly seasonal use of flea and tick preventatives was more common than seasonal use of heartworm preventatives. We were unable to assess whether reported seasonal use corresponded with the heartworm transmission season. Given the potential selection biases in our sample, we are also unable to comment on the extent to which our findings represent the general population of dogs and cats.

The American Animal Hospital Association conducted a study in 2003 to investigate the difference between veterinarians' perceptions of owner compliance with recommendations and actual practice statistics (AAHA, 2003). On average, veterinarians estimated that 70% of patients were receiving heartworm prevention, whereas the measured compliance based on the number of doses dispensed was only 48%. Possible explanations for the discrepancy include leveraging routine tasks, such as history taking and client education, onto technical staff without adequate follow through on the part of the veterinarian and the lack of appropriate training for reception staff that are directly responsible for ensuring preventative medications are sent home with the client after an appointment. In our study, we found that only about 19% of patients were being questioned about preventative use by the veterinary students, which raises concerns about the quality of client communication on parasite prevention if similar habits are continued in private practice after graduation. The difference in percentages may also reflect changes in the student populations rotating through clinical service or changes in the case load throughout the year that may limit the time that students have to collect patient history.

One of the limitations of analyzing data from a veterinary referral center is the ability to generalize study findings to the broader pet population. If owners are willing to seek advanced and often more expensive care for complicated medical problems, it is likely that they care enough and have the resources to invest in basic prophylactic medications. This hypothesis is supported by the finding that almost 80% of surveyed VHUP patients were receiving heartworm preventatives compared to the estimated 48% - 59% of the general pet population (Cummings et al., 1995; AAHA, 2003). The possibility that owners were inaccurately reporting preventative use must also be considered. The reason for patient presentation can also impact the quality of veterinary-client communication. During routine wellness appointments, veterinarians are more likely to engage in educational discussions and talk to owners about the pet's lifestyle than during problem appointments where 90% of the verbal exchange is directed towards data gathering (Shaw et al., 2008). Patients presenting to one of the specialty services at VHUP were significantly less likely to be questioned about preventative use than the patients presenting to the Emergency Service or Internal Medicine Service.

Regardless of the reason for presentation, it is still important to ascertain whether patients are receiving monthly heartworm, flea, and tick preventatives. Our study sample was based on patients that had a fecal analysis performed at the time of presentation, indicating a degree of clinical suspicion for endoparasitism and yet only 19% of patients were surveyed about prophylactic use. Of even greater concern was the finding that only 19% of patients with a known history of endoparasites were questioned and that the odds of these patients being questioned were not significantly different than those of healthy animals. It is also worth noting that patients presenting with cardiac signs were no more likely to be questioned than healthy animals even though heartworm disease should be included on the differential diagnosis list for many cardiac conditions. Patients that are at risk of environmental exposure, re-infection, or developing drug resistance, should have a thorough history taken, including all forms of parasite prevention (Gates and Nolan, 2009; Palmer et al., 2009). It is equally as important to investigate all aspect of parasite prevention in patients presenting to Oncology for immunosuppressive chemotherapy or in the younger patients presenting to Pediatrics that are expected to have a higher prevalence of intestinal parasites (Nolan and Smith, 1995). Further

research is warranted to confirm whether the trends based on presenting complaint are similar in private practice.

The analyses of factors influencing heartworm preventative use among dogs suggest specific patient cohorts that should be targeted to increase compliance. The significant differences between surveyed and non-surveyed patients with respect to sex and breed could indicate selection bias in this study, but neither of these factors were associated preventative use in subsequent analyses. Care must also be taken in interpreting our study results because of the other potential selection biases in the study sample (using only patients with heartworm survey results in addition to limiting the sample to only those patients with a fecal analysis) and the poor fit of the regression model in the multivariate analysis. Patients under 6 months of age and intact patients were less likely to be on monthly heartworm preventatives than other animals in the sample. This probably reflects the decreased perception of heartworm risk for the younger patients and less preventative care in intact patients. In a prior study of dogs presenting to VHUP, the most significant risk factors for endoparasitism were being less than 2 years old, intact, male, and from an urban locality (Kirkpatrick, 1988). One method of decreasing parasite risk in these cohorts would be to promote the use of heartworm preventatives in integrated parasite control programs. The poor fit of the multivariate regression model suggests that it is difficult to predict which patients are likely to be using preventative products based on signalment alone.

There was preliminary evidence in this study to suggest that local practitioners either do not spend enough time educating, or have more trouble convincing clients of the need for monthly preventatives during fall and winter months. Compared to the 90% of patients that were receiving heartworm preventatives when they presumably received a physical exam in spring, only 50% of animals that were seen for a physical exam in fall or winter received preventatives when questioned at a later time in the year. Overall this result is not surprising. In a previous survey of practicing veterinarians, only a third of respondents discussed the zoonotic potential of roundworms with dog owners and less than half prescribed prophylactic anthelmintics to puppies and dogs (Harvey et al., 1991). There is a clear need to reinforce both to veterinary students and practicing veterinarians the importance of routinely discussing parasite prevention and the role of monthly prophylactic medications with clients. This finding should also be explored in further detail because of the potential implications for how the veterinary profession can better market preventative medications throughout the year.

5. Conclusions

Despite inherent limitations in design, several important findings have emerged from this study. More emphasis on multimodal strategies for controlling parasites may be required in the veterinary school curriculum. The seasonality to preventative use suggests that many clients and veterinarians still perceive the value of these products in terms of heartworm control, rather than their broad-spectrum activity against common endoparasites. Indications that the season in which patients have their yearly physical exam can impact future use of preventative products hints at the challenge in convincing clients of the need for parasite prophylaxis year round. If heartworm preventatives are to be used as part of a comprehensive endoparasite control program, the veterinary profession must be more pro-active in communicating their efficacy and importance to public health, especially during seasons where the perceived risk of heartworm disease may be low.

Acknowledgments

A fellowship to M.C. Gates was supported by NIH grant RR07065 and a grant from Merck-Merial. We wish to thank Colleen Ward, the Medical Records department, and Rich Marcantuno from the parasitology lab for their help with this study.

References

American Animal Hospital Association. Practice tips for improving compliance. Denver (CO): American Animal Hospital Association; 2003. The path to high-quality care.

American Kennel Club. Breeds by group. 2008 [Jul 28 2008]. Available from: http://www.akc.org/breeds/index.cfm#

Blagburn BL, Lindsay DS, Vaughan JL, Rippey NS, Wright JC, Lynn RC, Kelch WJ, Ritchie GC, Hepler DI. Prevalence of canine parasites based on fecal flotation. Compend Contin Educ Pract Vet 1996;18:483–509.

Blagburn BL, Schenker R, Gagne F, Drake J. Prevalence of intestinal parasites in companion animals in Ontario and Quebec, Canada, during the winter months. Vet Ther 2008;9:169–175. [PubMed: 19003777]

Clark J, Daurio C, Plue R, Wallace D, Longhofer S. Efficacy of ivermectin and pyrantel pamoate combined in a chewable formulation against heartworm, hookworm, and ascarid infections in dogs. Am J Vet Res 1992;53:517–520. [PubMed: 1586021]

Cummings, J.; Vickers, L.; Marbaugh, J. Evaluation of veterinary dispensing records to measure “clinic compliance” with recommended heartworm prevention programs. In: Soll, MD.; Knight, DH., editors. Proceedings of the Heartworm Symposium '95. Batavia, Ill: American Heartworm Society; 1995. p. 183-186.

De Santis AC, de Raghavan M, Caldanaro RJ, Glickman NW, Moore GE, Lewis HB, Schantz PM, Glickman LT. Estimated prevalence of nematode parasitism among pet cats in the United States. J Am Vet Med Assoc 2006;228:885–892. [PubMed: 16536699]

Gates MC, Nolan TJ. Endoparasite prevalence and recurrence across different age groups of dogs and cats. Vet Parasitol. 200910.1016/j.vetpar.2009.07.041

Harvey JB, Roberts JM, Schantz PM. Survey of veterinarians' recommendations for treatment and control of intestinal parasites in dogs; public health implications. J Am Vet Med Assoc 1991;199:702–707. [PubMed: 1955360]

Horii Y, Otsuka Y, Tateishi M, Makimura S, Kusano K. Anthelmintic efficacy of milbemycin oxime against *Trichuris vulpis* in dogs. J Vet Med Sci 1998;60:271–272. [PubMed: 9524958]

Kirkpatrick C. Epizooiology of endoparasites infections in pet dogs and cats presented to a veterinary teaching hospital. Vet Parasitol 1988;30:113–124. [PubMed: 3245104]

Knight DH, Lok JB. Seasonality of heartworm infection and implications for chemoprophylaxis. Clin Tech Small Anim Pract 1998;13:77–82. [PubMed: 9753795]

McCall, JW.; McTier, TL.; Supakorndej, N.; Ricketts, R. Clinical prophylactic activity of macrolides on young adult heartworms. In: Soll, MD.; Knight, DH., editors. Proceedings of the Heartworm Symposium '95. American Heartworm Society; Batavia, IL: 1995. p. 187-195.1995

McTier TL, Siedek EM, Clemence RG, Wren JA, Bowman DD, Hellmann K, Holbert MS, Murphy MG, Young DR, Cruthers LR, Smith DG, Shanks DJ, Rowan TG, Jernigan AD. Efficacy of selamectin against experimentally induced and naturally acquired ascarid (*Toxocara canis* and *Toxascaris leonina*) infections in dogs. Vet Parasitol 2000;91:333–45. [PubMed: 10940533]

Mohamed AS, Moore GE, Glickman Larry T. Prevalence of intestinal nematode parasitism among pet dogs in the United States (2003-2006). J Am Vet Med Assoc 2009;234:631–637. [PubMed: 19250042]

New JC, Reinemeyer CR, Burr JR, Kelch WJ. Results of a survey to assess knowledge and expectations of veterinarians and their clients regarding heartworm preventatives and vaccinations in dogs. J Am Vet Med Assoc 1997;211:434–437. [PubMed: 9267503]

Nolan T, Hawdon J, Longhofer S, Daurio C, Schad G. Efficacy of an ivermectin/pyrantel pamoate chewable formulation against the canine hookworms, *Uncinaria stenocephala* and *Ancylostoma caninum*. Vet Parasitol 1992;41:121–125. [PubMed: 1532872]

Nolan TJ, Smith G. Time Series Analysis of the Prevalence of Endoparasitic Infections in Cats and Dogs Presented to a Veterinary Teaching Hospital. Veterinary Parasitol 1995;59:87–96.

Palmer CS, Robertson ID, Traub RJ, Rees R, Andrew Thompson RC. Intestinal parasites of dogs and cats in Australia: the veterinarian's perspective and pet owner awareness. Vet J. 2009 Epub ahead of print.

Schantz PM. Of worms, dogs, and human hosts: continuing challenges for veterinarians in prevention of human disease. J Am Vet Med Assoc 1994;204:1023–1028. [PubMed: 8045801]

Schantz P. Zoonotic ascarids and hookworms: the role for veterinarians in preventing human disease. Compend Contin Educ Pract Vet 2003;24:47–52.

Shaw JR, Adams CL, Bonnett BN, Larson S, Roter DL. Veterinarian-client-patient communication during wellness appointments versus appointments related to a health problem in companion animal practice. J Am Vet Med Assoc 2008;233:1576–1586. [PubMed: 19014290]

Shepherd AJ. Results of the 2007 AVMA survey of US pet-owning households regarding the use of veterinary services and expenditures. J Am Vet Med Assoc 2008;233:727–728. [PubMed: 18764705]

Stull J, Carr A, Chomel B, Berghaus R. Small animal de-worming protocols, client education, and veterinarian perception of zoonotic parasites in western Canada. Can Vet J 2007;48:269–276. [PubMed: 17436903]

United States Census Bureau. Census 2006 from American Factfinder. 2008 [Jul 30, 2008]. Available from: http://factfinder.census.gov

Zajac AM, Sangster NC, Geary TG. Why veterinarians should care more about parasitology. Parasitology Today 2000;16:504–506. [PubMed: 11121842]

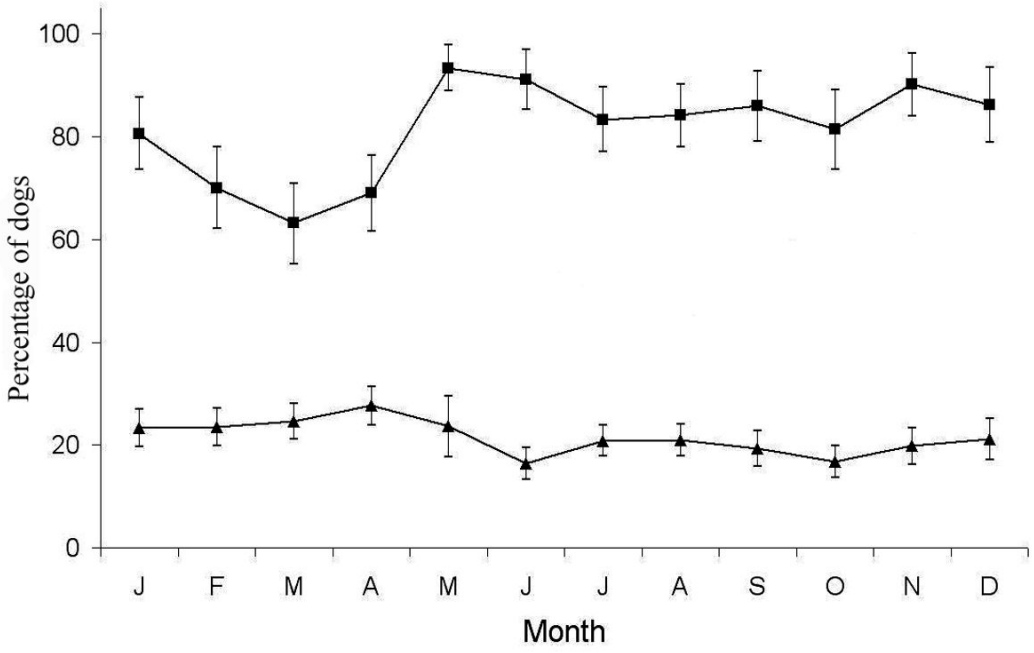

Figure 1.
Percentage of canine patients surveyed about heartworm preventatives (▲) and percentage reporting heartworm preventative use (■) by month in 5,276 dogs presented to a veterinary teaching hospital between 1999 and 2006 (95% confidence intervals are shown).

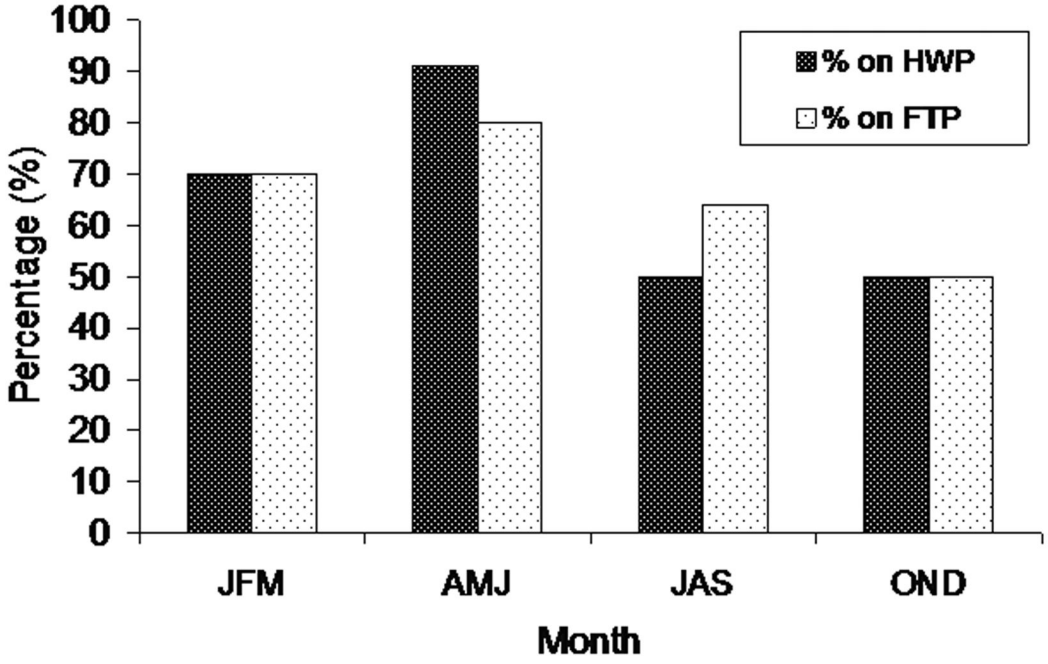

Figure 2.
Percentage of canine patients using heartworm preventatives (HWP) and flea and tick preventatives (FTP) based on estimated month of yearly physical exam in 1,408 dogs surveyed on presentation to a veterinary teaching hospital between 1999 and 2006.

Table 1

Comparison of mean age, mean weight, sex, and breed composition between the surveyed and non-surveyed groups in 5,276 dogs presented to a veterinary teaching hospital between 1999 and 2006.

Variable	Surveyed	Non-Surveyed	Test Statistics	
N	1,520	6,641		
Age (years)	5.502	5.309	t = -1.436	p = 0.152
Weight (lbs)	49.2	47.1	t = 0.257	p = 0.797
Sex (frequency)				
Male	735	2,467	$\chi^2 = 8.18$	p = 0.004
Female	674	2,687		
Breed Composition			$\chi^2 = 25.5$	p = <0.001
Mixed	27.6%	32.8%		
Small	12.3%	12.5%		
Medium	37.6%	36.9%		
Large	22.5%	17.8%		

Table 2

Estimating the odds of a patient being surveyed about preventative use based on the admitting clinical service and presenting complaints in 5,276 dogs presented to a veterinary teaching hospital between 1999 and 2006. Significant (P<0.05) associations are bolded.

Variable	n	% Surveyed	OR	95% CI	P
Admitting Service					
Emergency	3,330	24.1	1.00	-	-
Oncology	76	7.9	0.27	0.12 – 0.62	**0.00**
Medicine	1,774	24.2	1.01	0.88 – 1.15	0.93
Dermatology	125	13.6	0.07	0.02 – 0.22	**0.00**
Ophthalmology	17	11.8	0.49	0.29 – 0.83	**0.01**
Orthopedics	48	6.25	0.42	0.10 – 1.84	0.23
Genetics/Pediatrics	633	15.9	0.21	0.06 – 0.68	**0.01**
Soft Tissue	314	8.60	0.45	0.30 – 0.69	**0.00**
Neurology	70	7.14	0.24	0.10 – 0.60	**0.00**
Dentistry	43	16.3	0.61	0.27 – 1.38	0.23
Cardiology	27	0	-	-	-
Presenting Complaint					
Healthy	470	20.0	1.00	-	-
Prior Parasite History	200	16.0	1.06	0.66 – 1.72	0.80
Diarrhea	2,192	25.3	1.25	0.97 – 1.60	0.08
Vomiting	126	22.2	1.14	0.71 – 1.84	0.58
Vomiting & Diarrhea	114	21.1	1.07	0.64 – 1.76	0.80
Neurologic	442	21.0	1.15	0.56 – 2.35	0.71
Cardiac	245	17.8	0.85	0.57 – 1.26	0.62
Respiratory	211	23.2	1.21	0.81 – 1.79	0.34
Renal	120	20.8	1.05	0.64 – 1.73	0.83
Liver	50	28.0	1.38	1.05 – 1.83	**0.02**
Other	169	14.7	0.69	0.45 – 1.12	0.23

Table 3

Univariate analysis of factors influencing heartworm preventative (HWP) use in 1,408 dogs surveyed on presentation to a veterinary teaching hospital between 1999 and 2006.

Variable	n	% on HWP	OR	95% CI	P
Age					
Under 6 months	137	48.2	1.00	-	-
6 months – 1 year	124	80.6	4.73	2.83 – 7.90	0.00
1 year – 5 years	473	85.6	6.16	4.17 – 9.10	0.00
5 years – 9 years	357	85.9	6.91	4.57 – 10.4	0.00
9 years – 13 years	289	82.4	5.72	3.75 – 8.73	0.00
Over 13 years	64	76.6	2.89	1.63 – 5.12	0.00
Breed Size					
Small	146	80.1	1.00	-	-
Medium	522	83.1	1.13	0.75 – 1.72	0.56
Large	251	76.1	0.78	0.49 – 1.24	0.30
Sex					
Female	674	81.2	1.00	-	-
Male	735	80.0	1.01	0.79 – 1.30	0.92
Neuter Status					
Neutered	1016	84.4	1.00	-	-
Intact	8	25.0	0.08	0.02 – 0.41	0.00
Median Household Income					
$10,000 - $20,000	39	53.8	1.00	-	-
$20,000 - $30,000	110	60.9	1.30	0.64 – 2.65	0.46
$30,000 - $40,000	189	68.3	1.78	0.90 – 3.49	0.09
$40,000 - $50,000	235	78.7	2.94	1.47 – 5.84	0.00
$50,000 - $60,000	180	76.1	2.62	1.30 – 5.29	0.01
$60,000 - $70,000	197	75.1	2.61	1.31 – 5.21	0.01
$70,000 - $80,000	100	75.0	2.46	1.15 – 5.29	0.02
$80,000 - $90,000	55	63.6	1.52	0.67 – 3.42	0.30
$90,000 - $100,000	19	15.7	3.92	0.94 – 16.3	0.04
Over $100,000	43	65.1	1.71	0.72 – 4.04	0.22

Variable	n	% on HWP	OR	95% CI	P
Month of Presentation					
January	124	80.6	1.00	-	-
February	127	70.1	0.59	0.33 – 1.07	0.08
March	144	63.2	0.35	0.20 – 0.63	0.00
April	152	69.1	0.51	0.29 – 0.90	0.02
May	121	93.4	1.89	0.93 – 3.82	0.07
June	91	91.2	1.85	0.85 – 4.03	0.12
July	138	83.3	0.98	0.53 – 1.81	0.95
August	139	84.2	0.95	0.52 – 1.75	0.88
September	100	86.0	1.16	0.58 – 2.32	0.67
October	97	81.4	0.74	0.39 – 1.40	0.34
November	93	90.3	1.74	0.81 – 3.71	0.14
December	87	86.2	1.23	0.60 – 2.51	0.57

Table 4

Multivariate analysis of factors influencing heartworm preventative use in 1,408 dogs surveyed on presentation to a veterinary teaching hospital between 1999 and 2006. Significant observations (P<0.05) are bolded. (LR χ^2 = 69.5, LL -411.9, p < 0.001; Hosmer-Lemeshow $\chi 2$ = 17.04, p = 0.029)

Variable	OR	z	95% CI	P
Neuter Status	0.073	-3.58	0.01 – 0.38	0.000
Month of Presentation				
January	1.000	-	-	-
February	0.664	-1.10	0.32 – 1.37	0.269
March	0.465	-2.20	0.24 – 0.92	**0.028**
April	0.550	-1.68	0.27 – 1.11	0.094
May	2.516	1.91	0.98 – 6.47	0.056
June	5.903	2.30	1.30 – 26.8	**0.021**
July	1.971	1.56	0.84 – 4.61	0.118
August	1.210	0.47	0.55 – 2.68	0.640
September	2.606	1.78	0.91 – 7.49	0.076
October	1.540	0.90	0.60 – 3.94	0.368
November	2.401	1.61	0.83 – 6.97	0.107
December	1.245	0.48	0.51 – 3.04	0.630
Intercept	1.609	5.75	1.06 – 2.16	**0.000**