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Risk factors for endoparasitism in dogs: retrospective case-control study of 6578 veterinary teaching hospital cases

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Summary

OBJECTIVES—The diagnostic utility of routine fecal examinations can be greatly enhanced through an appreciation of risk factors most commonly associated with endoparasitism.

METHODS—From a sample of 6,578 canine patients presenting to a veterinary teaching hospital between 1996 and 2006, this study used univariate and multivariable techniques to examine putative signalment, medical history, and demographic factors predisposing dogs to intestinal parasites.

RESULTS—Age and median household income were the strongest predictors of endoparasitism. The odds of a patient being diagnosed with endoparasites were 0.82 times smaller for every 1 year increase in age (OR=0.82, 95% CI: 0.80 – 0.84) and for every \$10,000 increase in Median Household Income, the odds were 0.86 times lower (OR=0.86, 95% CI: 0.83 – 0.89). The variables gender, neuter status, month of diagnosis, admitting clinical service, and primary diagnosis were not significant predictors. Animals that presented for underlying medical conditions were less likely to have parasites and the presence of diarrhea was associated with 76% lower odds of endoparasitism compared to healthy animals (OR=0.76, 95% CI: 0.64 – 0.90).

CLINICAL SIGNIFICANCE—Clinicians should maintain a high index of suspicion for parasites in younger patients that live in high population density, low income neighborhoods.

Introduction

Although routine fecal evaluations are fundamental to the diagnosis of companion animal endoparasites, the sensitivity of a single fecal exam in time can change with parasite biology, fecal examination method, and technician skill (Foreyt 1989, Broussard 2003). Infected animals may be tested during asymptomatic parasite pre-patent periods when no diagnostic stages are present in the feces. If the animal is only lightly infected with parasites, the density of ova or cysts may be below the detection threshold of the particular examination technique. For example, the passive fecal flotation method used commonly in private practice for its simplicity and speed, is known to be less reliable in the diagnosis of whipworm and *Giardia* infections than the gold standard zinc sulfate centrifugation (Zajac and others 2002, Dryden and others 2006, Dryden and others 2006, Zajac and Conboy 2006). As the failure to control zoonotic parasite infections represents a health risk to

anyone in contact with the animal, it is important for clinicians to appreciate the odds of their patient being infected as a means of ruling out differential diagnoses and providing empirical treatments when there is a high index of clinical suspicion (Barriga 1991, Lindsay and Blagburn 1995). While many studies have calculated the prevalence of endoparasites in canine populations across the United States, few in recent years have attempted to characterize risk factors for the development of endoparasitism (Jordan and others 1993, Blagburn and others 1996, Nolan and Smith 1995). Based on a population of well cared for dogs presented to a veterinary teaching hospital, the purpose of this study was to identify patient signalment, history, and demographic risk factors most commonly associated with the diagnosis of common endoparasites.

Materials and Methods

A retrospective case-control study was performed using medical records and parasitology data from the Matthew J. Ryan Veterinary Hospital at the University of Pennsylvania (VHUP). The computerized medical records were searched for any canine patient that had a fecal examination performed at the time of presentation to VHUP between January 1st 1996 and December 31st 2006. This resulted in 6578 patients after repeat fecal examinations on the same animal were excluded from the sample. A case was defined as any animal testing positive for at least one species of parasite on gross examination and/or upon zinc sulfate centrifugation of the fecal specimen. The controls were defined as animals with no parasites seen upon fecal examination. There were a total of 797 cases and 5781 controls.

When available, information on the patient age, breed, American Kennel Club (AKC) breed classification (AKC 2008), weight, sex, neuter status, month of visit, admitting clinical service, and primary diagnosis were recorded. The primary diagnoses, recorded by the clinician in the electronic medical records, were grouped into 14 categories (healthy animals, parasitized, dermatologic, gastrointestinal, neurological, cardiac, respiratory, endocrinopathy, renal, hepatic, musculoskeletal, neoplasia, trauma, and other). Based on the owner's ZIP code, an estimate of population, median household income, and median per capita income was obtained from the US Census Bureau (US Census Bureau 2008). Age, population, median household income, and median per capita income were analyzed as both continuous and categorical variables. Because weight is highly age dependent, the variable breed size was substituted for weight in the univariate analysis. Using the AKC standards, breeds were divided by average weight into small (0 – 25 lbs), medium (26 – 50 lbs), large (Over 51 lbs), and mixed breed. Age groups were determined by year of age with the exception of patients under 1 year, which were split into 0 – 6 months and 6 months – 1 year. The population and income estimates were divided into groups of 10,000 people or dollars, respectively.

Procedures

A preliminary univariate analysis of the putative risk factors for endoparasitism was performed and the odds ratios (ORs) were used as a measure of association between the independent variables and the outcome of interest. Odds ratios with values <1 were indicative of protective effects, while odds ratios >1 indicated increased risk (Dohoo and others 2003). The significance of the univariate associations was determined by use of the Pearson χ^2 test or likelihood ratio χ^2 statistic. Exposures with a P value < 0.20 that were not correlated with any other variable were included in the multivariable logistic regression model. The variables neuter status, AKC breed group, primary diagnosis, month of diagnosis, and admitting service were not retained. The components of the final multivariable 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 by use of the Hosmer-Lemeshow goodness-of-fit test and inspecting a

histogram of the residuals. All analyses were performed using STATA statistical software, version 9.2.

Results

The mean monthly prevalence of canine endoparasite infections in the patients presenting to the veterinary teaching hospital was 1.77% for *Toxocara canis*, 0.22% for *Toxascaris leonine* 1.43% for *Ancylostoma caninum*, 0.05% for *Uncinaria stenocephala*, 2.33% for *Trichuris vulpis*, 0.29% for tapeworms, 4.82% for *Giardia* spp. and 3.45% for *Cystoisospora* spp. Approximately 87.9% of the fecal exams were negative, 10.3% had 1 parasite, 1.5% had 2 parasites, 0.28% had 3 parasites, and 0.08% had 4 parasites. As the number of parasites increased, the mean age of the patients decreased from 5.63 years (95%CI 5.52 – 5.74) for patients with no parasites to 0.42 years (95%CI: 0.16 – 0.68) for patients with 4 species of parasite.

Patient age was by far the strongest predictor of endoparasitism in the well cared for dog population (See Table 1). The odds of a patient being diagnosed with endoparasites were 0.82 times smaller for every 1 year increase in age (OR=0.82, 95%CI: 0.80 – 0.84). Sporting, Non-Sporting, and Herding breed dogs were significantly less likely to have parasites than mixed breed dogs, but the size of the breed had no real effect. Purebred dogs under the age of 6 months were significantly also less likely to have parasites than mixed breed puppies (OR=0.63, 95%CI: 0.47 – 0.84). The factors neuter status, gender, and month of diagnosis were not found to be risk factors for parasitism in the univariate analysis.

Animals that presented to the Medical Genetics service at the veterinary teaching hospital, predominantly pediatric patients with a mean age of 4 months, had 3.6 times greater odds of being diagnosed with parasites than patients presenting to the Emergency Service (OR=3.6, 95%CI: 2.94 – 4.41). The mean age of dogs seen in the Emergency Service was 5.12 years. Animals presenting to any of the other specialty services had equal or lower odds of being diagnosed with parasites compared to animals seen by the Emergency Service. In general, animals that presented for other underlying medical conditions were less likely to have parasites and animals with diarrhea had 0.76 times lower odds of endoparasitism compared to apparently healthy animals (OR=0.76, 95%CI: 0.64 – 0.90).

From Table 2, it can be seen that patients living in ZIP codes with high population and lower median household incomes are at the greatest risk for endoparasitism. Compared to ZIP codes with populations of less than 10,000, the odds of finding parasites in patients from a ZIP code with between 60,000 and 70,000 were 3.38 times greater (OR=3.38, 95% CI: 1.87–6.12). However, when the population was over 70,000 the odds were not significantly different (OR=1.34, 95% CI: 0.86 – 2.10). For every \$10,000 increase in median household income, the odds of finding parasites were 0.86 times lower (OR=0.86, 95% CI: 0.83 – 0.89). A significant downward trend in odds was noted for median household income ($\chi^2=30.76$, $p<0.000$). There was a significant, but weak, negative correlation ($r=-0.425$, $p=0.000$) between population and median household income. More highly populated ZIP codes were associated with slightly lower incomes.

The final multivariable model was based on 4,649 observations as some animals had to be dropped due to some missing information for one or more of the variables, but the Hosmer-Lemeshow χ^2 for goodness-of-fit was 14.39 ($P=0.072$) and the histogram of the model residuals was clearly non-normal suggesting problems with model fit. When the model was tested against the study sample, it was unable to predict any positive cases of endoparasitism. Given concerns with the validity of the model, although the results included in Table 3 support the univariate findings, they must be interpreted with caution.

Discussion

In a prior study of dogs presenting to the veterinary teaching hospital at the University of Pennsylvania, the most significant risk factors for endoparasitism were being less than 2 years old, intact, male, and from an urban locality (Kirkpatrick 1988). While there is no evidence to suggest that gender or sterilization are associated with parasitism in recent years, younger animals and animals from heavily populated ZIP codes still possess the greatest risk of infection. Compared to dogs under 6 months old, the odds of a dog between the ages of 6 mos – 1 year being parasitized were 0.48 times smaller and the odds for dogs between the age of 1 – 2 years were 0.21 times smaller. These findings are consistent with numerous other studies that have documented parasitism as being primarily a concern of younger patients (Visco and others 1977, Hoskins and others 1982, Nolan and Smith 1995, Pullola and others 2006).

The fact that sterilization is no longer a protective factor may reflect changes to patient population at the veterinary teaching hospital over the past 20 years. Whereas 26.1% of the patients seen prior to 1988 were intact (Kirkpatrick 1988), only 0.5% of dogs in the 1996 – 2006 sample were unneutered. Pets that undergo sterilization at most veterinary clinics are likely to have been examined for parasites or to have been given prophylactic deworming. Age is unlikely to be a confounding factor because the mean ages of intact patients and neutered patients were not significantly different in either study. It is possible that being unneutered in past years meant that the animal was receiving a lower quality of preventative care or maintained in an environment that would predispose it to parasitic infections.

Interesting trends were uncovered in the univariate analysis of demographic factors associated with endoparasitism. Patients from lower income ZIP codes were more likely to be parasitized, likely caused by a higher prevalence of parasites and lesser degree of preventative care received by animals in lower income neighborhoods. Assuming the patients presenting to VHUP were well cared for, they may be receiving a greater degree of environmental exposure. Larger ZIP code populations were associated with an increased risk of parasitism. The odds of patient living in a ZIP code with between 60,000 and 70,000 people having parasites were almost 3.5 times greater than for patients living areas with less than 10,000 people. However, there was no difference in the risk when ZIP codes with greater than 70,000 people were compared to the ZIP codes with less than 10,000 people. While this effect may simply be an artifact of the small number of patients from high population areas, 70,000 people might also represent the critical balance between population density, environmental contamination, and quality of pet care for the average income level. Further investigation is warranted.

Admitting clinical service and primary diagnosis were not useful predictors for the types of patients in the general population at greatest risk from parasitism. Other studies have documented that dogs with gastrointestinal signs have a higher prevalence intestinal parasites, including *Giardia* and *Toxocara* (Batchelor and others 2008), however, animals from VHUP displayed gastrointestinal signs or diarrhea had no greater odds of infection than healthy animals. Furthermore, animals that presented to almost any specialty service rather than emergency were less likely to be diagnosed with parasites. By the time patients present to a tertiary care facility, most referring vets have presumably screened for parasites as an underlying cause of gastrointestinal signs and provided appropriate treatments where necessary. This study also demonstrated that in a referral hospital setting, diarrhea is not a useful predictor of endoparasitisms and thus clinicians seeing these patients should not rule out parasitism based on lack of gastrointestinal signs.

Compared to mixed breed dogs in the sample, purebred dogs had almost uniformly similar or decreased odd of harboring intestinal nematodes. The exception was in the univariate analysis of breed size where mixed breed dogs had slightly decreased odds of being diagnosed with parasites than small breed dogs. Toy breeds and Hound breeds were slightly more predisposed to *Giardia* infections, but all the breed groups were equally infected by *Cystoisospora* spp. The findings are generally consistent with prior surveys that have demonstrated no real association between breed and susceptibility to parasites (Kirkpatrick 1988, Blagburn and others 1996). The small differences that were found in this study may reflect differences in the origin, use, and living environment of the dogs rather than inherent breed susceptibility to parasites.

Based on the univariate analyses, clinicians should maintain a high index of suspicion for parasites in younger patients that live in high population density, low income neighborhoods. While the results from the multivariable analysis support these findings, they must be interpreted with caution. Based on the poor fit and the inability to predict any positive cases from the study sample, the model appears to have limited utility in predicting cases of endoparasitism. This is likely a reflection of the low parasite prevalence in the well cared for pet population, the particular covariate patterns observed in our study sample, and the complex nature of endoparasite infections. The lack of conclusive findings from the multivariable model may itself be significant, highlighting the dangers of using history, clinical signs, and demographics alone to diagnose endoparasite infections. Therefore, risk should always be interpreted in the context of the animal's level of care in the home and family circumstances, which we could not document in this study. Clinicians should still err on the side of caution if the fecal examination results are negative, but the clinical signs are likely attributable to parasites or there is a significant public health risk to leaving the animal untreated. The lack of sensitivity in the multivariable model based on patient risk factors confirms the need for a combination of routine fecal examinations, thorough history taking, and prophylactic de-worming to provide the best prevention and control of canine endoparasites.

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Table 1

Univariate analysis of signalment factors associated with the diagnosis of endoparasitism in patients presented to a veterinary teaching hospital

Variable	Risk Factor	Cases	Controls	OR	95% CI	P-value
Age	< 6 mos	371	727	1.00	NA	NA
	6 mos – 1 year	104	424	0.48	0.37 – 0.62	<0.001
	1 – 3 years	103	988	0.20	0.16 – 0.26	<0.001
	3 – 5 years	48	705	0.13	0.10 – 0.19	<0.001
	5 – 10 years	105	1781	0.12	0.09 – 0.15	<0.001
	10 – 15 years	57	1042	0.11	0.08 – 0.15	<0.001
Gender	> 15 years	5	98	0.10	0.04 – 0.25	<0.001
	Female	358	2786	1.00	NA	NA
Neuter	Male	438	2948	1.14	0.98 – 1.33	0.08
	Neutered	393	4894	1.00	NA	NA
	Intact	2	24	1.53	0.35 – 6.68	0.57
AKC Breed Group	Mixed Breeds	213	1240	1.00	NA	NA
	Sporting	123	1125	0.64	0.50 – 0.81	0.00
	Hound	58	356	0.95	0.70 – 1.30	0.76
	Working	125	731	1.00	0.79 – 1.27	1.00
	Terrier	64	497	0.75	0.56 – 1.02	0.06
Breed Size	Toy	109	813	0.78	0.61 – 1.00	0.05
	Non-sporting	44	471	0.55	0.39 – 0.77	0.00
	Herdling	61	544	0.66	0.49 – 0.89	0.01
	Small	186	1702	1.00	NA	NA
	Medium	109	702	0.87	0.69 – 1.11	0.27
Diarrhea	Large	294	2165	1.10	0.86 – 1.41	0.45
	Mixed Breed	206	1206	0.70	0.55 – 0.91	0.01
	Absent	278	1686	1.00	NA	NA
	Present	335	2674	0.76	0.64 – 0.90	0.00

Univariate analysis of the demographic risk factors associated with the diagnosis of endoparasitism in patients presented to a veterinary teaching hospital

Table 2

Variable	Risk Factor	Cases	Controls	OR	95% CI	P-value
Population	0 – 10,000	122	1097	1.00	NA	NA
	10,000 – 20,000	185	1602	1.15	0.88 – 1.51	0.30
	20,000 – 30,000	152	1111	1.46	1.10 – 1.93	0.01
	30,000 – 40,000	200	1518	1.28	0.98 – 1.68	0.07
	40,000 – 50,000	105	811	1.34	0.98 – 1.82	0.07
	50,000 – 60,000	181	701	2.60	1.94 – 3.48	0.00
Median Household Income	60,000 – 70,000	17	63	3.38	1.87 – 6.12	0.00
	Over 70,000	40	256	1.34	0.86 – 2.10	0.19
	Under \$20,000	139	434	1.00	NA	NA
	\$20,000 – \$30,000	168	891	0.59	0.43 – 0.80	0.00
	\$30,000 – \$40,000	197	1279	0.43	0.32 – 0.58	0.00
	\$40,000 – \$50,000	158	1202	0.41	0.30 – 0.55	0.00
	\$50,000 – \$60,000	89	892	0.30	0.21 – 0.43	0.00
	\$60,000 – \$70,000	119	1132	0.30	0.22 – 0.42	0.00
	\$70,000 – \$80,000	68	659	0.29	0.20 – 0.42	0.00
	\$80,000 – \$90,000	29	322	0.28	0.17 – 0.46	0.00
	\$90,000 – \$100,000	8	111	0.18	0.07 – 0.43	0.00
	Over \$100,000	27	237	0.35	0.22 – 0.58	0.00

Table 3

Multivariate analysis of risk factors associated with endoparasitism.

Variable	OR	z	P-value	95% CI
Age ^a	0.83	-12.54	0.000	0.81 – 0.86
Median Household Income ^b	0.92	-3.40	0.001	0.88 – 0.97
Breed Size ^c	1.10	2.34	0.019	1.02 – 1.20
Population ^b	1.05	1.99	0.046	1.01 – 1.11

^a Age is expressed in units of 1 year.

^b Median Household Income and Population are expressed in units of 10,000 dollars and people, respectively.

^c Breed Size categories move from small to medium to large breed dogs.