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GI Zoonoses in Companion Pets of the Homeless : the Effects of Environment and Behavior on the Prevalence of GI Parasites, and the Role of Veterinarians in Public Health Education

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GI Zoonoses in Companion Pets of the Homeless:

The effects of Environment and behavior on the prevalence of GI parasites, and the role of veterinarians in Public Health Education.

An undergraduate honors thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in University Honors and Biology Honors

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PORTLAND STATE UNIVERSITY 2016

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Portland State
UNIVERSITY

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Abstract

Veterinarians are the front-line in the world of pet-health and zoonoses, which in turn means they also are at the front-line of human health and have an important role of educating clients on behaviors that would both reduce the risk of human and pet contracting a disease. In this study we collected 85 canine stool samples at a charitable veterinary clinic for homeless and low-income individuals in Portland, Oregon. Prevalence of parasites was found to be 27.1%, including 2.4% *Ancylostoma Sp.*, 4.7% *Cryptosporidium sp.*, 7.1% *Isopora sp.*, 9.4% *Taenia sp.*, 2.4% *Giardia sp.*, and 2.4% *Toxocara sp.* In addition to sampling, a questionnaire surveyed owner and animal demographics, risk behaviors, owner risk perception and owner education surrounding zoonoses and deworming protocols. Of the risk factors surveyed, socialization with dogs, living environment (unstable and transitional), and pet gender (male) all were associated with increased parasite prevalence. In contrast, dog park use had a negative correlation with prevalence, suggesting exposure elsewhere despite dog park environmental contamination. Notably, individuals who dewormed their pet on a symptomatic basis had similar prevalence to those who never deworm; deworming as little as annually reduced the risk of pet infection by 75%. Furthermore, over 20% of asymptomatic pets were parasitized, over double the expected (5-10%). Lastly, the majority of the population surveyed (67.2%) had little knowledge of zoonoses or the potential for animal to human transmission. Pet owners indicated they were well informed by veterinarians about deworming frequencies, but not about zoonoses. Veterinarians have a duty to educate clients on the importance of regular screening and deworming regardless of symptoms, particularly in light of the zoonotic potential of many parasites.

Introduction

Approximately 62% of US households have at least one pet, 50% of which have multiple pets. Dogs alone, account for over 77 million pets in US households (1). In the US pets often may be treated as family, in a bond that goes beyond simple ownership. In this capacity pets have been associated with numerous benefits for health and well-being be it through increasing physical and social activity, and/or providing mental support such as stress and anxiety relief. (2, 3). But, from bites to skin allergies, there are many negative health aspects too. Companion pets are sharers of emerging diseases, sentinels for existing zoonotic conditions, and indicators of environmental health (2-4).

Of public health and veterinary importance globally, pet dogs and cats have been associated with more than 60 zoonoses, including bacterial, viral, fungal, and parasitic diseases. Protozoal and Parasitic diseases are particularly insidious, with large numbers of asymptomatic animals able to transmit to others. (5)

Veterinarians play a major role in public health (especially zoonoses) as the front-line of pet health, monitoring, client education, and formulating preventative guidelines (6). Informational brochures in clinic waiting areas could be one possible effective educational preventative measure (3). Considering the often close bonds between pets and their owners, it is imperative that awareness and prevention of zoonoses is made a priority, in order both to protect pet health and prevent human disease. Many of the risks surrounding canine zoonoses could be minimized if animal owners were better informed of the risks and how they may best be avoided (3). Local and updated information is essential to understanding the epidemiology of gastrointestinal parasitic diseases in dogs and to design rational control strategies at local, regional and/or national scales.

One Health

Zoonoses, due to their complexity, require a unique approach to reduce impact. One movement that encompasses this has been coined “One Health”. One Health is the collaborative effort of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals, and our environment. Essentially recognizing that humans are part of a wider ecosystem, in which every organism’s activities intricately affects all others, we are not isolated from the system we exist within. This movement bridges medical fields (physicians, veterinarians, dentist, and nurses) with other scientific-health and environmentally related disciplines. Thus leading to collaborative research and education, improved cross-communication and surveillance, and joint efforts to educate the public sector and political leaders. As such, the umbrella of One Health is complex connecting a wide range of topics including: food safety, antibiotic resistance, human-animal bonds, environmental hazards exposures, and zoonoses, amongst many others (7).

Canine Zoonotic Gastrointestinal Parasites

Giardia

Giardia duodenalis (also known as *G. intestinalis* or *G. lamblia*), cause giardiasis which is a commonly occurring infection in both humans and animals (1). Around, 16,000 cases are reported annually in the United states, in 2012 the CDC reported the first general decline and 5.8 cases per 100,000 people (8). Transmission occurs through ingestion of infective stage cysts via fecal-oral route or ingestion of contaminated food and water. Cysts are immediately infective once shed and infected species might shed 1-10 billion cysts daily, yet swallowing as few as 10 cyst might cause a person to

become ill (9), although most humans clear an infection spontaneously within as few as 41 days. Cysts can remain in the environment between 7 to 84 days depending on the conditions (10). It should be noted that even though *Giardiasis* is zoonotic, infected dogs pose a smaller risk to humans, as not all assemblages that infect dogs can infect humans (10-12). Humans typically are infected by assemblages (A & B), cats (A & F), and dogs (A, B, C, and D) . However, limited studies have examined the assemblages by which dogs are infected and many human assemblages are being found in canine fecal samples. Recent prevalence data by the Oregon Health Authority (OHA) regarding ova and parasite microscopic examination (O&P) confirmed cases vs. enzyme-linked immunosorbent assay (ELISA) confirmed cases have shown that the gold standard in identification of *Giardia* is the ELISA test, as even experienced laboratory technicians easily miss *Giardia* cysts and trophozoites. Furthermore, sodium nitrate is the most commonly used fecal flotation media in clinical practice, as is preferable for most other parasitic ova. Yet sodium nitrate may be overly hypertonic and distort cysts, thereby lowering surveillance accuracy through O&P.

Coccidia

Isospora sp. are small single-celled organisms (20µm), commonly known as coccidia. They belong to a group of protozoans known as the Apicomplexa (13). The zoonotic potential of coccidia is poorly understood, although different species can infect a broad variety of vertebrates such as mice, rats, cattle, cats, humans and dogs, among others. Although, canine species are generally assumed to be limited to dogs and intermediate hosts such as rodents, ruminants and horses. Animals pass mainly unsporulated oocysts into the environment through their feces, and must undergo sporogony to become infective (13). Once in the environment, infective sporozoites are produced exogenously, which can then be ingested by other animals to continue the cycle. Notably, coccidia sporozoites can undergo

a multiple-fission process in the gut epithelial cells to become merozoites, which can invade extraintestinal tissues (14). Coccidia are viable for at least 23 months in the extraintestinal tissues of mice. A single oocyst can produce up to 24 million oocysts in the next life cycle. The life-cycle of *Isospora* sp. is generally self-limiting and can end in a few weeks without reinfection (13).

Coccidia's virulence is influenced by a variety of stressors, and is most prevalent in conditions of poor nutrition, poor sanitation, and overcrowding (15). These factors conspire to make coccidiosis of high concern for the study population.

Roundworm

Toxocara canis and *T. leonina* are roundworms (ascarids) that infect many different species including both feline and canine. *Toxocara* is one of the most important parasites affecting companion animals worldwide (16). Humans are incidental hosts but, when infected, display a variety of severe outcomes, such as visceral larva migrans (VLM) and ocular larva migrans (OLM) among others. Some humans may even be asymptomatic furthering spread. Nonembryonated eggs are passed in feces and require 2-4 weeks (1 week for *T. leonina*) in the environment to progress to the infective third stage larval form. Infective eggs can last prolonged periods under a wide variety of climatic conditions, and are found routinely in parks, beaches, playgrounds, and family gardens (17-20). Up to 200,000 eggs may be excreted by female ascarids per day leading, potentially leading to rapid and widespread environmental contamination. However, this shedding is not constant, leading to difficulty identifying infection during surveillance. Transmission is via ingestion of infective eggs or larvae, usually involving contaminated soil (4). Studies have shown eggs can persist in dog hair, providing another possible source of pet to human transmission. Eggs have even been found in the hair of dogs who are uninfected themselves (21, 22). Strict hygiene is the most important prevention method due to the adherence of the ova to a multitude of surfaces, soil, dust, etc.

Tapeworm

Tapeworms, *Taenia* sp., come in many forms; the most important species linked to human infection are mainly associated with Beef (*T. saginata*) and Pork (*T. solium*) as the main route of transmission is ingestion of undercooked meat. Dogs can occasionally act as intermediate hosts for *T. solium*, but are not a definitive host and thus do not shed eggs or develop patent intestinal infections (23). Although, with morphologically indistinguishable *Taenia* spp. larvae, canine-sourced cysticercosis may be under-reported (24). The main worry regarding canine-associated disease is cystic infection causing unilocular cysts in the CNS, eye, and within the muscle and subcutaneous tissues (24, 25). Most cases are associated with “significant” prior canine exposure, along with poor hygiene (25). Nonetheless, the potential transmission and severity of subsequent disease warrant preventative consideration, and with homeless populations unable to maintain high hygienic standards, their risk is substantially higher than the general populations.

Lungworm

Capillaria aerophila, also sometimes known as *Eucoleus aerophilus*, is a trichurid nematode of the lungs that until recently was a relatively uncommon parasitic infection, but is rapidly coming to be seen as an emerging zoonotic pathogen (26-30). Adult lungworms live within the epithelium of the bronchioles, bronchi and trachea. Female worms lay eggs that are coughed up, swallowed and passed in feces. For ova to become infective they require 30-45 days of environmental incubation, and transmission is via ingestion of ova or infected earthworms (which digest ova that then develop into larval stages)(4). Ingested ova hatch in the small intestine and then migrate to the lungs via the bloodstream, where the infective cycle restarts (4). Human risk of infection from pets is low considering the long incubation period outside the host, but symptoms can be severe and environmental contamination could play a large role in transmission, as with hookworm (see below). Studies thus far have been insufficient to assert whether there is low risk, and recent studies at both the Oregon State

Health Department/Oregon Health Authority (OHA) and Oregon State University are showing an increased prevalence of lungworm in Oregon pet dogs and dog parks (**UNPUBLISHED DEBESS 2016**). As a result, lungworm is becoming an increasing public health concern.

Cryptosporidium

Cryptosporidium sp. are eukaryotic coccidian parasites, well known in those who work with young cattle, lambs, kids, foals, and piglets. However, the clinical relevance of companion animals remains unclear(4). The source of infection is oocysts that are immediately infected and sporulated at excretion, leading to fecal-oral transmission. Oocysts are resistant to most disinfectants, and can survive for several months in cool and moist conditions leading to prolonged environmental exposures. Human symptoms range from diarrhea in healthy hosts, to life-threatening intestinal and extra-intestinal infections in immuno-compromised hosts(4). Taxonomy is a controversial topic given the current capabilities for genotypic characterization, but the general consensus is that the genus contains over 30 named species, yet current phylogenetic schema remain nebulous(31). This confusion and the morphologically indistinguishable oocysts, makes it difficult to assert public health significance and identify at risk populations (32). OHA's current study has found an extremely high prevalence of *Cryptosporidium*, suggesting this parasite is of importance in urban areas such as Portland. *Cryptosporidium hominis* and *C. parvum* are relatively common in immunocompromised groups and in children, the former being a major risk factor of the homeless.

Hookworm

Hookworms, *Ancylostoma* spp. (*A. caninum*, *A. braziliense*, and *Uncinaria stenocephala*) are parasitic nematodes that live in the small intestine of their hosts, and are often subclinical or of mild infectivity in adult dogs. Alongside *Toxocara* sp., *Ancylostoma* spp. have been identified as the most

important parasites affecting dogs worldwide (16). When transferred to humans, they can cause a variety of conditions such as larva migrans, eosinophilic pneumonitis, localized myositis, folliculitis, erythema multiforme, and eosinophilic enteritis(4, 33). Eggs are shed in feces of infective hosts, but need to hatch, larvate, and develop into infective third-stage larvae before becoming a source of infection (approx. 2-9 days), and can persist in soil for a few months in favorable conditions.

Transmission is through contact with larvally contaminated environments, and entry into the definitive host is facilitated through skin penetration or ingestion. The CDC estimate that 576-740 million humans are infected worldwide.

Past studies

There have been numerous studies (Table 1) assessing the prevalence of GI parasites in canine populations; most studies identified one or more of eight different species and genera of parasites; *Giardia* sp., *Ancylostoma* sp., *Taenia* sp., *Capillaria* sp., *Isospora* sp., *Trichuris* sp., and *Toxocara* sp. (34). Not all the studies were applicable to US populations, and many of those carried out in the US are out of date or limited in scope (35-37). For example in lower-income and tropical populations, parasite prevalence can be over 85% (5, 19). Yet Higher-income countries (European, US, etc.) tend to see much lower prevalence at most reaching around 42% (36, 38-40), with recent national US studies by Antech as low as 12.50%(40). One study in Northern Germany only found a 9.4% prevalence (34). The exact population studied, however, is the variable that most contributes to variation in findings of prevalence. For example, in Brazil, two studies conducted 2 years apart exhibited markedly different prevalence due to the use of household pets over strays: 54.33% and 92.60%, respectively (19, 41). Risk behaviors such as dog-park use also affect prevalence, with one study in Colorado seeing only 7% (37), yet a similar study in Canada found 50.2% (42). One particularly interesting study in Buenos Aires compared the difference in the prevalence of *T. canis* in two populations based on socioeconomic and urban status,

and found that prevalence of parasitic infection in dogs was 9% (5/53) in middle income households, vs. 19% (10/52) in low income households (43) .

Homeless Vulnerability:

The general population in the US is fairly well protected by good nutrition, sanitation, and hygiene, but homeless populations are not so fortunate. In Multnomah County (primarily Portland, Oregon), some 3,800 people currently sleep every night on the street, in a shelter, or in temporary housing. A further 12,000 people share housing of others due to loss of housing or economic hardship (referred to as “doubled up”), meaning around 16,000 individuals are experiencing unstable living conditions in Portland (a developed US city) every night and consequently exposed to the negative health outcomes associated with these living conditions. Significantly, of this number, over 370 on the streets are children, 1,064 are substance abusers, 33 have HIV/AIDs, 21 have developmental disabilities, 787 have mental health issues, 198 have chronic health conditions, and only 400 were employed. These are just the numbers in unstable living environments, thus do not include “doubled up”/transitional individuals (44).

Homeless populations, due to a variety of social determinants, have a disproportionate burden when it comes to health-related issues. For example, a seminal study of civil servants in the UK found social class and social standing to be a strong determinants of health and well-being (45). Homeless populations are about as low as one can get on a social class scale: they are stigmatized and made to feel invisible on a daily basis. In addition, homeless populations have lower access to key services—including health-care, hygiene, sanitation, food, etc.—and thus trend towards poor nutritional, health, and mental status. Homeless populations, like refugee and migrant populations, are exposed to unsanitary, crowded, living environments, making communicable diseases such as TB, HIV/AIDs, and STIs, of extreme importance, as these diseases lead to individuals becoming immunocompromised and

thus more susceptible to other, rarer infections such as canine zoonoses. For example, with both *Giardia* and *Cryptosporidium*, the host plays an important role in the disease expression and clinical impact (12). *Giardia* disproportionately affects those with poor nutritional status, particularly the young, leading to failure to thrive and poor cognitive function(46). *Cryptosporidium* infections persist in immunocompromised hosts causing intractable diarrhea and potentially death (32, 46).

Furthermore, there is a disparity in access to veterinary care between lower income populations and the general population. Most dogs and cats in private households are usually well cared for and receive regular anti-parasitic treatments. As such, endoparasite prevalence data from diagnostic laboratories often may be biased due to their reflection of well-cared for animals belonging to higher-income, more stable, populations. The combination of a dearth of low-income veterinary services and ubiquity of low funds in homeless populations means that anti-parasitic treatments are of low priority and in many cases given rarely or not at all. Furthermore, lack of employment and safe housing leads to constant close contact between owner and companion, thus creating the high levels of contact required for transmission of certain diseases. In both unstable and transitional settings, this can mean contact with multiple transient populations (animals and people) who are possible sentinels of disease; repeated contact can thus lead to increased risk of spread. It should also be noted that due to the high levels of interaction in shelter settings means that zoonotic risk from companion pets goes beyond the owner to the multitude of staff and other shelter users with routine exposure to the same environment. Mechanical transmission of zoonotic disease by dogs is often ignored aspect in socio-economically underprivileged parts of Asia, South America, Australia and Africa (3).

Portland Animal Welfare Team

Portland Animal Welfare Team is a charitable organization that serves the needs of pets of people who are homeless or living in dire poverty. PAW Team uses the federal poverty guidelines to

determine the eligibility of clients, taking into account any resources, expenses, and size of household (if applicable). The owners surveyed in this study are all below a specific minimum annual income ranging from around \$12,000 to \$20,000, depending on household size.

Methods

Sample Collection

Unpreserved sample were stored in closed containers at 4°C, and processed within 24 hours. Every fecal sample was examined by combined sedimentation–flotation technique using Fecasol® (Sodium Nitrate Solution) and also via direct fecal smears. Both slides for each sample were examined macroscopically to detect gastrointestinal diseases. All eggs, cysts, and oocysts found were identified using morphological criteria under a light microscope. A dog was classified as positive if at least one of these elements was present in its stool sample. In addition, the IDEXX ELISA Giardia Snap test was used to confirm any cases of *Giardia* and to test a select number of samples to establish a baseline for giardia prevalence. It would have been preferable to use ELISA testing over O&P for *Giardia* surveillance, but cost was limiting in this study (see Discussion for further information). Due to the morphological similarity among the oocysts of many species, multiple species in a genus are considered as a complex. For example, *Isopora* sp. includes *I. belli*, *I. canis*, *I. ohioensis*, *I. burrowsi*, *I. felis*, *I. rivolta* and *I. suis*; in this study all *Isopora* are therefore grouped as *Isopora* sp. complex. Furthermore, due the lack of significant numbers of individual species, and for the sake of statistical analyses, grouping into species groups was both more instructive and productive. There are notably certain species within a genus that are zoonotic, thus the relative risk of zoonotic potential cannot be directly ascertained from these data: only speculated. Oregon State University’s Veterinary Teaching Hospital has agreed for future samples to be analyzed by their lab to identify specific zoonotic species.

Questionnaire

Portland Animal Welfare team runs volunteer clinics for ADA/special need clients weekly and a larger all client clinic once monthly. On arrival at each clinic, clients are taken through a check-in process in which this study was presented to all clients as a free service in exchange for a quick questionnaire. Clients also were offered fecal screening of their pets without questionnaires being filled out in order to make this as optional as possible. The questionnaires used (Figure 1; Figure 2) included multiple sections: screening, owner demographics, dog demographics, risk behaviors, owner education, and owner risk perceptions. Owner demographics included age, gender, zip code, and living conditions (ranging from homeless on the street to own home). Dog demographic variables included breed, gender, age, and spay/neuter status. Risk behaviors included 1. Dog park use (frequency, location and average duration of visit), 2. Walk patterns (frequency, time, and distance), 3. Off-leash behaviors (frequency and environments), 4. Animal Socialization (Frequency and type [Dogs, Cats & Other]), and 5. Veterinary Care (Deworming frequency). Owners also were asked if their dog presented with any of a variety of symptoms within the last 12 months. Multiple veterinarians were consulted with respect to overt symptoms they would associate with parasites in order to collate this list. Lastly, for the education and risk perception section, owners were quizzed on what they believed to be the correct deworming frequency, the likelihood of zoonotic transfer, the information received from their veterinarian regarding these issues, and their perception of risk in a variety of environments. Some of the resultant data were too broad for this study; as a result, certain data points were grouped for efficiency, including: zip-code to general area, age to age-group, Dog Park totals, walk totals, and Living conditions. For zip-code, it was decided to group Portland zip-codes by the 5 Compass regions of Portland Central (N, NE, NW, SE & SW) as defined by street names and over a certain distance from downtown were grouped as suburbs (E, W & S), defined by freeway boundaries and local understanding. Living conditions were

separated into unstable, transitional, and stable according to categories such as homeless, transitional housing, and own home, as well as others.

For the perception of risk and education section, questionnaires were handed out to every dog owner that came to clinics regardless of having an animal to participate in the study or being eligible in terms of deworming frequency. As such, the sample size for the population involved in this section is much larger than that of the sample study.

Baseline Prevalence Calculations

Multiple methods were applied in order to establish a baseline to compare prevalence data of this study against the general population of Oregon & Portland. First, a study conducted of Acute and Communicable Diseases by the Oregon Public Health Department is currently being undertaken assessing the prevalence of parasitism in fecal samples left in Portland city dog parks. The preliminary prevalence data for that study was released to this study as preliminary results (Table 2). Secondly, the same department receives regular zoonotic disease reporting from veterinary clinics across the state as part of its normal surveillance of the general population. Using these data alongside an estimate of the Oregon pet dog population (891,723) using the AVMA pet ownership calculator (47) allows calculation of an estimated prevalence of specific zoonoses.

Lastly, prevalence found in other studies (Table 1) also was used as a comparison to this study, especially the western region of the Antech study due to its regional applicability (40).

Statistical Analysis

SPSS V23 was used to map and perform statistical analyses on the data obtained from the questionnaires and the laboratory findings. Firstly, demographics were established for both the owner and animal populations. These data were then cross-tabulated against a simple positive or negative result to get the relative risk associated with each against that particular demographic group. This

included: owner age, owner sex, owner living conditions, animal age, and animal sex. Once these population baselines were established, further evaluations were performed using similar cross-tabulations against behaviors and diagnoses such as: dog park use, off-leash frequencies, off-leash environments, animal socializations, symptomatic nature of animal, and parasiticide/dewormer use. Lastly, initial frequencies were calculated of diagnoses and locations of diagnoses by zip code area to map frequencies and calculate prevalence in the population. Graphing of all data was undertaken using tables generated by SPSS transferred to Microsoft excel to format.

Results

Overall Prevalence:

The overall prevalence of dogs infected with at least one parasite was 27.1% (Table 3). With adult animals (aged 4-10 years) accounting for 37.6% of the population sample but 43.5% of the diagnosed positive total and with 31.3% of all adult samples were positive (Figure 7). Also, young adults showed a similar pattern with 27.1% of the samples, 39.1% of the total positive samples and 39.1% young adult samples were positive (Figure 7).

Species Found:

The observed species groups were: *Ancylostoma* sp. (2.4%), *Cryptosporidium* sp. (4.7%), *Isopora* sp. (7.1%), *Taenia* sp. (9.4%), *Giardia* sp. (2.4%), and *Toxocara* sp. (2.4%).

Owner Demographics:

Within the human age groups (Figure 6), 40-49 and 20-29 show the highest positive frequency of positives at 53.3% and 40.0% respectively, in comparison to 30-39 (**23.1 %**), 50-59 (22.2%), 60-69 (15.8%), 70-79 (0.0%), **and the study average (27.1%)**. For gender (Figure 9), male pet owners had 37.5% (n=16) positive samples against females at 24.6% (n=69), although we note that the sample size

of either group differed vastly. Living conditions (Figure 12) was particularly significant with both transitional housing (35.7%) and unstable housing (24.0%) showing higher likelihood of pet infection than stable living (21.9%), these may not be statistically significant however. RUN VARIANCE ANALYSIS ON DATA.

Dog Demographics:

Pet gender (Figure 11) showed a slightly increased risk for male v. females and for intact v. spayed or neutered: Male Intact (30.8%), Male Neutered (29.0%), Female Intact (26.7%), and Female Spayed (23.1%). Pet age (Figure 10) suggested both young adults (39.1%) and adults (43.5%) were at a higher likelihood of positive results than seniors (8.7%) and puppies (8.7%).

Behaviors:

Of the behaviors sampled two came back with significant findings in relation to being infected with parasites: Socializing with dogs (Figure 14) and De-worming frequency (Figure 15). Notably, dog park use (Figure 13) was negatively associated with positive samples, with frequent use at 13.2% positive vs. no use at 41.5%. Dog socialization (Figure 14) however showed a significant difference at 29.9% for frequent socialization vs. 16.7% for none. Lastly, deworming frequency data showed that owners that deworm on a symptomatic basis (26.92%) had only a slight decrease in risk in comparison to no deworming (30.43%), whereas those that dewormed at least on an annual basis with some regularity lowered percentage positive to 11.11%, a 60% decrease in risk.

Symptomatic vs. Asymptomatic:

As expected, overt symptoms showed an increase in positive samples for that group, 36.11%. Asymptomatic patients had 21.74% positive samples, which is over double what is expected in an average sample in a disease surveillance system which normal reports 5-10% or less.

Education of Owners:

(Figures 17-20) 116 owners were surveyed for their opinions on zoonoses and veterinarians' conversations with them regarding deworming and zoonotic potential of parasites. For the owners' perception of zoonotic potential, 67.2% had never heard of zoonoses or thought them to be very unlikely. Furthermore, 31.9% of owners strongly disagreed or disagreed that their veterinarian had had a conversation with them about zoonoses and their potential to be transmitted between their pet and themselves, and 20.7% were neutral or unsure. For the conversation about deworming, the spread was more even with 36.2% at Strongly Disagree or Disagree, 21.8% Neutral and 34.5% Strongly Agree or Agree.

Discussion:

Pre-discussion Note:

Whilst some of the findings at this point are significant, it has become apparent in the analysis of the study's data that a larger sample size will be required to further elucidate the significance of many of the findings. This study will likely be continuing beyond this initial summary and once a more appropriate sample size is reached, analyses similar to those above will be carried out on the relevant variables to further assess results. As such, all findings at this time are preliminary and will direct further research on this topic.

Overall Prevalence:

The overall prevalence of parasitism among pets owned by homeless individuals is fairly high when compared to the calculated baseline prevalence (0.63%) and the nationwide Antech study (West = 14.00%, National = 12.50%) (40). This suggests that the homeless population sampled is at higher risk than the general population or the general population of individuals who attend to veterinarians, as

both methods of calculating a baseline are using data reported directly from veterinarians and as such involve owners who have the wherewithal to frequent veterinarians more regularly than the PAW Team clients.

Giardia Prevalence:

The Oregon Public Health Department recently sent out an informational email to licensed veterinarians in Oregon indicating that *Giardia* is on the rise in the state. Also, most importantly, that traditional microscopic techniques (O&P, methods used in this study) are insufficient for *Giardia* surveillance and ELISA snap-tests should be used instead whenever possible, as the sensitivity of the latter is much higher (Figure 5). Unfortunately, one of the limitations of this study was the funds to complete an ELISA snap-test for *Giardia* on every sample. Therefore it was decided to undertake a random sampling of 15 ELISA tests in order to set a baseline prevalence. As expected, two samples were found to be positive for *Giardia* via ELISA with no obvious cysts or trophozoites in the direct or flotation slides. *Giardia* is notably one of the most common human and animal zoonoses, with multiple studies finding it as the predominant gastrointestinal disease (39-42). Thus, considering the aforementioned cost limitations and subsequent sampling techniques used in this study, it is extremely likely that *Giardia* is underreported in this study. Thus, the baseline prevalence established from the small sample range (2/15= 13.33%) is more likely to be accurate (if not much higher) over the study's findings of 2.4% (Table 2).

Species Found:

Species found in this study were as expected, with the exception of whipworm which had a zero prevalence in this study and a range from 0.8% to 38.2 from past studies completed in the USA. Notably, *Taenia* sp., *Isopora* sp. and *Cryptosporidium* sp. were found in higher quantities than past studies, which is in line with the current data in the dog park study from the Oregon Public Health Department.

Ancylostoma sp. was found with a lower prevalence than previous studies but higher than the OPH study. This fits in with other hypotheses derived from the study in that hookworm is most probably not being acquired from dog parks, but instead from frequent use of specific non-dog park spaces that are unmaintained by the city and thus at higher risk of environmental exposure and also frequent socialization with the same few dogs in these areas.

Owner Demographics:

The demographics of this study vs. the official Portland homeless count shows a slight tendency towards an older age range (Figure 6 & Figure 7) and predominantly female ownership (Figure 8) (although this is slightly skewed by the primary owner being listed as female and the female partner being more willing to complete a questionnaire). Whilst there are differences between age groups and gender in the percentage of pet samples returned positive, these results need to be further analyzed for significance (hopefully with a larger sample size). Male owners and those within the age groups of 20-29 and 40-49 appear to display a larger risk of a parasitized pet. Simple cross-frequencies between age groups and other significant risk behavior variables came up with no statistical significance. It therefore would appear that members of these groups could potentially be prone to unstudied risk behaviors as it seems unlikely that owner demographics in themselves are a risk other than the behaviors they allow in their animals.

Dog Demographics:

Pet Age

The findings associated with age of pets do not align with that of previous studies in terms of percentage of puppies with positive results. Previous studies have concluded that puppies and juveniles are more prone to a positive diagnosis due to a mixture of animal behavior at that age and immune susceptibility. Most notably, other studies find a higher prevalence of *Giardia*, as previously noted,

especially in Juveniles. Thus, if Giardia surveillance were more accurate (ELISA testing), juvenile risk could have potentially matched that of other studies. However, this study's findings point to a higher prevalence in the 1-4 and 4-10 pet age ranges, at 39.1% and 43.5% respectively. This suggests that the species found in this study are more prone to be found in adults who may have more prolonged socialization with other dogs due to a better temperament with other animals, versus excitable puppies or more introverted seniors.

Pet gender & S/N status

The slight increase in proportion of positive samples in males vs. females suggests that male dogs' behaviors lead to a higher susceptibility, be it off-leash, socialization or other. Intact animals increased risk may be due to socialization behaviors arising from their differing hormone levels to spayed counterparts. Although, the divide between genders is much more significant than that between intact vs. spay/neutered. However, there remains a need for a larger sample size in order to further elucidate the significance of these findings, and their relation in comparison to other significant factors such as deworming frequency, living condition, and/or dog park use.

Behaviors:

Dog park use

Surprisingly, dog park use had a negative correlation with positive sample likelihood. This finding is in direct conflict with dog socialization likelihood, suggesting that this socialization is occurring outside of dog parks and potentially with the same dogs (maybe within the same household or shelter). Furthermore, with the increased risk perception of dog park transmission, owners who attend dog parks in the general population may be more likely to be more preventative in their veterinary care. Another factor could be herd immunity within populations attending Dog Parks. It should be noted that the OPH Dog Park study has found a higher prevalence of parasites than the general population or this study,

which could be in part to their taking samples not picked up by owners, suggesting poor observation or care by owners. One could potentially extrapolate a proclivity for substandard care in pet owners who do not clean up after their pets. Otherwise, environmental exposure of samples could lead to increased prevalence. Regardless, this finding suggests that dog parks are environmentally exposed and as such, makes the findings of this study more surprising.

One theory as to why this variable has a negative correlation with positive diagnoses is that risk perception of dog parks is high and as such, owners who frequent them may be more anxious to use prevention methods, thereby leading to herd immunity in the general population. In addition, dog parks are generally city or state maintained whereas other areas of socialization that are unauthorized may not be, leading to higher levels of environmental exposure. Lastly, dog parks are used frequently by a variety of users, which, alongside maintenance, could potentially reduce survival of parasites through disturbance of environment.

Socialization with Dogs

As previously noted, the socialization with dogs suggested by this survey is different than simple dog park use. From surveying the homeless clients and knowing their other risk behaviors, it seems likely that this socialization is within household or shelter, or with similar dogs in non-official dog areas that are unmaintained by the city. Both scenarios would lead to increased and repeated environmental exposure to parasites and thus increased prevalence.

Deworming frequency

Perhaps the most statistically significant finding of this study is deworming frequency and the associated relative risk of positive samples. Notably, those who deworm their dog on a symptomatic basis are not statistically different from those who never deworm their dog or don't know*. In fact, clients who dewormed with any regularity at all (even annually) had a quarter the risk of a parasite

infection. This finding suggests that regular screening and deworming protocols are increasingly pertinent for dogs, even as infrequently as annually.

*It should be noted that for every 'don't know' response, medical records were checked to see if their animal had been dewormed with any regularity and were reassigned accordingly.

Symptomatic vs. Asymptomatic:

Having overt symptoms in a dog was more indicative of the likelihood of a positive sample than one being asymptomatic. However, the prevalence amongst asymptomatic patients is 21.74% which is barely under that of the overall population. This is particularly important within a population that have little to no knowledge of zoonotic potential of GI parasites (Figure 17), let alone that their pets could be asymptomatic and have a parasite load. For veterinarians, the need becomes apparent to regularly screen patients regardless of symptoms.

Education

The results of this section show that veterinarians are clearly speaking about deworming to clients, as over a third remember a recent conversation (Figure 19). However, veterinarians talking with their clients is not translating into action, as evidenced by with the deworming frequencies that were found in this study. This lack of urgency to deworm is likely due to a combination of two factors: 1. a lack of understanding of the zoonotic potential of many of the canine GI parasites (Figure 17); and 2. a lack of understanding that patients could be asymptomatic and still have a parasite load. This second point would be an interesting survey question for future sampling, as the majority of conversations undertaken with owners resulted in finding that most owners believed that all parasites presented with visible worms. Furthermore, with only 20.7% of clients acknowledging a conversation with a veterinarian about zoonoses, there is a clear educational gap that veterinarians need to fill to make GI zoonoses and the importance of deworming more apparent to owners.

It is notable that the findings of this study are similar to previous studies conducted of a similar fashion. For example, Katagiri and Oliveira-Sequeira (2007) reported that 70.1% (54/77) of owners questioned were unaware of the possibility of dogs harboring parasites capable of infecting man (41).

Conclusion

Overall, the prevalence of this study was higher than expected compared to the national average taken from the Antech Study. This difference is most probably due to the socio-economic circumstances of the study population, such as lack of access to consistent veterinary or preventative care or overcrowded living environments. A notable number of the parasites found are zoonotic with the only exception being Coccidia. Zoonotic potential is of particular interest in this population due to their unstable and overcrowded shelter environments, repeated contact with many animals, and humans, and lower access to care. Just as One Health acknowledges that humans are not in isolation of their environment, we need to recognize that the homeless/lower income populations are not in isolation of the general population. As such, higher prevalence in these communities puts the rest of the local population at higher risk of parasite loads with overlapping utilization of communal spaces such as dog parks. One of the more notable findings of this study was the percentage of positive patients that were asymptomatic, which means that owners are not correctly identifying the right to deworm their animals. This was further clarified by the findings that owners deworming their pets symptomatically had no lower prevalence/risk than that of those who never dewormed. It was notable that those who deworm annually however have almost a quarter of the risk. All of these findings highlight the need for regularity in GI parasite prevention be it deworming or screening, both need to occur on a regular basis (even annually) to ensure the entire population is at a lower risk. Further studies need to be carried out to further elucidate this regularity and will most probably need to be carried out in a higher income population that has been deworming on varying schedules with regularity (monthly, every three months, every six months, annually etc.). The demographic findings

of this study show that the higher socializing age-groups are more likely to carry a parasite load. Also in the parasite load of dogs socializing with other dogs was significantly higher, but not in those who use dog parks, suggesting this socialization is either repeated with the same dogs or in unmaintained environments with higher exposures. The importance of prevention of zoonotic parasites is not just for the health of this specific community but the wider population and environment. Ultimately, this study has shown that there is a significant prevalence of zoonotic infection in a population that is unable to control or prevent without assistance from groups such as Portland Animal Welfare Team. Furthermore, this population (like the general population) is seemingly unaware of zoonotic potential of parasites or the risk of parasitism in asymptomatic pets. Thus, veterinarians have an educational gap that needs to be filled in order to ensure successful future prevention programs for the safety of local pets, humans and the overall ecosystem that exists in Portland, other urban centers and beyond.

Ethical clearance;

Permission was obtained from the Portland Animal Welfare Team board of directors. Individual consent was obtained from the dog owners prior to sample taking on their dogs and administration of the questionnaires.

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- Heartfelt Veterinary Clinic
- Portland Animal Welfare Team

Conflict of Interests:

Matthew Peter Edwards worked as the clinic coordinator for Portland Animal Welfare team for the duration of this study.

Literature Cited;

Literature Cited

1. Esch KJ, Petersen CA. Transmission and epidemiology of zoonotic protozoal diseases of companion animals. *Clinical microbiology reviews*. 2013;26(1):58-85.
2. Paul M, King L, Carlin EP. Zoonoses of people and their pets: a US perspective on significant pet-associated parasitic diseases. *Trends in parasitology*. 2010;26(4):153.
3. Sterneberg-van der Maaten T, Turner D, Van Tilburg J, Vaarten J. Benefits and Risks for People and Livestock of Keeping Companion Animals: Searching for a Healthy Balance. *Journal of comparative pathology*. 2015.
4. Weese JS, Fulford MB. *Companion animal zoonoses*: Wiley Online Library; 2011.
5. Eguia-Aguilar P, Cruz-Reyes A, Martínez-Maya J. Ecological analysis and description of the intestinal helminths present in dogs in Mexico City. *Veterinary parasitology*. 2005;127(2):139-46.
6. Mani I, Maguire JH. Small animal zoonoses and immunocompromised pet owners. *Topics in companion animal medicine*. 2009;24(4):164-74.
7. King LJ, Anderson LR, Blackmore CG, Blackwell MJ, Lautner EA, Marcus LC, et al. Executive summary of the AVMA One Health Initiative task force report. *Journal of the American Veterinary Medical Association*. 2008;233(2):259-61.
8. CDC. Giardiasis Surveillance — United States, 2011–2012. 2012 2016/03/18/05:42:30 [cited 2016; Available from: <http://www.cdc.gov/mmWR/preview/mmwrhtml/ss6403a2.htm#Tab1> files/109/ss6403a2.html
9. Robertson LJ, Hanevik K, Escobedo AA, Morch K, Langeland N. Giardiasis--why do the symptoms sometimes never stop? *Trends in parasitology*. 2010 Feb;26(2):75-82.
10. Feng Y, Xiao L. Zoonotic Potential and Molecular Epidemiology of Giardia Species and Giardiasis. *Clinical Microbiology Reviews*. 2011;24(1):110-40.
11. Thompson RC, Palmer CS, O'Handley R. The public health and clinical significance of Giardia and Cryptosporidium in domestic animals. *The Veterinary Journal*. 2008 Jul;177(1):18-25.
12. Thompson RCA, Ash A. Molecular epidemiology of Giardia and Cryptosporidium infections. *Infection, Genetics and Evolution*. 2008.
13. Kirkpatrick C, Dubey J. Enteric coccidial infections: Isospora, Sarcocystis, Cryptosporidium, Besnoitia, and Hammondia. *Veterinary Clinics of North America: Small Animal Practice*. 1987;17(6):1405-20.
14. Dubey J, Lindsay DS, Lappin MR. Toxoplasmosis and other intestinal coccidial infections in cats and dogs. *Veterinary Clinics of North America: small animal practice*. 2009;39(6):1009-34.
15. Batte EG. Gastrointestinal parasitism in the dog. *The Veterinary clinics of North America*. 1973;2(1):181-8.
16. Traversa D. Pet roundworms and hookworms: a continuing need for global worming. *Parasites & Vectors*. 2012;5(1):91-110.

17. Mizgajska H. Eggs of *Toxocara* spp. in the environment and their public health implications. *Journal of Helminthology*. 2001;75(02):147-51.
18. Dunsmore J, Thompson R, Bates I. Prevalence and survival of *Toxocara canis* eggs in the urban environment of Perth, Australia. *Veterinary Parasitology*. 1984;16(3):303-11.
19. Mandarino-Pereira A, de Souza FS, Lopes CW, Pereira MJ. Prevalence of parasites in soil and dog feces according to diagnostic tests. *Veterinary Parasitology*. 2010 May 28;170(1-2):176-81.
20. Holland C, O'connor P, Taylor MR, Hughes G, Anthony Girdwood R, Smith H. Families, parks, gardens and toxocariasis. *Scandinavian journal of infectious diseases*. 1991;23(2):225-31.
21. Roddie G, Stafford P, Holland C, Wolfe A. Contamination of dog hair with eggs of *Toxocara canis*. *Veterinary parasitology*. 2008;152(1):85-93.
22. da Cunha Amaral HL, Rassier GL, Pepe MS, Gallina T, Villela MM, de Oliveira Nobre M, et al. Presence of *Toxocara canis* eggs on the hair of dogs: a risk factor for Visceral Larva Migrans. *Veterinary parasitology*. 2010;174(1):115-8.
23. Ito A, Wandra T, Li T, Dekumyoy P, Nkouawa A, Okamoto M, et al. The present situation of human taeniasis and cysticercosis in Asia. *Recent patents on anti-infective drug discovery*. 2014;9(3):173-85.
24. Tappe D, Berkholtz J, Mahlke U, Lobeck H, Nagel T, Haeupler A, et al. Molecular identification of zoonotic tissue-invasive tapeworm larvae other than *Taenia solium* in suspected human cysticercosis cases. *Journal of clinical microbiology*. 2016;54(1):172-4.
25. Ing MB, Schantz PM, Turner JA. Human coenurosis in North America: case reports and review. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*. 1998 Sep;27(3):519-23.
26. Atkinson M. Lungworm in dogs. *Veterinary Record*. 2015;176(19):500-.
27. Alho AM, Mouro S, Pissarra H, Murta A, Lemos M, Gomes L, et al. First report of *Eucoleus boehmi* infection in a dog from Portugal. *Parasitology research*. 2016:1-5.
28. Traversa D, Di Cesare A, Milillo P, Iorio R, Otranto D. Infection by *Eucoleus aerophilus* in dogs and cats: is another extra-intestinal parasitic nematode of pets emerging in Italy? *Research in veterinary science*. 2009;87(2):270-2.
29. Lalosevic D, Lalosevic V, Klem I, Stanojevic-Jovanovic D, Pozio E. Pulmonary capillariasis miming bronchial carcinoma. *The American journal of tropical medicine and hygiene*. 2008 Jan;78(1):14-6.
30. Traversa D, Di Cesare A, Conboy G. Canine and feline cardiopulmonary parasitic nematodes in Europe: emerging and underestimated. *Parasites & Vectors*. 2010;3(1):62.
31. Tibayrenc M, Ayala FJ. *Cryptosporidium*, *Giardia*, *Cryptococcus*, *Pneumocystis* genetic variability: cryptic biological species or clonal near-clades? *PLoS Pathog*. 2014;10(4):e1003908.
32. Checkley W, White AC, Jaganath D, Arrowood MJ, Chalmers RM, Chen X-M, et al. A review of the global burden, novel diagnostics, therapeutics, and vaccine targets for *cryptosporidium*. *The Lancet Infectious Diseases*. 2015;15(1):85-94.
33. McCarthy J, Moore TA. Emerging helminth zoonoses. *International Journal of Parasitology*. 2000 Nov;30(12-13):1351-60.
34. Becker A-C, Rohen M, Epe C, Schnieder T. Prevalence of endoparasites in stray and fostered dogs and cats in Northern Germany. *Parasitology research*. 2012;111(2):849-57.
35. Otto G, Hazell SH, Fox JG, Howlett CR, Murphy JC, O'Rourke JL, et al. Animal and public health implications of gastric colonization of cats by *Helicobacter*-like organisms. *Journal of Clinical Microbiology*. 1994 Apr;32(4):1043-9.
36. Hackett T, Lappin MR. Prevalence of Enteric Pathogens in Dogs of North-Central Colorado. *Journal of the American Animal Hospital Association*. 2003;39(1):52-6.

37. Wang A, Ruch-Gallie R, Scorza V, Lin P, Lappin MR. Prevalence of Giardia and Cryptosporidium species in dog park attending dogs compared to non-dog park attending dogs in one region of Colorado. *Veterinary Parasitology*. 2012 Mar 23;184(2-4):335-40.
38. Villeneuve A, Polley L, Jenkins E, Schurer J, Gilleard J, Kutz S, et al. Parasite prevalence in fecal samples from shelter dogs and cats across the Canadian provinces. *Parasites & vectors*. 2015;8(1):281.
39. Claerebout E, Casaert S, Dalemans AC, De Wilde N, Levecke B, Vercruyse J, et al. Giardia and other intestinal parasites in different dog populations in Northern Belgium. *Veterinary Parasitology*. 2009 Apr 6;161(1-2):41-6.
40. Little SE, Johnson EM, Lewis D, Jaklitsch RP, Payton ME, Blagburn BL, et al. Prevalence of intestinal parasites in pet dogs in the United States. *Veterinary Parasitology*. 2009 Dec 3;166(1-2):144-52.
41. Katagiri S, Oliveira-Sequeira TC. Prevalence of dog intestinal parasites and risk perception of zoonotic infection by dog owners in Sao Paulo State, Brazil. *Zoonoses Public Health*. 2008 Oct;55(8-10):406-13.
42. Smith AF, Semeniuk C, Kutz SJ, Massolo A. Dog-walking behaviours affect gastrointestinal parasitism in park-attending dogs. *Parasites & Vectors*. 2014;7(1):1-10.
43. Rubel D, Zunino G, Santillán G, Wisnivesky C. Epidemiology of Toxocara canis in the dog population from two areas of different socioeconomic status, Greater Buenos Aires, Argentina. *Veterinary parasitology*. 2003;115(3):275-86.
44. Smock K. 2015 Point-in-time: Count of Homelessness in Portland/Gresham/Multnomah County, Oregon; 2015 June.
45. Marmot M. Social differentials in mortality: the Whitehall studies. 1995.
46. MICROBIOLOGICALRISKAS S. Multicriteria-based ranking for risk management of food-borne parasites. 2014.
47. AVMA. Pet Ownership Calculator. 2016 [cited 2015 5/22/2015]; Available from:
48. Fontanarrosa MF, Vezzani D, Basabe J, Eiras DF. An epidemiological study of gastrointestinal parasites of dogs from Southern Greater Buenos Aires (Argentina): age, gender, breed, mixed infections, and seasonal and spatial patterns. *Veterinary Parasitology*. 2006 Mar 31;136(3-4):283-95.
49. Martínez-Moreno F, Hernández S, López-Cobos E, Becerra C, Acosta I, Martínez-Moreno A. Estimation of canine intestinal parasites in Cordoba (Spain) and their risk to public health. *Veterinary Parasitology*. 2007;143(1):7-13.
50. Lillis WG. Helminth survey of dogs and cats in New Jersey. *The Journal of parasitology*. 1967;1082-4.
51. Jaskoski BJ. Intestinal parasites of well cared for dogs. *American Journal of Tropical Medicine and Hygiene*. 1971;20(3):441-4.
52. Lightner L, Christensen B, Beran G. Epidemiologic findings on canine and feline intestinal nematode infections from records of the Iowa state University Veterinary Clinic. *Journal of the American Veterinary Medical Association*. 1978;172(5):564-7.
53. Hoskins JD, Malone JB, Smith PH. Prevalence of parasitism diagnosed by fecal examination in Louisiana dogs. *Am J Vet Res*. 1982 1982/06//;43(6):1106-9.
54. Kirkpatrick CE. Epizootiology of endoparasitic infections in pet dogs and cats presented to a veterinary teaching hospital. *Veterinary parasitology*. 1988;30(2):113-24.
55. Jordan H, Mullins S, Stebbins M. Endoparasitism in dogs: 21,583 cases (1981-1990). *Journal of the American Veterinary Medical Association*. 1993;203(4):547-9.
56. Nolan TJ, Smith G. Time series analysis of the prevalence of endoparasitic infections in cats and dogs presented to a veterinary teaching hospital. *Veterinary Parasitology*. 1995;59(2):87-96.

57. Blagburn BL, Lindsay DS, Vaughan JL, Rippey NS, Wright JC, Lynn RC, et al. Prevalence of canine parasites based on fecal flotation. *The Compendium on Continuing Education for the Practicing Veterinarian (USA)*. 1996.

Figures;



GI Disease Risk Factor Questionnaire:

Thank-you for agreeing to participate in this study. Essentially in return for you filling out this questionnaire, we will perform a free fecal examination for your dog and let you know ASAP if anything is found. This data will allow us to look at the risk of GI (gastro-intestinal) diseases in lower income population's Dogs. This study will allow us to further justify and fund the work we do. Your participation is essential in helping us expand the number of people we can serve.

Screening: Are you over the age of 18? **YES NO** Is this your dog? **YES NO**

Personal info: Please note this is only so we can contact you with results, all personal data will be anonymized in the study. Although, Zip and Living conditions are very important to associate risk of specific areas and to maximize the importance of this study so please provide at least this.

Name: _____ Age: _____

Zip: _____ Email: _____ Phone: _____

Your Dog: Dog Age: _____ Breed: _____ (Circle) Intact Neutered Spayed

Current Living Conditions: (circle all that apply).

Homeless live on street	Homeless Shelter	Own Home,
Established Homeless Camp	Transitional Housing	Rent
Homeless - live in car	Government funded housing	OTHER: _____

Risk Factors:

- How often do you take your dog to a dog park (average per week)? _____
 - Average length of visit (minutes)? _____
 - Do you have a favorite location(s)? _____
- How often do you take your dog on a walk (average per week)?
 - Average length of walk (Distance and time)? _____
- How frequently do you let your dog off-leash (average per week)? _____
 - In what kind of environments? (Circle all that apply)

Trails	City Parks	Rural areas
Dog Park	Suburbs	Backyard
OTHER: _____		
- How often do you clean up after your dog when away from your living space?

Always	Most Times	Occasionally	Never
--------	------------	--------------	-------
- How many different dogs does your dog socialize with per week? _____
- How often does your dog socialize with other animals?
 - List species (e.g. Cat) & number?

Figure 1: Survey Questionnaire Page 1



Veterinary Care:

- Has your dog visited the vet within the last year, other than this visit? _____
- In the last 12 months, has your dog been dewormed? **YES NO DON'T KNOW**
 - Including heartworm medication? **YES NO DON'T KNOW**
 - How frequently do you deworm your dog?
 - Monthly, Yearly, Symptomatic, Never, OTHER: _____
 - How often do you think you should deworm your dog?

- Has your dog experienced any of the following symptoms in the last 12 months? (Circle all that apply).

Diarrhea	Gas	Constipation
Loose stool	Vomiting	Blood or Mucus in stool
Changes in stool consistency or frequency	Loss of appetite	Visible worms in stool
	Weight loss	Swollen or painful abdomen

Please provide any details here:

Education surrounding Parasites, other GI diseases and Zoonotic Infections:

- How likely do you think it is your dog will transmit a parasite to you or a family member
 - Highly likely, likely, Occasionally, Not very likely, Will never happen
- My veterinarian talks to me about de-worming my dog
 - Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
- My veterinarian talks to me about parasites that can be transferred from animals to people
 - Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
- It is likely my dog will get a GI disease from (Circle most appropriate)
 - **Going to the Dog Park:** Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
 - **Socializing with friends dogs:** Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
 - **Walking off-leash:** Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
 - **Walking on-leash:** Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
 - **Where I live:** Strongly agree, Agree, Neutral, Disagree, Strongly Disagree
- Would you change your behavior if you could reduce the risk to your dog? **YES NO**

I agree for my Dog to participate in the GI disease prevalence risk study and authorize the information above to be used in said study. I recognize that all data will be anonymized in order to protect my privacy and acknowledge that I will only be called with the test results in the case of abnormal findings.

SIGNATURE: _____ **DATE:** _____

Figure 2: Survey Questionnaire Page 2

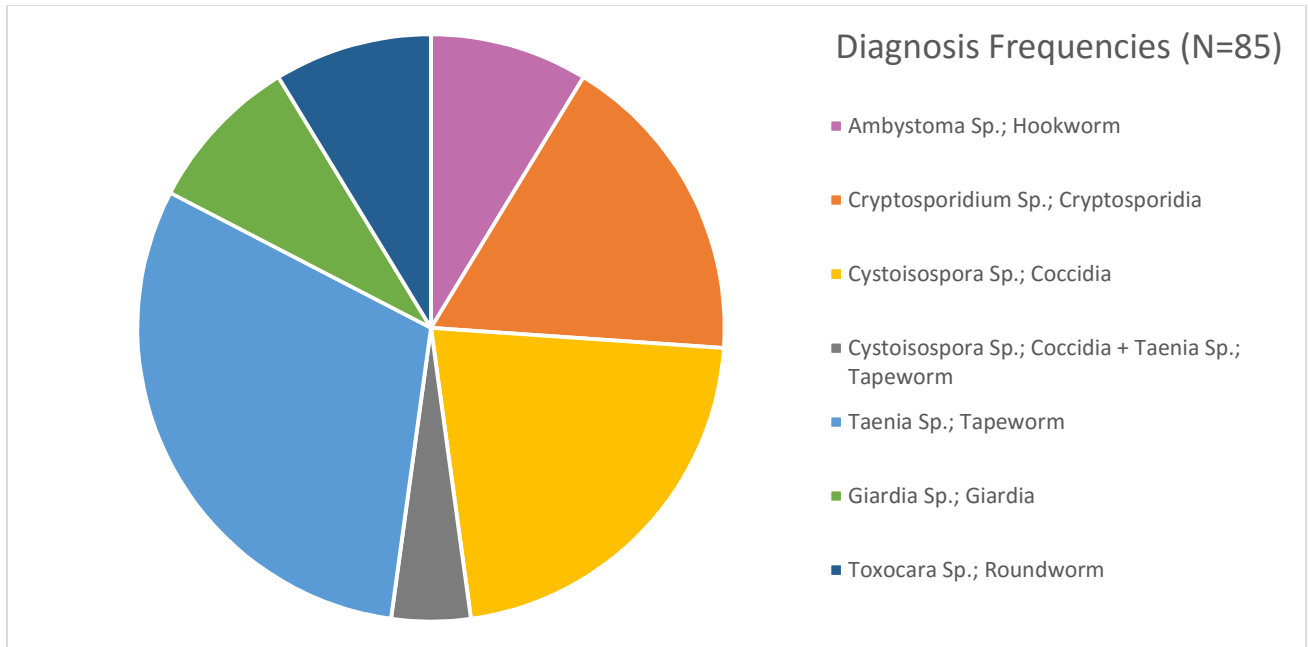


Figure 3: Positive diagnosis proportions in relation to each other.

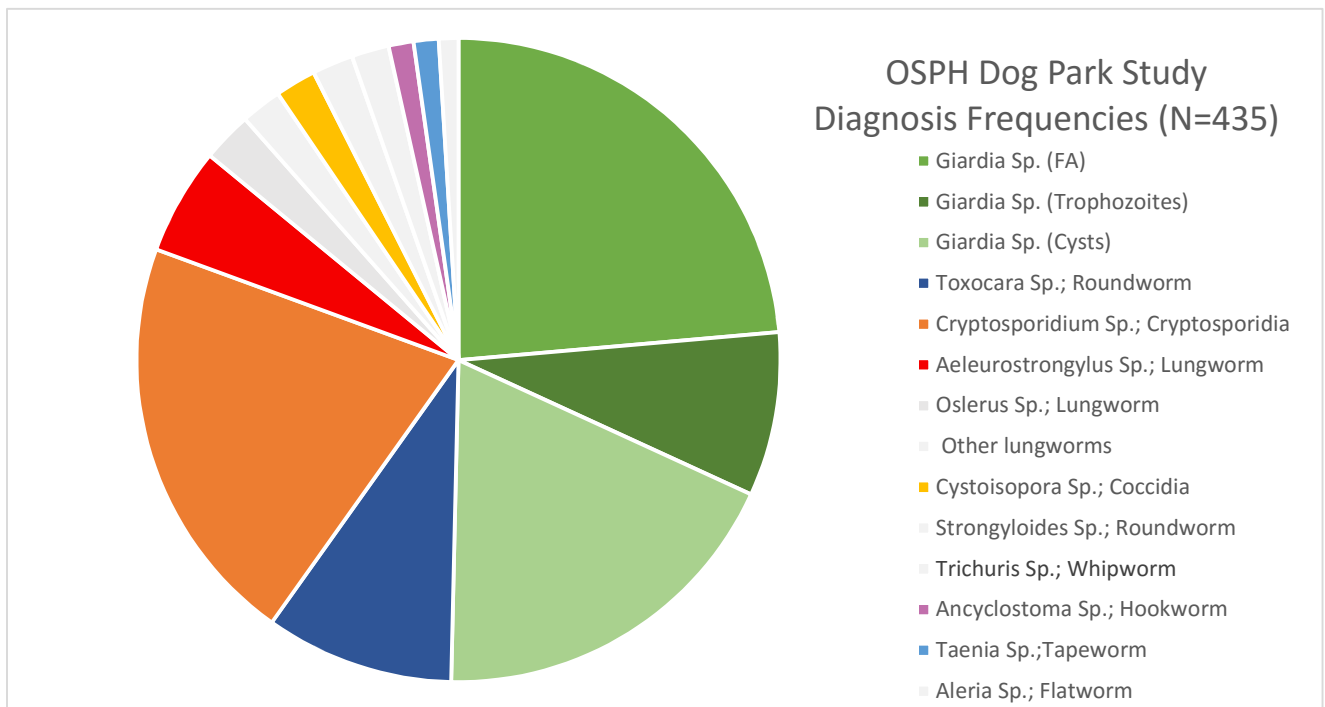


Figure 4: Oregon State Public Health Acute and Communicable Disease Program Dog Park Parasite Study Percentage of Samples Positive Diagnosis Frequencies (N=435)

Table 1: Prevalence data from past studies related to current study

Year	Author	Where?	Sample Size	Overall Prevalence	Giardia Sp.	Ancylostoma Sp.	Taenia Sp.	Cryptosporidium sp.	Isopora Sp.	Toxocara Sp.	Trichuris Sp.
2010	Mandarino et al	Brazil	81	92.60%	0.00%	80.30%	0.00%	3.70%	7.40%	4.90%	6.20%
2006	Fontanarrosa et Al	Argentina	2193	52.40%	9.00%	13.00%	0.00%	22.80%	15.40%	21.00%	2.40%
2007	Martinez-Moreno et al	Spain	1800	71.33%	1.00%	0.00%	11.86%	0.00%	32.22%	22.66%	1.66%
2009	Claerebout et al	Belgium	1159	20.40%	9.40%	0.70%	0.20%	0.00%	2.00%	4.60%	0.17%
2008	Katagiri et al	Brazil 2	154	54.33%	16.90%	37.80%	0.00%	3.10%	3.50%	8.70%	7.10%
2004	Eguía-Aguilar et al	Mexico City	122	85.00%	NR	NR	NR	NR	NR	NR	NR
2009	Little et al	USA - West (Antech)	309,948	14.00%	6.30%	1.40%	NR	NR	5.20%	2.80%	0.50%
2009	Little et al	USA - National (Antech)	1,199,293	12.50%	4.00%	2.50%	NR	NR	4.40%	2.20%	1.20%
2003	Hackett and Lappin	USA - Colorado	130	26.10%	5.40%	0.80%	0.00%	3.80%	2.30%	3.10%	0.80%
2015	Villeneuve et al	Canada - Shelters	1086	33.90%	3.50%	2.90%	1.60%	3.00%	10.40%	14.60%	4.40%
2014	Smith et al	Canada - Calgary	355	50.20%	24.70%	NR	NR	14.70%	16.80%	NR	NR
1967	Lillis	USA - New Jersey	2,737	44.65%	NR	32.90%	NR	NR	NR	12.20%	38.20%
1971	Jaskoski	USA - Chicago	601	13.70%	NR	4.80%	NR	NR	3.80%	4.30%	2.30%
1978	Lightner et al	USA - Iowa	33,594	8.50%	NR	4.10%	NR	NR	2.60%	2.00%	0.80%
1982	Hoskins et al	USA - LSU	4,058	35.90%	0.80%	38.50%	NR	NR	2.70%	8.50%	14.90%
1988	Kirkpatrick	USA - U Penn	2,294	34.80%	7.20%	14.40%	NR	NR	<5%	5.50%	12.30%
1993	Jordan et al	USA - Oklahoma	12,515	36 to 55%	2 to 4%	15 to 39%	NR	NR	3.10%	5 to 8%	9 to 12%
1995	Nolan and Smith	USA - U Penn	8,077	NR	4.70%	9.70%	NR	NR	4.80%	5.70%	9.70%
1996	Blagburn et al	USA - Nationwide (Shelters)	6,458	NR	0.60%	20.20%	NR	NR	2.30%	15.20%	20.20%

(5, 19, 36, 38-42, 48-57)

Table 2: Diagnosis frequencies of this study against the Oregon Public Health Department’s dog park study and veterinary reporting in Oregon, 2015.

	OPH	STUDY	Veterinary Zoonotic Disease Reporting, Oregon 2015
<i>Ancylostoma Sp.;</i> <i>Hookworm</i>	1.40%	2.40%	0.01%
<i>Cryptosporidium Sp.;</i> <i>Cryptosporidia</i>	23.20%	4.70%	0.01%
<i>Isopora Sp.;</i> <i>Coccidia</i>	2.30%	7.10%	0.07%
<i>Taenia Sp.;</i> <i>Tapeworm</i>	1.40%	9.40%	0.00%
<i>Giardia Sp. (FA)</i>	26.40%	2.4% or 13%*	0.44%
<i>Toxocara Sp.;</i> <i>Roundworm</i>	10.60%	2.40%	0.05%
<i>Lungworms</i>	11%	0%**	

<i>Strongyloides Sp.;</i> <i>Roundworm</i>	2.30%	0.00%	0.02%
<i>Trichuris Sp.;</i> <i>Whipworm</i>	2.10%	0.00%	0.01%
<i>Alaria Sp.;</i> <i>Flatworm</i>	1.10%	0.00%	0.00%

Table 3: Positive vs. Negative frequencies of total samples (n=85)

Diagnosis; Positive or Negative?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Negative	62	72.9	72.9	72.9
	Positive	23	27.1	27.1	100.0
Total		85	100.0	100.0	

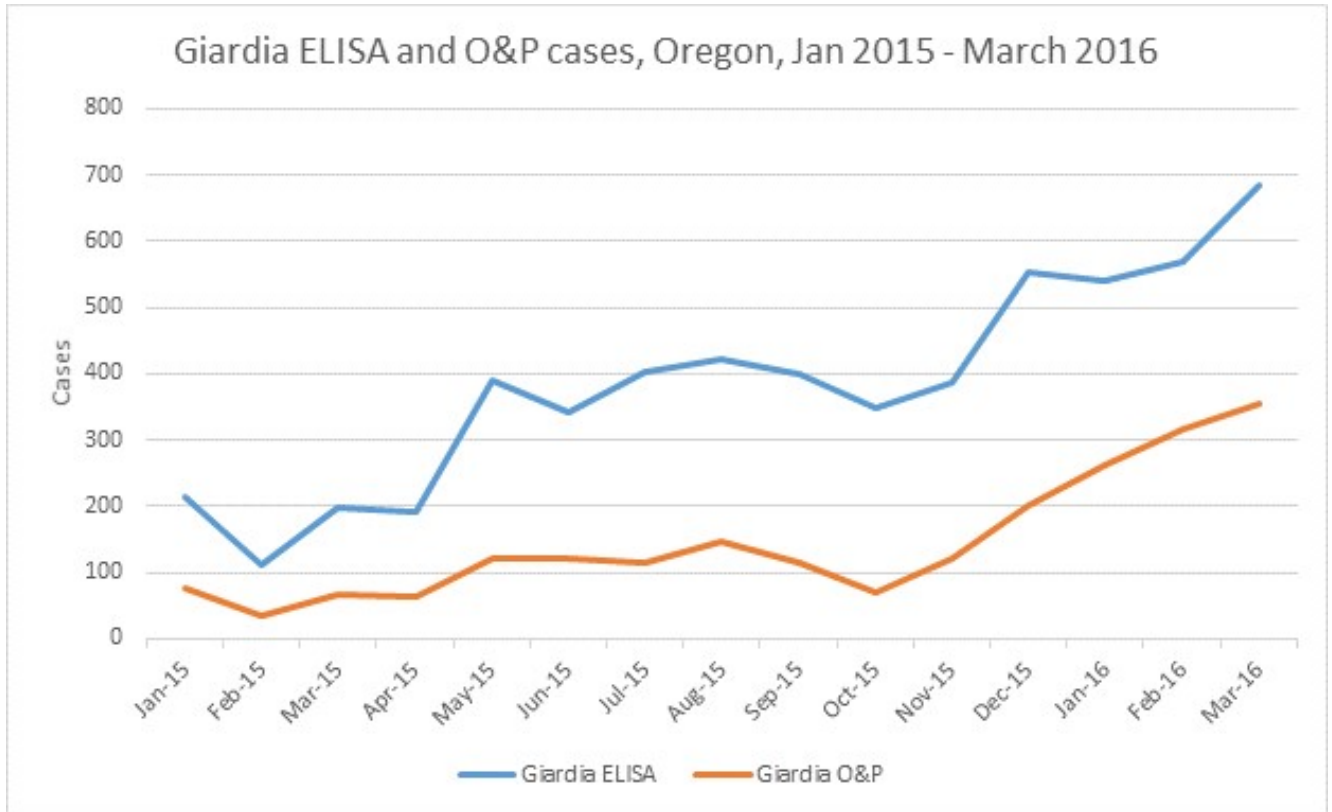


Figure 5: Oregon Public Health Department findings regarding the number of giardia cases reported via two different laboratory methods between Jan 15 and Mar 2016 (O&P vs ELISA).

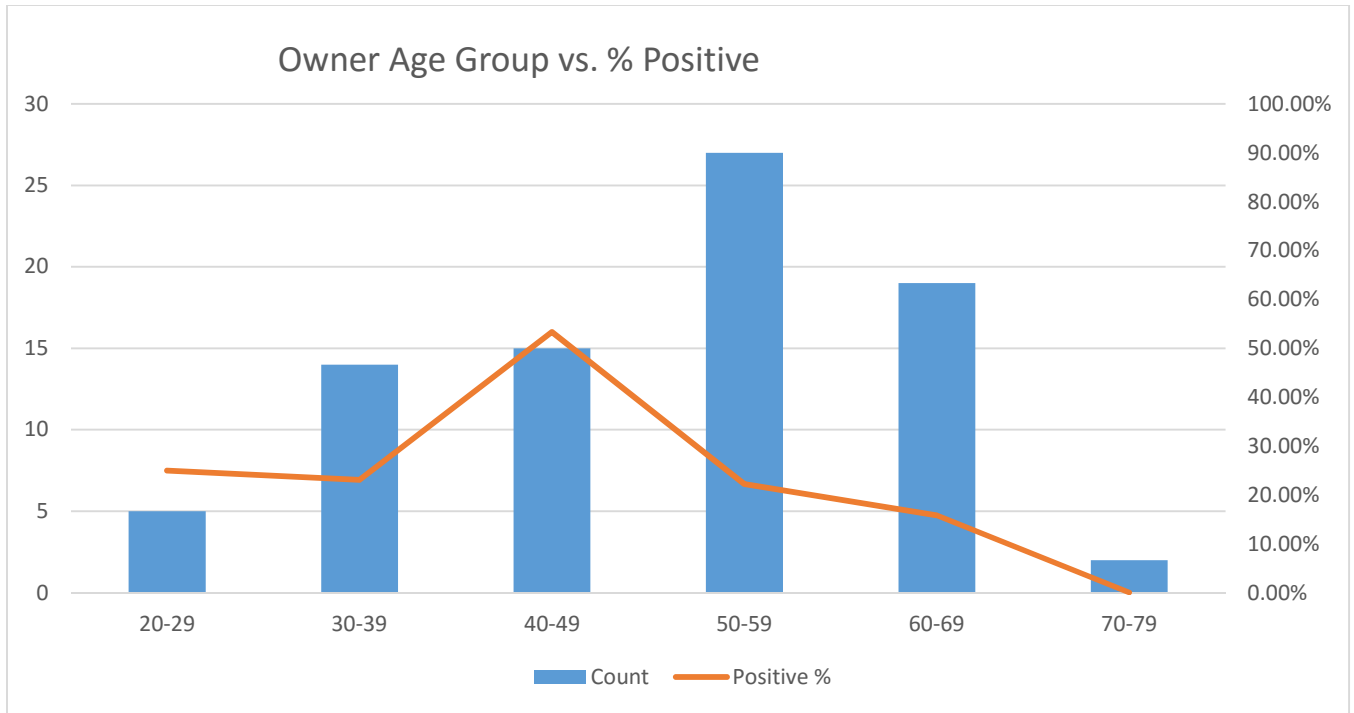


Figure 6: Owner age group count plotted against the percentage of samples identified as positive within this group.

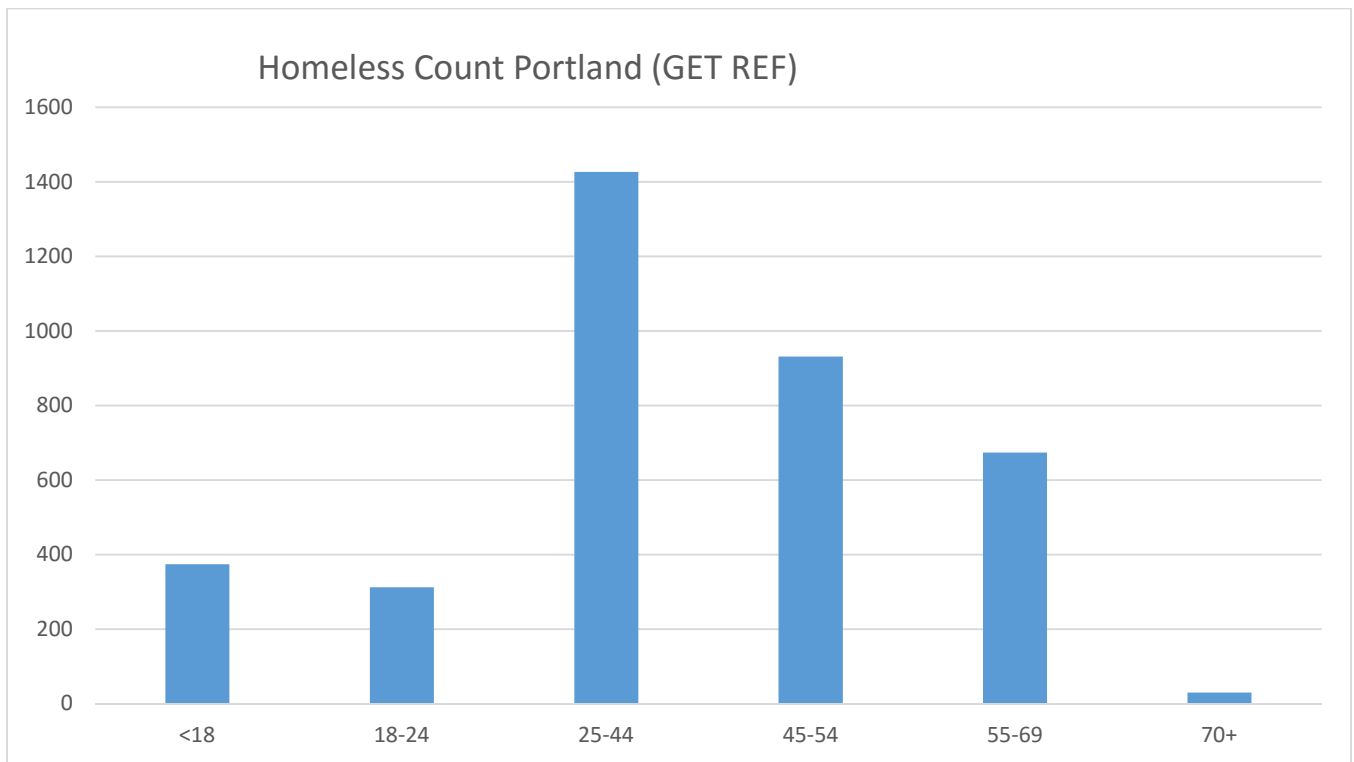


Figure 7: Age demographics from the official Portland, OR homeless count.

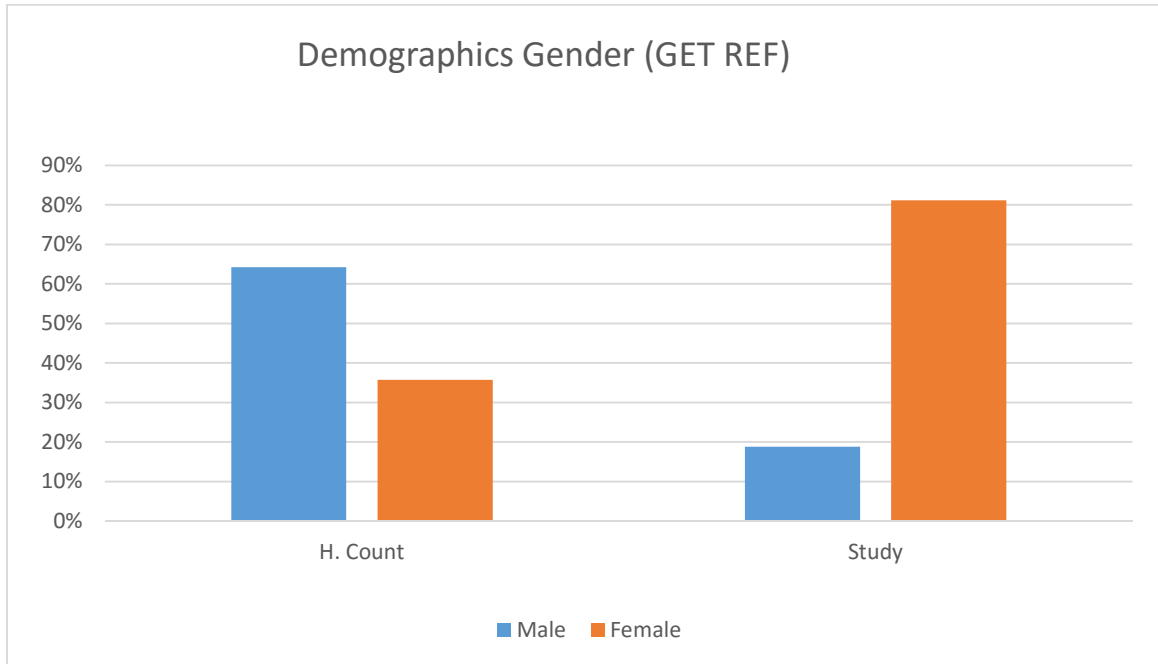


Figure 8; Gender demographics of study vs. Demographics of the Portland Homeless Population via the official Portland homeless count

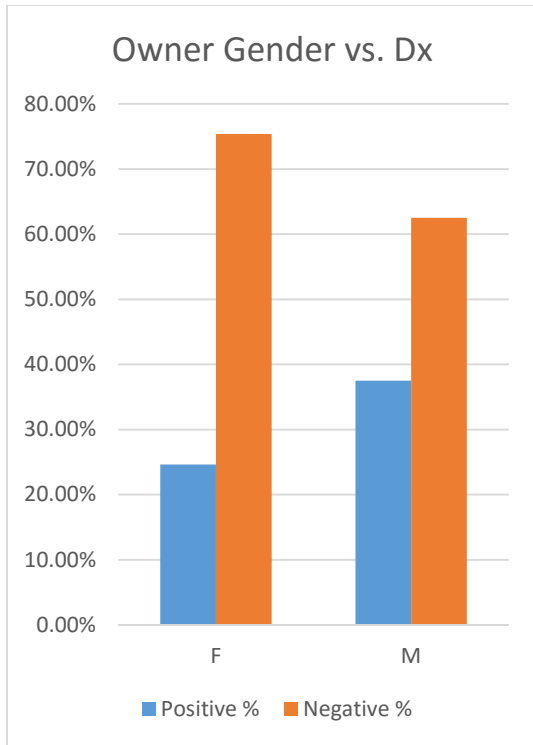


Figure 9: Percentage of positive vs. negative results separated by owner gender demographics.

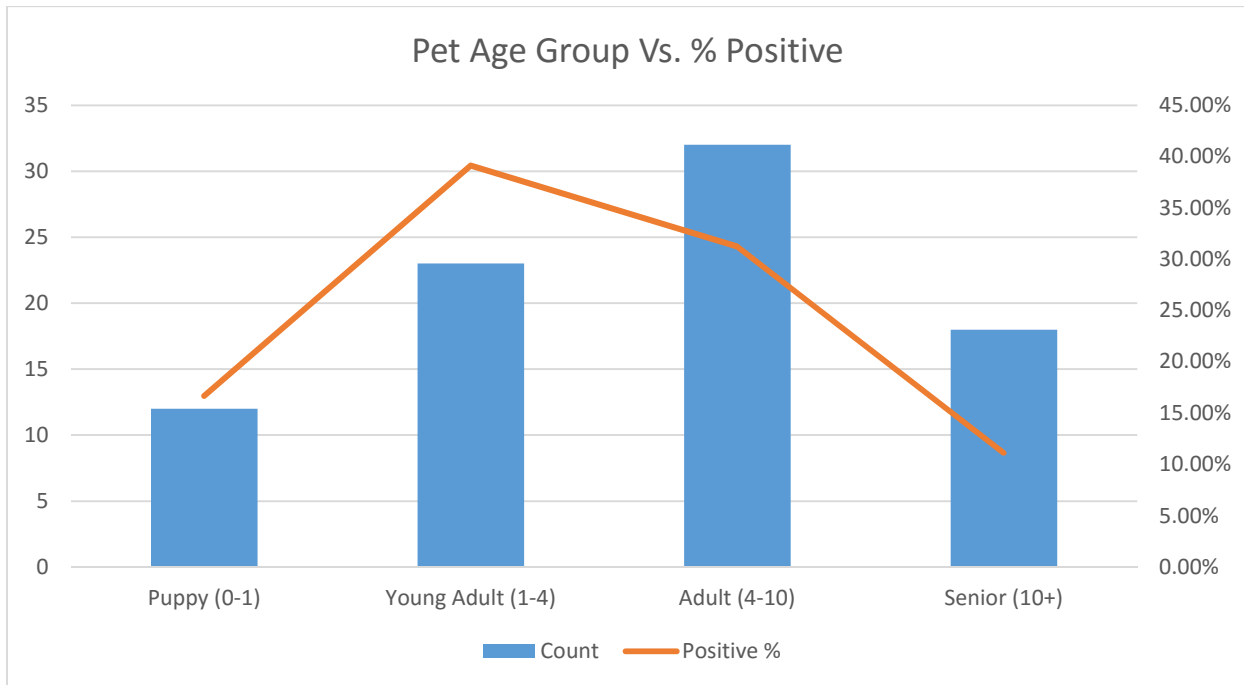


Figure 10: Age demographics of pet population sampled vs the percentage positive samples found within each population respectively.

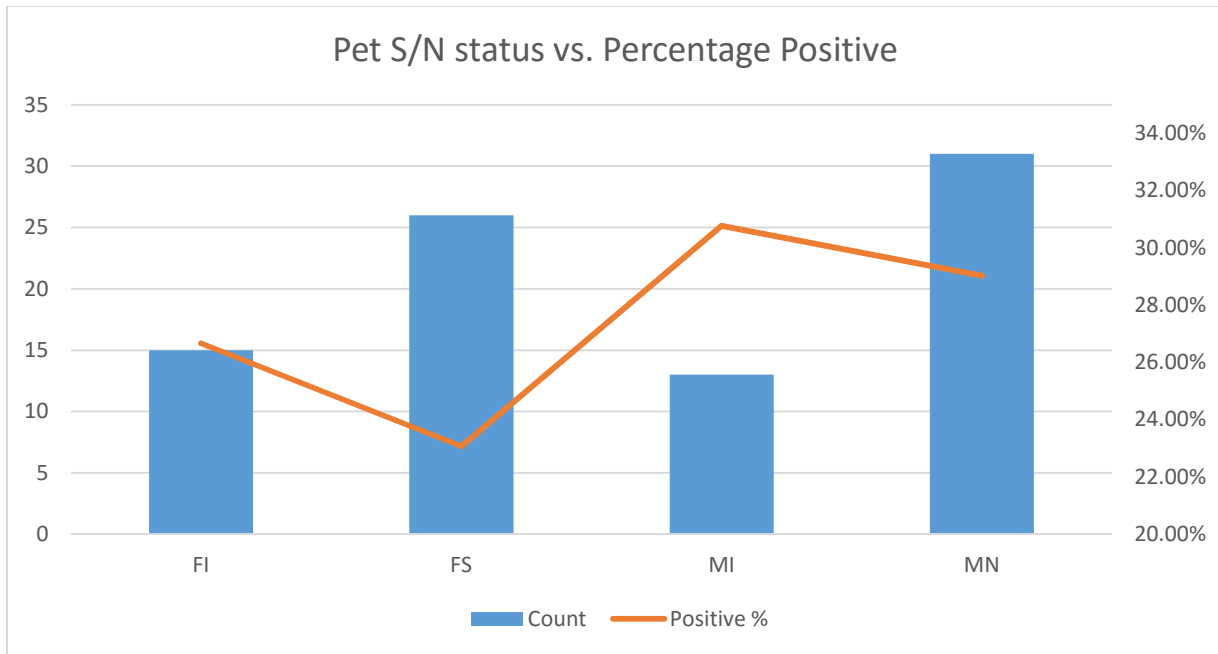


Figure 11; Pet spay/neuter status and gender demographics plotted with the percentage of samples within each group found positive in laboratory tests.

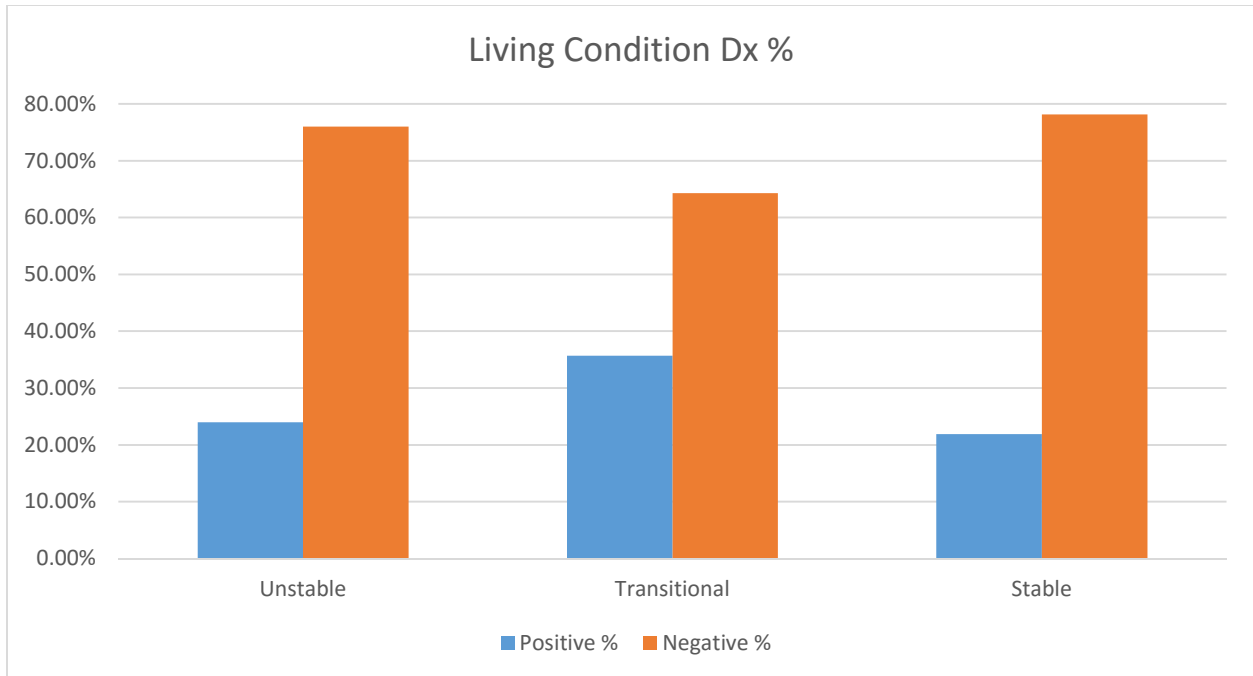


Figure 12; Percentages of negative and positive samples against the living conditions of population sampled.

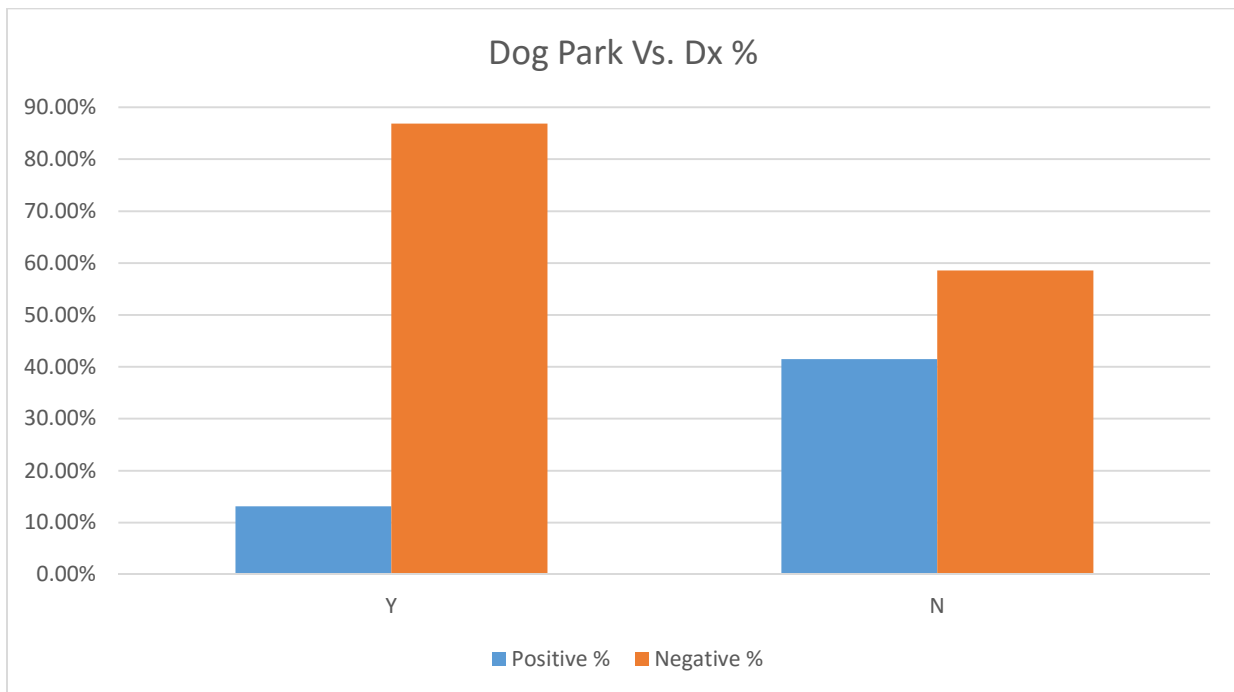


Figure 13: Behavior vs. Diagnosis percentages #1; Dog park use

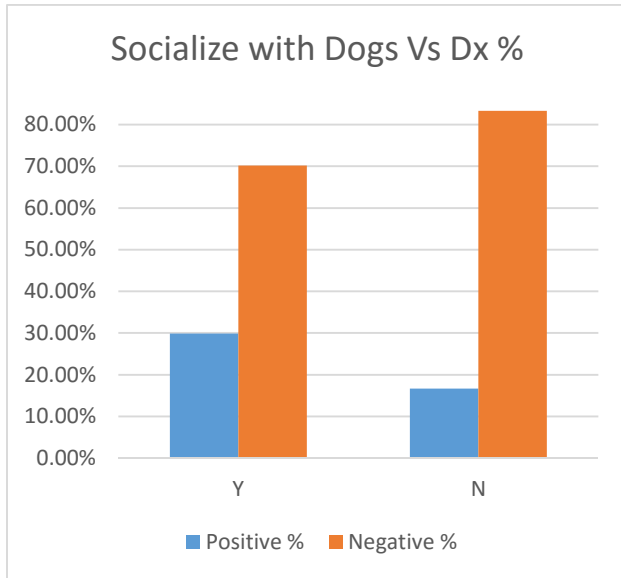


Figure 14: Behavior vs. Diagnosis percentages #2; Socialization with Dogs

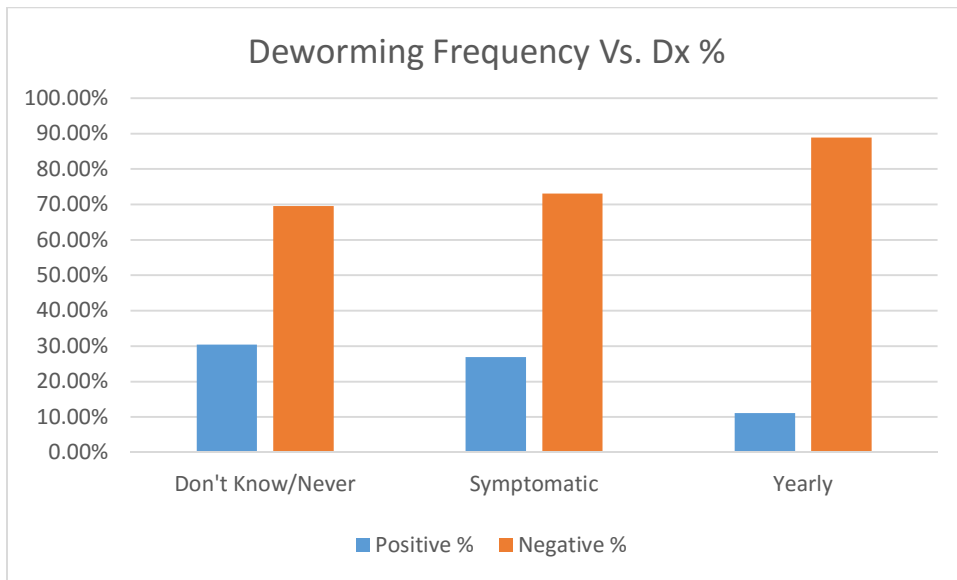


Figure 15 Behavior vs. Diagnosis percentages #3; Deworming frequency

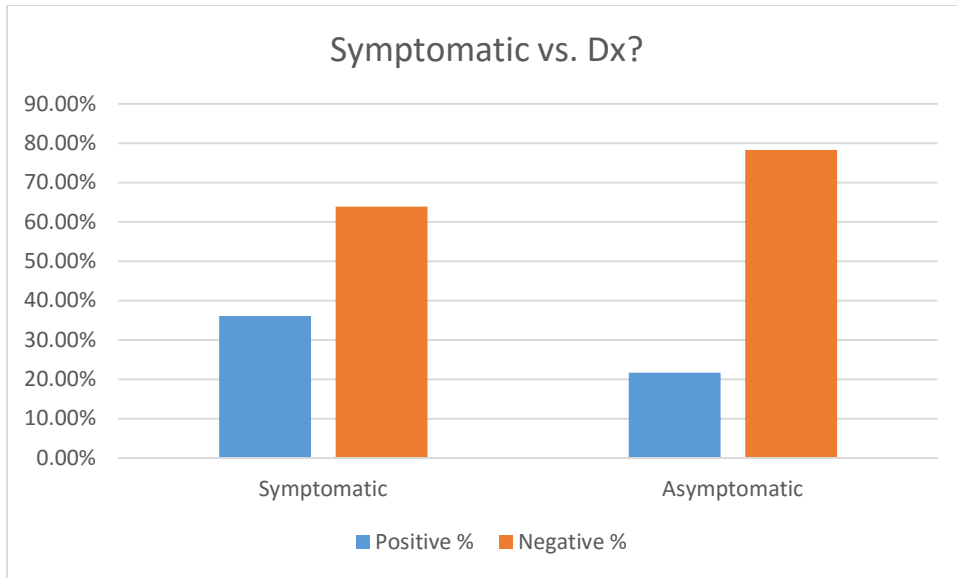


Figure 16: Diagnosis Percentage vs. Symptomatic status

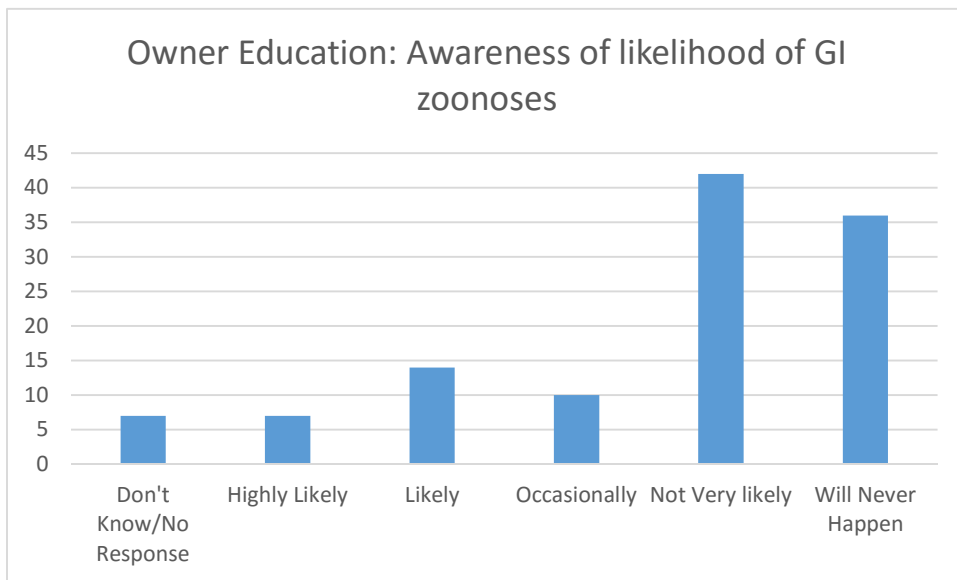


Figure 17: Results from the owner education section of the questionnaire showing the owners beliefs regarding the likelihood that their animal could transmit a parasite to them or a family member.

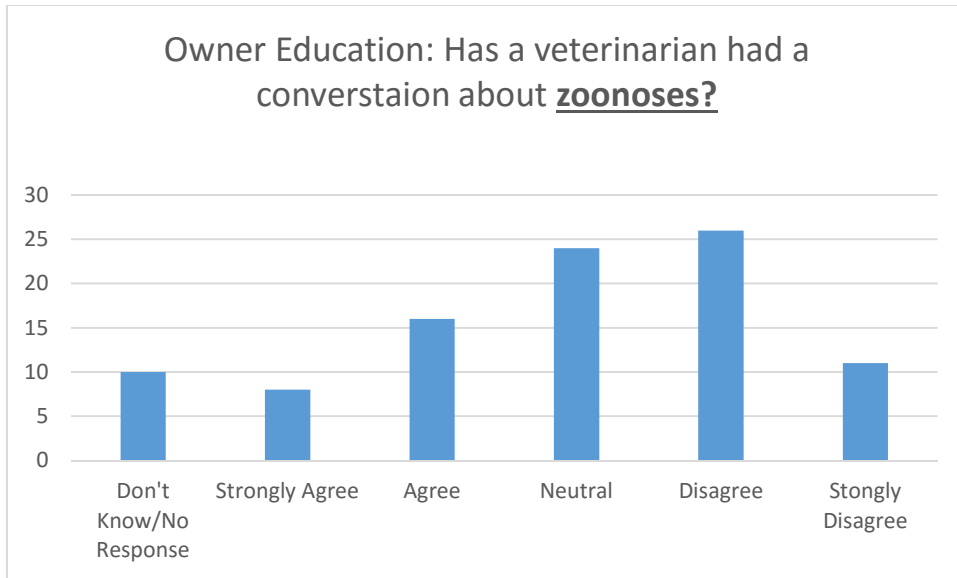


Figure 18: Results from the owner education section of the questionnaire showing the frequency that owners believe they have been spoken to by a veterinarian about zoonoses.

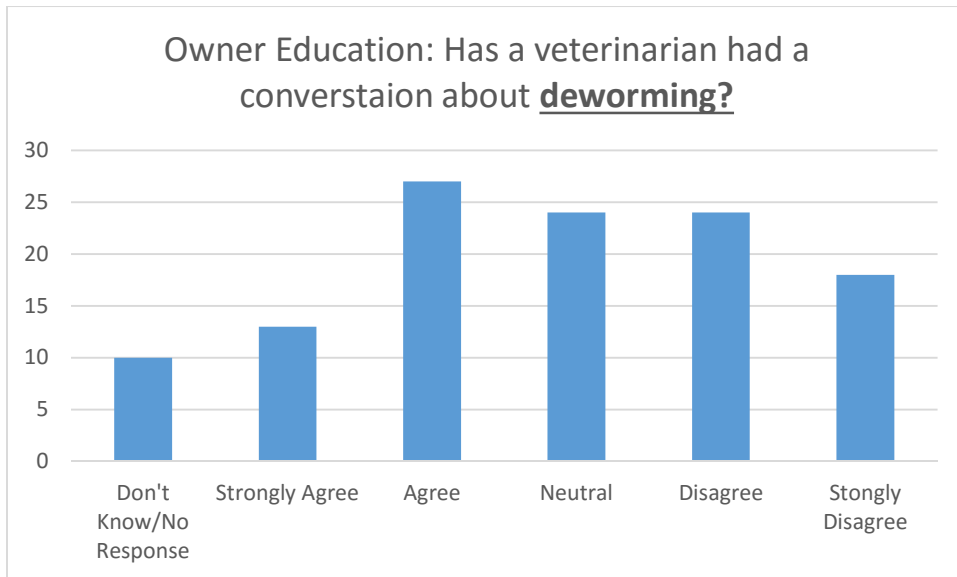


Figure 19: Results from the owner education section of the questionnaire showing the frequency that owners believe they have been spoken to by a veterinarian about deworming.

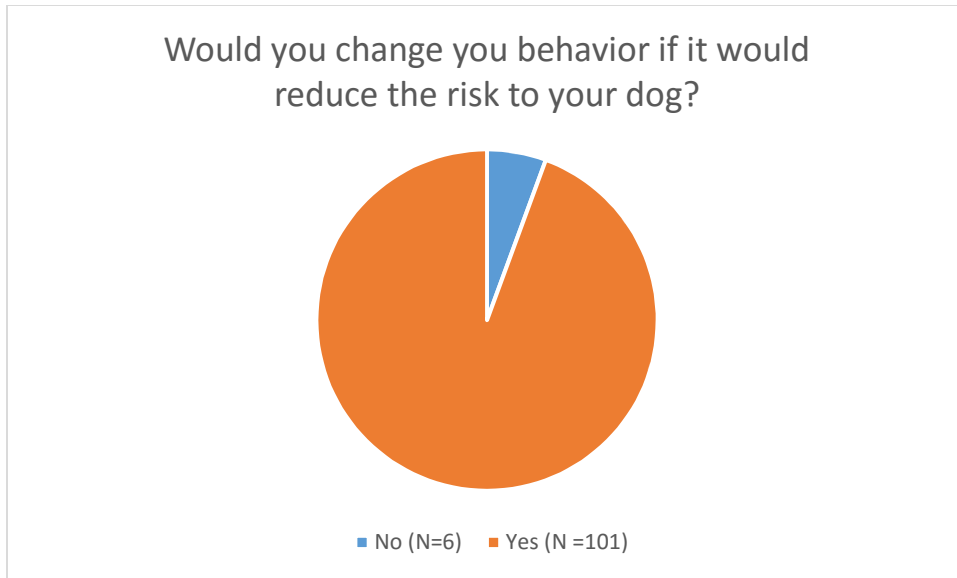


Figure 20: Questionnaire results; frequency of owners who would change their behaviors if they would reduce the risk to their dog.

Table 4: Spay/Neuter status of canine vs. deworming frequency given by owner

			Current Deworming Frequency		
			Don't Know/Never	Symptomatic	Yearly
	Female	Count	8	5	2
	Intact	%	53.3%	33.3%	13.3%
	N=15	within S/N?			
		Count	15	6	3

Spay/Neuter Status	Female	%	57.7%	23.1%	11.5%
	Spayed	<i>within</i>			
	N=26	<i>S/N?</i>			
	Male	Count	8	3	1
	Intact	%	61.5%	23.1%	7.7%
	N=13	<i>within</i>			
		<i>S/N?</i>			
	Male	Count	15	12	3
	Neutered	%	48.4%	38.7%	9.7%
	N=31	<i>within</i>			
	<i>S/N?</i>				
	Total	Count	46	26	9
		%	54.1%	30.6%	10.6%
		<i>within</i>			
		<i>S/N?</i>			